NATIONAL COOPERATIVE SOIL SURVEY

Western Region Soil Survey Conference Proceedings

Bozeman, Montana
June 2-7. 1996

PROCEEDINGS

of the

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

June 2 - 7, 1996

Best Western Grantree Inn
Bozeman, Montana

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

Sponsored **by**
Soil and Water Conservation Society

Best Western Grantree Inn
Bozeman. Montana
June 2 - 7, 1996

Sundav. June 2

	GPS Navigation Field Trip - Mapping for Site Specific Management Demonstration
11:oo - 5:00	Registration: Foyer of Atrium
l:oo	Depart from Grantree Inn parking lot

Mondav. June 3

8:00 - 12:oo	Registration: Foyer of Atrium

- *Chuck Gordon - Moderator*

9:00 - 9:15	Opening Remarks - *Chuck Gordon, Conference Chair, Natural Resources Conservation Service, Bozeman,* MT
9: 15 - 9:25	Welcome by Natural Resources Conservation Service - *Dick Gooby, State Conservationist, Bozeman, MT*
9:25 - 9:35	Welcome by Montana State University - *Thomas McCoy, Dean, College of Agriculture, Bozeman, MT*
9:35 - 9:45	Welcome by Bureau of Land Management - *Fran Cherry, Associate State Director, Billings, MT*
9:45 - 9:55	Welcome by Forest Service - *Dave Garber, Forest Supervisor, Bozeman. MT*
9:55 - 10:30	Break
	Agency Reports
10:30 - 10:45	Natural Resources Conservaion Service - Jim *Culver, NSSC,* Lincoln, *NE*
10:45 - ll:oo	West Regional Agricultural Experiment Stations - *Paul McDaniel, Moscow, ID*

11:00 - 11:15	Bureau of Land Management *- Bill Ypsilantis, Coeur d'Alene, ID*
11:15 - 11:30	Forest Service *- Walt Russell, Washington, DC*
11:30 - 11:45	National Park Service - Larry *Pointer, Fort Collins, CO*
11:45 - l:oo	**Lunch**
1:00 - 5:00	Agency Breakout Sessions

3:00 - *Break*

Tuesday. June 4

- *Chien-Lu Ping - Moderator*

8:00 - 8:20	*Richard Arnold, Washington, DC*
8:20 - 10:00	Panel Discussion - Heavy Metal Contamination
lo:OO - 10:30	Break
10:30 - 11:45	Yellowstone National Park Soil Survey *- Henry Shovic. Ann Rodman, Eric Compas. Mike Wilson*
11:45 - 1:15	Lunch
1:15 - 2:15	Committee Breakout Sessions
2:15 - 3:15	Committee Breakout Sessions
3:15 - 3:45	Break
3:45 - 4:45	Committee Breakout Sessions
6:30 - 9:00 pm	Buffet Mixer: Atrium

Wednesday. June 5

	Yellowstone National Park Field Trip - Park issues and soil response; hydrothermal soils; landscape analysis; and natural contaminants
7:30 am - 6:30 pm	Busses depart from Grantree Inn parking lot at 7:30 am

Thursday, June 6

- *Christopher Smith - Moderator*

8:00 - 8:30	Natural Resources Health--What Signature Will We Leave? - *Dorothy Bradley, Montana State University, Water Resource Center, Bozeman. MT*
8:30 - 9:20	Soil Health - *Robert Meurisse, Forest Service, Portland, OR and Cathy Seybold, Natural Resources Conservation Service, Corvallis, OR*
9:20 - lo:oo	NASA Mission to Planet Earth - Remote Sensing Products for Soil Survey - *Jerry Nielsen, Montana State University. Bozeman, MT*
10:00 - 10:30	Break
10:30 - 11:00	NCSS Work Planning - Brainstorming Session
ll:oo -11:45	Long Term Soil Productivity - *Deb Dumroese, Forest* Service, *Moscow, ID*
11:45 - l:oo	Lunch

- *Gary Ford - Moderator*

l:oo - 3:oo	Poster Session: Atrium
3:oo -3:30	Break
3:30 - 4:00	Interagency Partnering Success Story--Owl Mountain - *Scott Davis, Bureau of Land Management, Lakewood, CO*
4:00 - 4:30	Rangeland Health - *Mike Pellant, Bureau of Land Management, Boise, ID*

Friday, June 7

- Bill Ypsilantis - Moderator

8:00 - 8:30	NASIS (National Soil Information System) *- Mike Hansen, Natural Resources Conservation Service, Bozeman. MT*
8:30 - 9:00	Soil Taxonomy Report *- Bob Engel, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE*
9:00 - 10:30	Committee Reports
10:30	Adjourn *- Chuck Gordon, Conference Chair, Natural Resources Conservation Service, Bozeman, MT*
10:30	Business Meeting
1:00	Conference Steering Committee Meeting

Panel Discussion
Heavy Metal Contamination

Members:

Tom Keck, Natural Resources Conservation Service

Pat Plantenberg, Department of Environmental Quality

Doug Dollhopf, Montana State University

Troy Smith, Golden Sunlight Mine

Committees

Committee - Soil Health/Quality

Charges:

a. Develop interagency soil health definition
b. Propose criteria for field assessment
c. Propose standard methods for measuring
d. Define inherent potential of soils

Committee - Future Marketing Strategies

Charges:

a. Develop educational strategies to promote public interest in soil health (youth groups, schools, and land users, both public and private)
b. Develop a catalog of available soil educators
c. Compile sources of available soil education tools

Committee - Research and Development

Charges:

a. Identify and prioritize soil research and development needs related to NCSS roles
b. Opportunities for meeting R & D needs (eg. sources of funding, collaborative agreements) within new organizational structures

Committee - Riparian Soils

Charges:

a. Develop definition of riparian soils
b. Propose interagency criteria for field mapping of riparian areas
c. Propose methods to identify riparian areas using existing soils data

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WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

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W E L C O M E

to the

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

June 2 - 7, 1996

Best Western Grantree Inn
Bozeman, Montana

Welcome

by Richard J. Gooby, State Conservationist, Natural Resources Conservation Service, Bozeman, Montana

Welcome to the great state of Montana. We are pleased to host the 1996 Western Regional Cooperative Soil Survey Conference.

1 believe meetings like this are important to develop and continue a cooperative effort that began in the 1930s. The National Cooperative Soil Survey initiative was the first of its kind.

In my estimation, the Cooperative Soil Survey process is leading the way when it comes to cooperating and working together to reach a common goal.

Within the Natural Resources Conservation Service, we rely on soils information to give us our most basic data needed for natural resource planning. Other groups and agencies also rely on soils data for natural resource planning, development, and management. The information that you generate is vital.

Because of this, the need to cooperate is critical.

A concern I hear about often is the duplication of work conducted by federal and state agencies, universities, and other groups. This cannot be said for the NCSS. I believe you have long served as an example of an excellent cooperative effort. I challenge you to continue this collaborative process.

I hope you have an effective session. What you discuss and decide will have far-reaching effects for my agency — and everyone else involved in natural resource planning. Good luck.

Welcome

FRAN CHERRY
Associate State Director
Bureau of Land Management
Montana, North & South Dakota
Billings, Montana

I want thank you for inviting me to speak at your conference and to extend to you, a BLM thank you and welcome to Montana. I'm quite pleased to be here and I look forward to this National Cooperative Soil Survey (NCSS) conference. I congratulate you on selecting the timely and important topics: Soil health/quality and Riparian mapping.

Montana is truly the "Last Best Place" with some of the largest unspoiled areas, and a great untamed river- The Yellowstone, National Parks, majestic mountain ranges, and wilderness areas. The Beartrap Canyon, on the Madison River just west of here, is BLM's first Wilderness area dedicated in 1984. Dramatic elevation ranges in the state are illustrated by Granite Peak, at 12,799 feet on the North edge of the Beartooth Plateau, to 1820 feet at the Idaho border NW of Libby. You will see and perhaps visit some of the Absaroka or Beartooth area on your field trip to Yellowstone Park.

But let's not forget about the Eastern two-thirds of Montana; The Northern Great Plains, with its isolated mountain ranges, wilderness areas and immense, diverse and breathtaking prairies. Closer inspection reveals many surprises about the land and people.

One third of Montana is Federally owned. The Bureau of Land Management administers about 8 million surface and 38 million subsurface mineral acres in the state. This land encompasses a wealth of natural and historical resources that represent a National treasure to be passed on to future generations.

Major populations of deer, antelope, elk, moose, game birds and Rocky Mountain bighorn sheep inhabit and are dependent upon BLM land for habitat.

Recreational use of public lands has provided new challenges in recent years. BLM is cooperating with the Bureau of Reclamation on managing the Canyon Ferry. This area contains wide diversity of wildlife, a highly productive trout fishery, and public recreation. New programs, such as watchable wildlife, block management and BLM's Back Country Byways, are expanding.

In northwest Montana, the potential exists for the listing of the bull trout as a threatened species. This would have a major impact on land management activities within its habitat.

Wolf reintroduction into the Greater Yellowstone may have far reaching and long term impacts not yet fully understood.

The Clean Water Act amendment of 1987 placed additional emphasis on nonpoint source pollution control by requiring BLM and FS to meet state standards.

PART 2

The Bureau, like other agencies, is currently in the midst of reorganization, downsizing and reduction of staff, as well as trying to modernize for a technological future. Teams and team leaders are being developed to address and implement the many issues BLM encounters. Retirements, buyouts, adjusting to reduced budgets constantly changes team membership slowing progress.

Public land administration has come a long way since the inception of the BLM in 1946. BLM's 50th birthday is just 43 days away on July 16.

Demands on the resources are ever increasing and becoming more diverse. Laws and regulations that must be complied with are far reaching, more complex and controversial than they were just a few years ago. The challenges that face public servants are considerable.

Management of various programs, such as soil, water, range, wildlife, forestry, minerals, lands, recreation, and others, has been the traditional means of administering the wide array of resources and uses of the lands the BLM administers. However, the emphasis is shifting towards a more holistic management of entire ecosystems.

The soil surveys that you people have completed on most of the private and public lands in Montana now needs to be utilized to a much higher degree. New initiatives will require the assessment of the quality or health of soil, water, and vegetation. Assessments will, at times, need to be made quickly and sound data will increase the accuracy. The data that in NCSS data bases will go a long way in providing that accuacy.

From everyday mail to electronic data bases providing for working GIS systems, technology is becoming the answer for a better understanding of how to manage the issues. Recent changes in organization, staffing and budget of all agencies has made this concept and application of the automated resource data even more valuable to the nation. These changes should bring about a closer and more frequent working relationships between the agencies. Your scheduled committee discussions tomorrow will provide the valuable insight and produce the needed definitions, and develop the lists of criteria for riparian mapping.

One effort that comes to mind is the Interagency Technical Teams effort to develop a common ecological map. This effort clearly indicates that common resource data systems such as the National Soil Information System (NASIS) that Mike Hansen will discuss on Friday are critical to resource issues. The vast amount of field, research and monitoring data must be integrated into any assessments for wise management of our natural resources.

The consistent standard attributes needed to delineate area's or provide data for the "issue" at hand. National data bases can and will be used to provide for a faster, consistent, less expensive method of producing maps or information for professionals and managers alike to address resource issues.

These two multi-scale spatial mapping programs will be used more and more in the future. The use will vary from national and regional planning efforts for STATSGO, to small watersheds with several land managers for SSURGO.

PARTNERSHIPS:

BLM is and has been a NCSS cooperator in the inventory of western forest and rangeland resources for many years. I know that you are aware of Bill's efforts as an active promoter of NCSS's adjustment to address future needs. The BLM looks forward to maintaining this involvement and particularly in the use of natural resource data by electronic methods.

Partnerships are often easy to establish, but require on-going support and involvement to sustain. Successful partnerships are "win-win" situations that require give-and-take from all involved. The successful partnerships that have sustained the NCSS will be one cornerstone for the future. Cooperation between Federal and state agencies, user and conservation groups is essential to success.

Rangeland Reform has had a profound impact on the workload of the BLM. Here in Montana the creation of four Resource Advisory Councils and selecting representatives from the public to advise BLM on Public land initiatives will have positive influences on complex resource issues.

Ecosystems and "resource parts" need to be consistently assessed and managed across political and agency boundaries. However, that does not mean management of private land will be dictated by Federal agencies. BLM in Montana and the Dakota's administer leases and permits to some 4400 operators. This represents about 23 % of the BLM's total. Hopefully, we can work together with private land owners to build consensus about making good land stewardship decisions that will benefit all interested parties.

The basic resources, Soil, Water, Air and Vegetation will continue to be integral to our understanding of terrestrial landscapes, relationships, processes and thus ecosystems. Much of the species richness and diversity of ecosystems is encompassed in the soil mantle. We need to discover more about how our management of the land impacts these and other components. Our prosperity and ultimately our very survival may depend upon the answers to these questions.

In closing, I'm confident that you will determine and agree on the needed definitions; determine the necessary criteria for an interagency field assessment of soil health and field mapping of riparian areas.

BLM and I wish you an enjoyable and productive conference, Thank YOU.

PRESENTATIONS/REPORTS

of **the**

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

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Western Regional Cooperative

Soil Survey Conference

Bozeman, Montana

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Agency Report
Soils Division
Natural Resources Conservation Service

Presented by Jim Culver, National Soil Survey Center, Lincoln, NE

Reorganization and restructure of our respective Federal and State agencies since our last excellent combined West and Midwest Regional Cooperative Soil Survey Conference at Coeur d'Alene, Idaho have been significant. This morning I would like to share with you the current organizational structure of the Soil Survey Program within the Natural Resources Conservation Service. I would also like to highlight a few current soil survey activities and the purpose, thrust, and processes of the Soil Survey Division as we collectively strive to maintain a highly productive and responsive National Cooperative Soil Survey Program (NCSS).

I - Reorganization within the Natural Resources Conservation Service (NRCS)

By now most of you are aware that Dick Arnold, Director of the Soils Division for a number of years, has been selected to be Special Assistant to Chief Paul Johnson on Soil Science. Dick's new title will be "Senior Soil Scientist." The vacancy announcement for the Director of Soils Division is currently being advertised in both the Federal and university sectors.

Six Regional Offices now provide a wide variety of support to the states. Seventeen Major Land Resource Area Officer have been established and staffed to conduct the business of soil survey production. Quality assurance and manuscript editing responsibilities for soil survey production have been reassigned from the National Soil Survey Center to MLRA and Field Soil Survey Project Offices.

The following is an* overview *of the functions performed at the I) Soil Survey Project Office, 2) MLRA Region Office, 3) State Office, and 4)

National Soil Survey Center. Soil Survey Project Office Functions --

Soil Series development and maintenance
Manuscript and publication development
Soil investigations and special studies
Soil performance and data collection
Interdisciplinary coordination
Project soil survey planning and management
Soil survey mapping qualify control
Evaluate, maintain, and update soil surveys

MLRA Region Office Functions --

Database development and maintenance
SSURGO and STATSGO development and maintenance
Manuscript edits
Publication generation (multi-media)
Final correlations
Provide data for regional interpretations
Coordinate with other disciplines to integrate soil databases with other resource databases
Program planning and management
Develop budgets and staffing plans
Quality assurance and oversight
Coordinate with regional, State, NSSC offices, and NCSS cooperators
Develop memorandums of understanding
Provide technology transfer and training to project soil survey offices

State Office Functions --

Program planning and management (technical soil services)
State NCSS cooperator liaison
Coordinate with MLRA region offices
Coordinate cost-share agreements
Technical soil services interdisciplinary technology transfer
Supervise technical soil services soil scientist
Market soils information
Disseminate data to internal and external customers
Obtain customer feedback
Serve on interdisciplinary teams on the state level
Develop and maintain technical guides, i.e.. hydric soils lists, HEL list, etc.
State level support for FSA appeals
NRCS program quality assurance and oversight
Develop memorandums of understanding

National Soil Survey Center Functions --

Soil Classification Development
International services
National database management and development
NASIS development and support
NCSS research
Technology transfer
National soil survey leadership and strategic planning
National standards development and maintenance
National policy development
Soil characterization/investigation support
Soil interpretations criteria development
Global climate project management

II - Soil Survey Division Activities

Seven priorities are identified in FY96 by the Soil Survey Division. These priorities are 1) Soil Survey Database Quality, 2) Implementing the New Soil Survey Structure, 3) NASIS, 4) Soil Survey Publications Backlog, 5) Develop Alternative Products, 6) Scanned Soil Surveys on CD-ROM, and 7) Soil Taxonomy.

Training continues to be a major component of the NSSC. Some highlights are: 1) Soil Science Institute will be held at the University of California, Davis..

Dr. Randy Southard will lead this activity. Three sessions of Advance Hydric Soils planned this year. A new course, Soil Technology, Measured and Data Evaluation. will be offered this year. A second course, Soil Technology for program and Application, is scheduled for FY97.

Dr. Bob Ahrens is leading our project to update Soil Taxonomy. We axe on course to have this document published before International Soil Science meetings in Paris in 1998.

Recent publications, in addition to the traditional Soil Survey reports, include Soil Survey Laboratory Interpretations Manual, SSIR No. 45; Soil Survey Laboratory Methods Manual, SSIR No. 42; and a series of information sheets on soil quality.

A major agency initiative is to get all current soil surveys digitized to FGDC standards. In FY96 funding was earmarked for digitizing 155 state-identified priority soil survey areas.

The State Soil Scientists are now responsible for the use of soil survey information in the states. This provides a focus for activities designed to improve the data and providing more customer-driven products.

III - Purpose, Thrust and Processes of the Soil Survey Division

A. Purpose

The soil (pedosphere) is the thin, critical interface between the earth and the atmosphere, supporting much of the terrestrial life of the planet, filtering much of the water we drink, and catalyzing many of the chemical transformations upon which we depend. Knowledge about characteristics of soils and soil interactions with other factors helps people predict and control the influences of human and natural phenomena as we seek to create a "Productive Nation in Harmony With a Healthy Land."

The NCSS helps people understand soils and their responses to a variety of natural and human influences. It accomplishes this through a multi-purpose, science-based soil survey. NCSS products are:

(I) Information about the distribution and properties of soils and of factors affecting the soil environment

(2) Predictions of soil behavior and of the natural systems of which they are a part, and

(3) Guidance on how to apply the accumulated knowledge of soil survey.

B. *Soil Survey Division Thrust Areas*

1. Enhance the Quality of Soil Survey Information

a. Continue MLRA Approach to Soil Survey - Erase Political Fault Lines and Fill in Voids in Data.
b. Add Use-Dependent and Temporal Soil Property Data for Soil Horizons.
c. Create One Soil Survey For All U.S. Lands.
d. Create and Maintain National Standards for Soil Survey.

2. Accelerate Application of Soil Survey Information

a. Develop Soil Survey Interpretations (R&D, NASIS, Training).
b. Create Technical Soil Services Program - State Soil Scientists in 34 states.
c. Provide Training to Develop Soils and Soil Survey Technical Skills of Field Office Staff.
d. Digitize 2,500 Soil Surveys by the year 2000.
e. Re-engineer Publication Process.
f. Develop NCSS Role in Soil Quality Assessment (Baseline Indicators and Soil Condition Index).
g. Republish Soil Taxonomy.

3. Create Easy Access to Soil Survey Information

a. Provide a National and International Soil Data Access Facility (WWW/INTERNET).
b. Provide a National and International Soil Data Capture and Standardization Software (Windows Pedon).

4. Aggressively Apply New Technology in Soil Survey

a. Develop Remote Sensing Techniques for Soil Survey - ERDAS.
b. Develop GPS, GPR, etc. - Field Tools for Soil Survey.
c. Develop GIS - Select/Query/Report Tools for Soil Survey.

C - Supporting Processes

1. Create a NCSS Research and Development (R&D) Agenda.

   a. Develop a Comprehensive Listing of R&D Needs for **NRCS** and Partners.
   b. Select and Prioritize NSSC R&D Activities from NCSS R&D Agenda.
   c. Leverage NCSS R&D Agenda to Increase and Strengthen Partnerships and Accomplishments.

2. Develop and Maintain a National Soil Information System (NASIS)

   a.. Create NCSS Software Tools.
   b. Create a NRCS and NCSS Networked Information System.
   c. Integrate Data From Other Agencies and Institutions.
   d. Maintain and Manage 17 Integrated MLRA Natural Resource Data Bases

3. Provide for Resource (Human and Financial) Development

   a. Develop Leadership, Project Management and Team Skills of NSSC, MLRA, State, and Field Office Soils Staff.
   b. Increase Diversity within Soil Science Discipline.
   c. Increase Funding for Mapping, Digitizing, Technical Soil Services, and Soil Survey Laboratory- Investigate sale of products and services.

4. Increase National and International Policy Influence.

   a. Monitor Soil Resource Condition and Trends and Draft Policy Recommendations
   b. Continue Active Outreach in International Organizations.
   c. Ensure that Soil Survey Staff Remain in International Demand.

5. Ensure Political Support for Soil *Survey.*

   a. Develop and Implement Continuous Customer Feedback Process
   b. Actively Market Products and Services.

6. Ensure Scientific Credibility of Soil Survey.

   a. Graduate Studies of field staff.
   b. Sabbaticals (national and international)

BUREAU OF LAND MANAGEMEN:' RI:PORT
Bill Ypsilantis, BLM, Coeur d'Alei e, I.)

I'm very pleased to be here in front of you today to give this ELM repc rt. Actually, I'm dam lucky to be here at a time when you have to practically ask per.niss on io tri vel to the restroom. You can see by the BLM attendance that some of oui soi s pe ople weren't so fortunate. Having hosted the last regional conference in Coeur d'Ale.ie, 1 loo.: forward to doing my small part to help promote BLM participation in the Ni tion il C oope rative Soil Survey.

This is a time of rapid and sometimes confusing changes. We hav been throug h endless rounds of reorganizing, downsizing, rightsizing and, by some opinic as, iear cap: izing.

We have been through two furloughs where we were told we're non-ssentia1 emp loyees. However, as stewards of well over two hundred million acres of publ c lard, i fee' that our role to preserve and restore the health of the land for future generatiox s is very cri ical indeed.

We still face daunting budget constraints and the threat of RIF's. Some stat s de vot ovet 80% of their budget to personnel. It's hard to get much done on the gro md with tho e skewed numbers. So personnel adjustments will continue.

Budget limitations have cut deeply into the Bureau's soil activities. Soil urv y e fort are at a low ebb. However, some innovative new inventory methods have been impiemented I will say more about those in a minute.

In the Bureau the roles of leadership are changing. Our Washington office I as t een reorganized into teams and no longer has a physical soil presence. Bill Volk at the Montana state office, serves as the National soil lead with respect to coordination of tl e activities. The miles between him and D.C. presents a challenge in communication.

The Denver Service Center has evolved into the National Applied Resource Sci ences Ce nter or NARSC. Sounds like a branch of the ATF doesn't it? Al Amen serves as oi e oi the Bureau's senior soil technical leads and still has about 100 irons in the fire in thi ne v organization.

Many of the state leads in soils are multi-hatted individuals with numerous other progi ams to coordinate. Their background may or may not be in soils. Their highest priority may or nay not be soils.

Many field soil scientists find their workload and even titles shifting or evolving. Some have become Natural Resource Specialists with many duties and emphasis outside of soils.

I mentioned that soil survey in the Bureau is winding down. However, efforts to enhance existing surveys for new interpretations and needs are ongoing in several states. Al Amen is ssisting Utah and Wyoming, among other states in utilizing Informix and Imagine soft vare and GIS systems to create overlays of satellite imagery, DEMs, soils and geology maps. An integrated landscape analysis approach is used to portray soils, geology, vegetation communities, hydrology and other landscape features as needed.

Riparian ecological site inventory and soil mapping is ongoing in Alaska, Oregon, and other states. Various approaches are being used to accomplish these inventories including the line segment mapping technique. Our National Training Center is providing several riparian inventory training sessions throughout the West with a strong soil emphasis,

The major emphasis with regard to soil survey is in the assimilation of the vast amount of data already collected into a more useable format. The formidable task of digitizing of soil surveys is progressing in several states. Cooperation between BLM and NRCS has enabled this work to progress at a steady pace. The conversion of previously digitized soils information from the BLM's MOSS system to ARCINFO is another step that must be accomplished. Finally, the databases for the soil surveys must be linked to the spatial data in order to be able to realize our long term goal of being able to automate our massive soil survey information resource base so that we can readily access, manipulate, and integrate this information in a user friendly environment so that it will be readily available to any manager or resource specialist who needs this information for our resource management decision making process.

The Bureau's rangeland health initiative is ongoing. Each state is in the process of developing rangeland health standards and guidelines in cooperation with the Resource Advisory Councils within the states. These citizen councils representing the wide scope of users of public land are serving as advisors to the BLM in the management of the resources on public land. These rangeland health standards and guidelines have as their cornerstone the indicators of soil function and health.

Rangeland soil guidelines are in the initial stages of development with an emphasis on rangeland function and health. We are working jointly with NRCS and ARS in this effort Part of this effort is work with the NRCS soil quality team in Akron, Colorado.

The Bureau is working with NRCS to foster cooperation in use of the National Rangeland Inventory for assessing range health. Modifications of this process are being discussed to accomodate field testing and qualitative range health assessment.

In closing, I wish to point out the increasing need for partnering and cooperation between Federal agencies, and in fact with agencies at all levels of government and private organizations. The National Cooperative Soil Survey is a shining example of this type of partnering and is in a unique position to carry this cooperation into the future.

FOREST SERVICE REPORT - by Walt Russell

The USDA-Forest Service includes four Deputy Areas: Research, State and Private Forestry, International Forestry, and the National Forest System. My remarks today refer chiefly to the National Forest System.

The National Forest System is comprised of about 192 million acres of publicly owned lands, including 155 National Forests, and 20 National Grasslands. One hundred-one (65%) of the National Forests, 10 (50%) of the National Grasslands, and about 164 million acres (85%) of the total acreage of public lands in the National Forest System, lie within the Western Region of the National Cooperative Soil Survey.

The Forest Service is committed to the principles of ecosystem management, or an **ecological** approach to natural resource management.

An ecological approach means basically that our *main locus* is on the long-term condition and sustainability of ecosystems, rather than on single **reources,** or short-term production of goods and services. We still produce goods and services - such as wood products, forage for animals clean water, recreation use, minerals, wilderness experiences for people, etc. -- but each resource and each use, individually, is subservient to the larger goat of ecosystem management.

A major component and a prerequisite of our ecological approach to management is the Ecological Unit Inventory. An **Ecological** Unlt is defined as a mapped **unit** of land that reflects inherent capability, based on a combination of geo-climatic, physical, and biological factors -- soil, Geology, geomorphology, climate, and potential natural vegetation.

An Ecological approach requires various analyses and assessments across a range of scales, To facilitate **multiple** scale analyses and assessments, we have a framework for mapping Ecolgicat Units at different scales. It's called the National **Hierarchical** Framework of Ecological Unlts.

The National Hierarchical Framework of Ecological Units is a regionalization, classification & mapping system for stratifying the earth into progressively smaller areas of increasingly uniform ecological potentials. It is a structure to facilitate the mapping, display, and intepretation of Ecological Units at different spatial scales, to respond to different levels of planning and information needs,
(See figure 1).

We are moving more and more toward expanding our Soil Resource Inventories into Ecological Unit Inventories. Ecological Unit Inventories should, and we hope to soon have official direction that they must, incorporate all soil inventory/soil survey standards. At the same time, we are becoming more sensitive to the standards that other disciplines have for 'their' factors (e.g. geologic, geomorphic, vegetative community, etc.). in order to broaden the cross-discipline credibility of these inventories as ecological unit inventories,

I found it particularly gratifying this past year to see the amendment to the National Soils Handbook, incorporating procedures for correlating Ecological Units info the National Cooperative Soil Survey. This is an excellent example of agencies working togetherto achieve a common goal. I'd particularly like to commend Neil Peterson, Darrell Schroeder, Chad **McGrath,** Cam Loerch, Terry Bowerman, Terry Svalberg, Kimberly Johnson, Dennis **Lytle,** Tom Collins, and any others unnamed, that worked to develop this amendment, and get it incorporated into the National Soil Survey Handbook.

Figure 1:
the NATIONAL HIERARCHICAL FRAMEWORK OF TERRESTRIAL ECOLOGICAL UNITS

ECOREGION:

DOMAIN - global scale - millions of square miles (1:30,000,000 or smaller)

DIVISION - continental scale - 100,000s of square miles (1:30,000,000 to 1:7,500,000)

PROVINCE - 10,000s of square miles (1:15,000,000 to 1:5,000,000)

ECO-SUBREGION:

SECTION - 1,000s of square miles (1:7,500,000 to 1:3,500,000)

SUBSECTION - 100s to 1,000s of square miles (1:3,500,000 to 1:250,000)

LANDSCAPE:

LANDTYPE ASSOCIATION (LTA) - 1,000s of acres (1:250,000 to 1:60,000)

LAND UNIT:

LAND TYPE (LT) . 100s of acres (1:60,000 to 1:24,000)

LANDTYPE PHASE (LTP) - less than 100 acres (1:24,000 or larger)

The Natlonal Interagency Memorandum of Understanding to work toward a Common Spatial Framework of Ecological Units was recently signed by the heads of nine Federal agencies: Natural Resources Conservation Service (NRCS), Bureau of Land Management (BLM), Forest Service (FS), Environmental Protection Agency (EPA), Geological Survey (USGS), National Biological Service (NBS), Fish & Wildlife Service (FWS). National Park Service (NPS), and Agricultural Research Service (ARS). This effort grew out of a 3-agency commitment signed 2 years ago by the heads of the (then) SCS, FS, and BLM. The ultimate goal is to unify, or at least fully coordinate three existing frameworks: (1) the National Hierarchical Framework of Ecological Unhs. used by the FS; (2) the Major Land Resource Area - Land Resource Region (MLRA-LRR) framework used by NRCS; and (3) the ecological region framework used by the EPA. The MOU says, really, that we are not supposed to do Ecosubregion mapping and MLRA revisions independently of each other.

Although the three spatial frameworks were originally designed to serve somewhat different objectives, we are finding that the more we work together across agency lines to flesh out our objectives, the more commonality of objectives we are discovering, and the more coincident map unit boundaries are beginning to emerge. The Interagency Steering Committee and Interagency Technical Team to develop the Common Spatial Framework of Ecological Units are meeting this week in Sioux Falls, South Dakota.

PROGRAM TRENDS

We have coverage of spatial soils information of some kind over nearly all of our National Forest System lands. Much of it, however, is in need of updating to bring it up to current standards and/or make it detailed enough to meet current and near-future needs for land capability-response predictions and assessments. Working toward filling this need, we have maintained an annual level of about 5 to 6 million acres of EUI/SRI mapping for about the past 5 years.

Our soil scientist workforce (which makes up less than 1% of our total workforce) peaked at about 280 about 1960, then slowly declined to about 175 in 1986. then rebounded to about 200 in 1993, and now is again on a downward trend. Our current workforce in soil science is about 200, but with only about 175 to 180 actually doing soils work. We find ourselves today in a situation of increasing competition for declining funds and staffing levels, Our hope for survival lies with working with other disciplines to insure integration of vital soils knowledge, skills, and abilities into ecological resource management programs, and continually domonstrate the essential contributions to our common objectives that we as soil scientists make every day.

Fortunately our Chief and Deputy Chief are aware of and concerned about the erosion of technical skills in our work force, in soil science and other fields. They share this concern because they understand the necessity of maintaining a talented, dedicated workforce that is skill-diversified as well as culturally diversified, in order to meet our agency's resource management and Conservation Leadership responsibilities. Soil Science has been and must and will continue to be an essential component of that skill mix.

OTHER ACTIVITIES:

Soil scientists in the Forest Service are involved in a host of activities beyond soil survey and ecological unit inventory. To name just a few examples:

information/Data management: We are continuing with the development of an interactive soil and ecological unit inventory data base (SORIS). We'll probably change the name to something like Terrestrial Ecological Classification, Inventory and Monitoring Information System (TECIMIS) to reflect the more integrated ecological inventory and analysis components. It has recently been beta-tested, and is expected to be available for use later in June. We have worked hard to insure commonality of data elements with the NASIS, and also with the Common Survey Data Structure (CSDS) being developed by the Forest Service to house all Natural resource plot data.

Soil Quality activities: The Pacific Northwest Region held a workshop dealing with soil quality and ecosystem health in April, 1995. It was attended by more than 100 people from FS, NRCS, BLM, BIA, and others. We are very interested in increasing our involvement in Soil Quality and Ecosystem Health, particularly from perspective of Forest and Rangeland soils.

Monitoring: We are required to monitor environmental effects of management activities on lands that we manage. The National Long-Term Soil Productivity (LTSP) Study is designed to develop Soil Quality Standards to use in monitoring. Some preliminary results from the LTSP are beginning to emerge. I look forward to Deb Dumroese's presentation on Long Term Soil Productivity on Thursday.

Soil Management Support: Soil Scientists have always (at least for the past 30 years) been most valued in the FS for what we call 'Soil Management Support Services' _-that is, a mostly informal one-on-one, case-by-case consultation service for resource managers on the ground, for soil-related problems that arise in day-to-day resource management activities, Legal requirements: To name just a few examples: The Organic Act of 1897 established the forest reserves to be managed 'for the greatest good for the greatest number in the long run'. The Multiple Use-Sustained Yield act of 1960 requires that the National Forests be managed for a sustained yield of goods and services in perpetuity. The National Forest Management Act of 1976 requires that National Forests be managed to sustain or improve long term productivity of the land. The Clean Water Act puts limits on water pollution from land management and land use activities as well as other sources. The National Environmental Policy Act requires Federal land management agencies to assess the environmental consequences of their proposed land use and management activities. We in the Forest Service take great pride in the vital role our soil scientists play in helping insure that we meet our legal and moral responsibilities to insure sustainability of ecosystems and a quality environment.

CONCLUSION:

The Forest Service has been a member of the National Cooperative Soil Survey for many years. We are pleased to be a part of this organization. and expect to continue this relationship for the forseeable future. Thank you for inviting me here.

Mapping Soil Impact Classes on Smelter Affected Lands

T. J. Keck, D.E. Strom, B.D. Dougherty and R. Burt

Introduction

Impacts of past mining and smelting activities add to the complexity of mapping soils. In Deer Lodge County, Montana, nearly 100 years of smelting metal ores, primarily copper, has had a tremendous impact on the countryside surrounding the tow of Anaconda Estimates of smelter emissions near the turn of the century include 59,270 pounds of arsenic trioside, 4,775 pounds of lead and 5,083,600 pounds combined of sulfur dioxide and sulfur trioxide per day (Harkins and Swain, 1907). Exactly how much metal and acid contamination was generated during the entire period of smelter emissions; 1884 to 1980, remains questionable. Without a doubt, the amounts were staggering.

One of the primary purposes of any soil survey is to provide accurate interpretations about the potential use and management of soils within the survey area Impacts from smelting and related activities effect virtually every major soil interpretation. Foremost are human toxicity concerns. Standard interpretations for building site development, construction material, water management and recreational development all become suspect if soil materials used contain high concentrations of metal contaminants potentially toxic to humans.

If human toxicity is the top concern, then effects on vegetation are a close second. Changes in vegetation include altered species composition of plant communities, reduced plant growth, lost vigor and poor overall plant health Uptake of heavy metals by plants creates secondary toxicity concerns for animals, including man, that consume those plants or consume other animals from those areas. Crop yields, capability classification, woodland, windbreak and range interpretations are all directly impacted by changes in plant growth potential. Wildlife habitat suitability decreases as the plant community deteriorates. Finally, lack of plant cover increases the potential for soil erosion. For all the above reasons, the Deer Lodge Soil Survey must address the impacts of past smelting activities on land resources (i.e.: changes in soil potential) or risk being irrelevant to the major land use and resource management issues of Deer Lodge County.

Environmental Deeradation

Deposition of heavy metal and acid contaminants were not the only impacts of smelting activity. Hillsides were denuded of vegetation during the early period of ore smelting as nearly every tree for miles around was cut for cordwood to fuel the smelters. Tens of thousands, maybe even hundreds of thousands, of mules were used to haul that cordwood to the smelters. According to accounts of the period, mules were loaded with wood and then turned loose to graze the hillside on their way back to the smelters. Extreme overgrazing by mules and other domestic livestock resulted At the same time vegetation was being stripped from the hillsides, metal and acid contaminants were limiting germination of new plants.

With the bare hillsides came extreme soil erosion. It is not uncommon to find entire slopes where 2 to 3 feet of the original soil profile has eroded away. Bare ground provides an open invitation to noxious weeds such as spotted knapweed, Russian thistle, Canada thistle, whitetop and leafy spurge. These weed species are quite tolerant of high metal concentrations in the soil and today infest many of the surrounding hillsides as well as much of the valley floor. In some areas, soil contamination has created down-slope seep areas due to "contamination fallowing" in a manner similar to the formation of saline seeps in crop-fallow regions. In other areas, severe sheet erosion has resulted in armoring of the ground surface with gravels, cobbles and stones because soil material from around these rocks has either blown or washed away. Plant seeds or other propagules in these areas would have to first reach the soil surface before they could become established.

Metal Contamination and Plant Community Relationships

Apparent impacts from past smelting and related activities do not correlate well with the current concentrations of heavy metals found in soils around the Anaconda area Sites with exceedingly high total metal concentrations may show very little direct physical evidence of impact either in the plant community or in soil properties measurable in the field. Six soil characterization sites were sampled and analyses were run for trace metals and arsenic as part of the Deer Lodge Soil Survey. Characterization and trace element analyses were conducted by the National Soil Survey laboratory at Lincoln, Nebraska. Three of the six soil characterization sites, show little direct evidence of metal contamination, yet, all of the sites had significantly elevated total concentrations of lead, arsenic, copper and zinc (data to be published). High levels of extractable (DTPA) lead were also found.

For example, characterization site#1 was sampled in an apparently healthy lodgepole pine stand. This site had the second highest surface concentration of arsenic at 961 parts per million (ppm) and the highest extractable (DTPA) lead concentration of 49.8 ppm. Characterization site #6 is currently used as productive irrigated hayland. This site had the highest total concentration of lead (957 ppm) and zinc (1890 ppm) in the surface of the 6 sites sampled. The vegetative plant community at characterization site #4 shows greater influence due to soil salinity than due to any influence of metal contaminants. The top 0-3 centimeter depth at this site has total concentrations of 28 1 to 397 ppm lead, 854 to 857 ppm arsenic, 858 to 976 ppm copper and 510 to 739 ppm zinc. These three sites would in general not be identified as contaminated based on standard field mapping procedures if viewed out of context from the surrounding landscapes and the local history. Universally accepted standards have not been set for threshold metal concentrations of contaminated soils. To put the above values in context, however, Holmgren et al. (1993) reported average values for total metal concentrations of 10.4 ppm lead, 15.5 ppm copper and 41.1 ppm zinc in surface soils based on 2771 samples across the United States. In a separate study, total arsenic concentrations were repotted to vary from 0.3 to 38 ppm for several hundred non-contaminated soils in the United States, Costa Rico, and Puerto Rico (Williams and Whetstone, 1940 in Taskey, 1972).

On the other extreme, some of the most extremely impacted, highly eroded areas may have relatively low concentrations of metals remaining in the soil profile. Contaminated topsoil in these areas has long since washed and blown away. Metal contaminants are not readily leached downward into soil profiles and so remain primarily in surface horizons. Since the source of airborne contamination has been eliminated, many actively eroding hillsides may have been at least partially stripped of their metal contaminants. Metals that were there have by now have been washed or blown further down the watershed:' into the draws, out onto the valley floor and along the floodplain. While much of the original contamination may be gone so is much of the original soil resource. The net impact remains of greatly reduced productive potential for the land.

Soil pH Relationships

The available data contradict a previously held notion that soil pH could be used as an indicator of metal contamination. While two of the characterization sites had low surface pH's associated with high metal concentrations, two other sites had neutral to strongly alkaline surface soil pH values even though they have comparably high concentrations of metals. The remaining two characterization sites had only slightly acid conditions at the surface. These mixed results concur with numerous other field observations. While low soil pH often occurs in conjunction with metal contamination, pH alone cannot be used as a field test for the presence or absence of metal contaminants.

Plants are affected by metal contaminants more by how "available" or active those metals are in the soil than by the total concentrations in the soil. Lead pipes in a home present a reasonable analogy. The lead in the pipes does not hurt you, only the portion that gets into the water can cause problems. In general, a direct relationship exists between soil pH and metal availability: the lower the pH (more acidic), the greater the availability of metal contaminants in the soil. The reverse also holds true as metallic ions become less available at higher pH (more alkaline). A house with low pH water may have problems with lead leaching into the water supply while a house with neutral or alkaline water will not have a problem. Unfortunately, arsenic does not generally behave in such a predictable fashion.

Metal contaminants themselves have little effect on soil pH. It is the sulfur compounds that were emitted from the stack along with those metals that have caused the soil acidification often associated with smelter impacted soils. Soils vary in their ability to neutralize acids and thereby buffer pH. Calcium carbonate or lime in the soil presents the most obvious source of natural "buffering" capacity. Many other compounds, however, both in the soil organic matter and in the mineral portion, can similarly buffer soil acidity to varying degrees.

As acids in the soil become neutralized, soil pH goes up and the availability of metal species goes down The metals themselves have not gone away. In part, this is why metal concentrations cannot be mapped on the basis of soil pH alone. Concentrations of metal contaminants still have major impacts on soil interpretations even when they become less available in the soil. Interpretations based on human use or physical contact with the soil, such as use as playgrounds or homesites, continue to present health concerns when the availability of metals in the soil is low. Wildlife species that live in close contact with the soil, such as moles or ground squirrels, will also continue to be significantly impacted as will certain metal-sensitive plant species.

Impact Classes

During the past summer and fall, we mapped smelter affected soils in upland areas of Deer Lodge County on the basis of impact classes. Three broad classes of soil impact were used. Differences among classes relate primarily on the severity of past erosion at a site and observable differences in plant communities. These classes are broadly defined so they can be included as part of an order 2 soil survey using standard soil survey techniques and so they can be consistently recognized in the field. The classes used were slightly, moderately and severely impacted All three impact classes represent uniquely different soil interpretations from non-impacted soils.

Severely Impacted

The severely impacted class corresponds to those areas most dramatically affected by past smelting activities. Massive amounts of soil erosion have occurred on most of these areas. One or more soil horizons may be entirely lacking from soil profiles or may be represented by only relic remains. In extreme cases, nearly the entire soil profile has eroded away. Most of the ground surface is bare and gullies are common on steep hillsides.

Only remnant portions of the native plant community remain in severely impacted areas. In other areas, the native plant community has been completely lost. Where ground cover does occur, weedy species predominate which are highly tolerant of metal contaminants. Severely impacted soils occur within an area of intense past smelting activity and have historically received extreme amounts of metal and acid deposition from smokestack emissions. Many of these areas still contain high levels of metal contaminants in the soil although extreme erosion may have removed much of the contamination from some areas. The productive potential of the land and soil health has been greatly reduced.

Moderately Impacted

Moderately impacted areas in rangeland contain good ground cover of generally palatable plant species for livestock. While significant soil erosion may have occurred, soil horizons are reasonably intact. Metal tolerant species, such as basin wild rye, redtop, and aspens, dominate the plant community. Components of the potential native plant community may be present but are generally restricted to species tolerant of acid conditions and/or metal contaminants, such as Oregon grape, juniper, or woods rose.

Coniferous forests, where present, are largely devoid of typical understory plant species. Sensitive species like heartleaf arnica, wild strawberry, or rough fescue are absent. In some forested areas, all understory plant species are absent. High levels of metal contaminants exist in the uppermost soil horizon(s) and the productive potential of the soil has been reduced although not nearly to the extent as in severely impacted areas.

Vegetative composition in moderately impacted areas is fairly consistent at low elevations, i.e.: areas with a frigid soil temperature regime. Basin wild rye generally dominates the site with redtop, rabbitbrush and scattered conifers (Douglas-fir, limber pine and rocky mountain juniper) as common components in the plant community. Weedy species are also quite prevalent. Plant community relationships are more complex for higher elevation moderately impacted areas, At higher elevations, more of the native plant species are adapted to the naturally low soil pH conditions Thus, acid contaminants have had less of an impact on species composition in these areas The absence of certain key indicator species appears to be the most dependable criteria for identifying moderately impacted soils in high elevation areas.

Slightly Impacted

In slightly impacted areas, the native plant community has either reestablished itself or is showing definite signs of moving in that direction, Good ground cover protects the site and even plant species sensitive to metal contamination are becoming reestablished Some components of the native plant community may still be absent but, in general, the natural processes of water and mineral cycling, succession and energy flow are functioning well. Productivity of timber and rangeland resources is at or near expected levels based on the land's potential prior to disturbance.

We might conclude that the "availability" of heavy metal contaminants have reached an equilibrium with the ability of the biotic systems to tolerate and cycle them. Significant concentrations of metallic compounds remain in the soil but they no longer appear to be disrupting the physiology of plant species growing on the site. High concentrations of metals are, for the most part, restricted to the top several inches of soil.

Physiographic Boundaries

Areas of slight impact are defined on the basis of regional physiographic boundaries that would have acted as barriers to smokestack emissions. Slightly impacted soils include all soils within the area affected by smelting that do not fall within the severely or moderately impacted classes. Physiographic features such as mountain ridges, hills or divides provide logical boundaries for affected areas. The prevailing winds have to be considered to determine boundaries at different directions from the smokestack. Additional soil characterization sampling can then be used to determine the effectiveness of these physiographic boundaries.

Our initial sampling for metal contaminants in Deer Lodge and Silver Bow Counties did not extend far enough out to reach beyond the plume of smelter emissions. All of the sites sampled in both counties had high total concentrations of metals in the topsoil. Some potential boundaries for the impacted area surrounding the Anaconda smelter include Feeley Hill along I-15 south of Butte, low hills near Gold Creek in Powell County to the north, and mountain passes south of Anaconda along highway 273 towards the Big Hole River and highway 1 towards Georgetown Lake. Further sampling for heavy metals would need to extend beyond these boundaries.

Soil Interpretations for Slightly Impacted Areas

Severely and moderately impacted soils require the use of separate soil phases to capture interpretive differences. Different soil phases should also be used for slightly impacted soils to separate them from non-impacted areas. In slightly impacted areas, significant changes in the productive potential of the soil or vegetative resource may not be apparent. As a result, many agronomic interpretations will not be different behveen slightly impacted soil phases and their non-impacted counterparts. Other human use interpretations, however, such as use for playgrounds or homesites, would be effected by the presence of high concentrations of metals in the soil surface,

Our data strongly suggest that all soils within the affected area have significantly elevated levels of metal contaminants within the topsoil. Metals in the topsoil, even when they are less bioavailable, still present a threat to human health, especially for young children who may come in close contact with the soil while playing. Dust from blowing soil probably creates the greatest potential hazard. Metal compounds attached to dust particles are readily inhaled by both people and livestock. Previous studies in Deer Lodge County have found contaminated dust on plants eaten by grazing animals to be a significant source of metal ingestion by livestock (Rice and Ray, 1984). This source of metal contamination occurs even while the plants are effectively excluding heavy metals from their above ground tissues. Wildlife species who burrow in the ground are also likely to ingest metal contaminants directly from the soil,

Remcdiation efforts for slightly impacted areas would be aimed primarily at human use activities such as homesite or recreational development but could also apply to cropland areas. The goal of remediation would be to limit human and animal exposure to metal contaminants. Practices to accomplish this include deep plowing to dilute contaminants, liming to reduce their availability and maintaining good ground cover to avoid direct contact with the soil and to reduce dust problems. Sensitive areas like playgrounds or new schools might need to haul in clean soil materials to further dilute or cover metal contaminants. All of these practices represent important soil interpretations that would be lost if slightly impacted soils are lumped together with existing non-impacted soil types.

Field Mapping Trials

During the past field season we mapped soils for most of the severely impacted and many of the moderately impacted areas in Deer Lodge County using the above criteria for impact classes. We were able to communicate ideas and reach good agreement on what constituted severe, moderate and slight impact classes despite working in quite different environments. The use of impact classes provided mappable concepts which could be applied on a landscape scale and which resulted in significant interpretive differences among classes.

As with any classification scheme, boundary problems exist where portions of the landscape appear to fit between classes. Good communication among soil scientists and sound professional judgment can go a long way towards alleviating such potential problems. Setting more quantitative class limits which provide definitive endpoints between classes would also help but would require collecting additional field data to determine reasonable threshold values. Setting a maximum percentage of bare ground for moderately impacted areas is one example of quantitative criteria that could be developed

Care should be taken to avoid setting up additional classes to handle intermediate cases. While more classes add to precision in mapping, they greatly increase the complexity of class definitions and the difficulty with which concepts can be consistently applied to diverse landscapes. The level of refinement we can currently provide in soil interpretations does not justify this extra effort.

Conclusions

Three classes of soil impact have been identified and mapped in Deer Lodge County to address the effects of past smelting activities on soil resources. Impact classes are mappable at a scale consistent with other map unit criteria used in an order 2 soil survey. Concepts can be uniformly applied by different soil mappers provided good communication exists among members of the soil survey crew.

The use of 3 classes closely parallels many soil interpretations where soils are rated for slight, moderate or severe limitations for a particular land use, e.g.: septic tank adsorption fields or various building site interpretations. Impact classes correlate well with differences in reclamation strategy and with the expected response of the plant community to various management options. Specific soil interpretations can be drawn for each impact class which are uniquely different from interpretations for the other impact classes and from those of non-impacted soils. For these reasons, we have adopted the use of soil impact classes for soil survey mapping in both the Deer Lodge and Silver Bow County Soil Surveys. We are currently working with the Northern Rockies MLRA staff to develop specific land use interpretations for these classes. This approach to mapping contaminated soils could be easily adapted to other soil survey projects in areas where similar soil contamination problems exist.

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Heavy Metal Contamination
And The National Cooperative Soil Survey

by

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Heavy Metal Contamination
And The National Cooperative Soil Survey

Personal Introduction

I am a Reclamation Specialist with the Montana Department of Environmental Quality (MDEQ), Reclamation Division, Hard Rock Mining Bureau (HRB) in Helena, Montana. The HRB regulates th: mining hard rock mining industry in Montana under the Metal Mine Reclamation Act (Title 82, Chapter 4, Part 3, Montana Codes Annotated). We regulate all hard rock mining in Montana, except on Indian Trust lands.

As a Reclamation Specialist with MDEQ, I am responsible for reviewing applications for new operating permits, as well as amendments to existing mining operating permits. I must review the application and conduct an environmental analysis to ensure compliance with the Montana Environmental Policy Act (Title 75, Chapter 1, Part 1 and 2, Montana Codes Annotated). I also inspect operating mines for compliance with the operating and reclamation plans.

The major part of my work is reviewing the soil and vegetation baseline work, soil salvage plans and proposed reclamation plans. We specify use of existing National Cooperative Soil Survey Reports as well as more detailed Order 1 and 2 site specific soil surveys conducted to USDA specifications.

I don't have time to do soil surveys or to verify soil survey work for each project. I depend on the quality of work conducted by you- the soil surveyors. I have successfully defended the National Cooperative Soil Survey when challenged by mining companies who were upset about the quantity and qualities of soils we were asking them to salvage. I commend you on the quality of your work and ask that you keep up the high standards. The soil survey simply makes my job easier. Thank you.

Heavy Metals in MDEQ Mining Soil Surveys

The public does not understand the natural distribution of heavy metals, especially in mining districts. Soil metals are typically not measured unless the soil pH is below 5.5. This sampling is used to document the potential metals in soils that may influence plant growth in reclaimed profiles. In recent years, MDEQ HRB have been asking for more baseline evaluation of soil metals to document the natural background values at these mineralized sites. This is because of confusion by the public

that lowered pH and elevated levels of metals in some soils must be from man caused pollution. We have been trying to document natural acid rock drainage and metals deposition at these mineralized sites. We have also been trying to document the natural metals accumulations in baseline soils such as Fe, Mn, and Al commonly measured in some forested soils. In mining districts, backgrounds levels can be elevated for many metals. The presence of coniferous vegetation and the resultant acidic litter on the forest floor can contribute to accumulation of metals in various soil horizons. These and other natural examples of historic heavy metal accumulations need to be documented in the soil survey (i.e. presence of ferrocrete). We have had acidic seeps develop in topsoil stockpiles from decomposition of coniferous vegetation.

The HRB recommends use of land application of excess water from the mining operation to prevent surface water discharges. Stormwater and detoxified process solutions are discharged onto the soil surface relying on the natural soil's attenuation capacity. The EPA has identified the amount of metal than can be applied to soil in various applications, such as for deposition of municipal sewage sludge. The rates are usually controlled by the soil organic matter content, clay content, and cation exchange capacity (CEC). Baseline soil studies in the area have shown the presence of soluble metals in soils from historic smelter emissions.

Silver Bow County Soil Survey

What do we need in a soil survey in Silver Bow County? The largest historic mining and processing complex, as well as the largest current mining complex in Montana is located in the Butte-Anaconda area. It is the largest Superfund site in the US. The survey would provide a baseline to document status of soils in the county wide area. The survey could document the extent of some soil problems county wide. The survey could identify potential baseline soil conditions which we could try and reestablish on reclaimed areas. The survey would provide valuable information on sources of reclamation materials for use in county wide cleanup of contaminated areas. It is my opinion that baseline metals sampling should be part of this data base.

There is a lot of information being generated in the area because of Superfund litigation. The soil survey is a respected base of scientific information not biased by lawyers rebuttals and judges opinions. Superfund studies will concentrate on most directly impacted areas. The soil survey can provide us with a background of information on the entire county. The soil survey should use EPA sampling protocols to insure the compatibility of all the data being collected.

Historical perspective on Mining and Processing Contamination in the Area

The Butte-Anaconda area has significant amounts of land disturbance both direct and indirect. Cleanup to date has concentrated on the most serious direct land disturbances near the mining and processing areas. Cleanup has also concentrated on the contaminated waterways downstream.

Air pollution has resulted in significant amounts of heavy metal contamination from volatile metals (i.e. lead, cadmium, etc.) rising out of the stacks. Fallout from the stacks produced an acid rain effect on area soils. Many surface soil layers have acid surface layers with an increase in heavy metals. Vegetation on these areas has been reduced to acid tolerant plants. Areas even farther away from the pollution sources can contain potentially important amounts of heavy metals even though the vegetation community may not show the effects.

Current Superfund Studies

Superfund studies have generated significant amounts of valuable data on soil metals in the area (see references). Litigation by MDEQ as part of the Natural Resource Damage Program has concentrated on use of total soil metals values to document the extent of damage. MDEQ lawyers have rebutted the Principal Responsible Parties (PRP's), (i.e. ARCO) arguments that other methods such as extractable metals should be used because plant communities don't necessarily reflect effects from total metals values measured at many sites. The court date in the case has been set for January, 1997 (G. Mullen, MDEQ-NRDP. Personal communication. May 31, 1996).

MDEQ Studies

The MDEQ Abandoned Mine Reclamation Bureau completed an assessment of abandoned mined sites across the state in 1994. (Abandoned and Inactive Mines Scoring System (AIMSS).1994. MDEQ, AMRB, Helena, MT). Then they tried to evaluate cleanup priorities for abandoned mine sites based on total metals values in soil. They reviewed cleanup guidelines based on total metals values used in other states and federal programs and concluded that they were not usable. They opted to use a risk based assessment of metals (Vic Anderson, President National Association of Abandoned Mine Land Programs and Bureau Chief MDEQ, AMRB, Helena, MT. Personal communication, May 29, 1996.)

The MDEQ Abandoned Mine Reclamation Bureau completed their Final Report Risk-Based Cleanup Guidelines for Abandoned Mine Sites in February 1996. In their report, they concluded on page 98, that their may be reasons for selecting cleanup guidelines that differ from the risk based guidelines in the report. One of the reasons was background metal concentrations may differ from the risk based metal concentrations. Site reclamation may be directed at achieving background metal concentrations. Background conditions are considered to be naturally occurring concentrations of metals (i.e. metal concentrations that occur in areas uninpacted by nine wastes or tailings). The potential health risks posed by background concentrations of metals are considered to be generally acceptable.

Following US EPA guidance documents published in 1989 and 1992, the MDEQ report concludes that the upper confidence limits of the mean concentrations for background soils may be used as an alternative set of cleanup guidelines for metals in soils at abandoned nine sites. I contend that background metals values in mineralized areas surrounding active or abandoned mine sites may be subject to those sane conclusions. The soil survey could give us some of those background metal values.

The MDEQ report analyzed antimony ,arsenic, barium, cadmium, chromium (as III), cobalt, copper, cyanide, lead, manganese, mercury, nickel and zinc. On page 101, the measured maximum values at abandoned mine sites did not exceed the cleanup guidelines for most metals. The report concluded that the primary contaminants potentially requiring cleanup at abandoned mine sites may be antimony, arsenic, cadmium, copper, lead and manganese. In addition, only the median arsenic concentration in soil/waste exceeds the cleanup guidelines for the recreational use populations evaluated in the report. This suggests that arsenic may represent the primary contaminant representing excess health risks at 50% of the abandoned mine sites. The report uses conservative estimates to rank risk based on recreational use of the abandoned mine sites. The report cautions on page 164 that health risks to a residential population may require more conservation cleanup guidelines.

Other Soil Surveys in the Area

The soil survey for Deer Lodge county, which is adjacent to the Silver Bow county area and also heavily impacted by historic smelting pollution and tailings deposition, has been completed. The survey used an impact classification system based on erosion,amounts of bare soil, and dominance by acid tolerant vegetation species. Attempts to correlate the observed impact classification with limited soil metals measurements (as totals or extracts) could not be achieved at the level of sampling. In other words, some of the areas classified as only slightly impacted by soil metals based on observed effects on vegetation, still had high levels of total and extractable metals (T. Keck, personal communication. May 31, 1996).

Metals Sampling Needed In Silver Bow Survey

Despite this lack of correlation in the Deer Lodge survey, area land managers need these baseline metal values as well as the extent of observed surface pollution effects. No survey has been conducted across the entire area documenting area soils in the detail that a soil survey will provide. And with the additional work and sampling, an initial metals baseline could be established for the soil horizons identified in the various soil mapping units.

Natural as well as elevated background metal values in area soils should be documented. Often only a surface layer of metals and acidification has been sampled. The soil survey would provide the first general survey of metals in the entire county for all soil horizons. Metals values commonly are reported in total ppm. This value may or may not be relevant as the metal could be complexed in the soil and not be available to plants or be soluble for transport to groundwater. The survey could provide a valuable tool to show the historic influences of area mineralization and other natural soil forming processes on soil background values. If totals as well as extractable metals are run, EPA protocols should be used. If plant tissue metal analyses are run, EPA protocols should be used as well.

Future of The Silver Bow Area

The future development in the area looks promising with recreation and continued development to alternate non-mining land uses. Coniferous forests were removed in the area for timbers and firewood etc. Aspen groves are spreading over the foothills. The conifers are reestablishing in the altered soils under aspens. Natural reclamation is occurring as fast as possible. Man can speed up the process.

Mining continues to be important in the area. But a larger portion of the future mining will be for reclamation materials. Cleanup has begun and more resources are being devoted to looking for suitable borrow sources to reclaim disturbed areas. We not only have operating permits in the area for the active copper and molybdenum mine, but also for sand and gravel, clay, quarry rock for rip rap lined channels and limestone. Exploration continues for other sources of materials. The survey could help pinpoint some additional surficial geologic and soil materials appropriate for various uses in the cleanup efforts.

Special Soil Survey needs

Special land use classifications may be needed to direct housing growth into uncontaminated areas.

The standard soil pedon to 60 inches should be expanded in certain parent materials to the total depth of the sampling e-quipment to help identify sources of reclamation materials, (i.e. alluvium, colluvium, loess, glacial till, clay layers, sand, limestone, etc.)

Some of the same control research sites being used in EPA, Forest Service or BLM studies in the area should be used. The entire county needs the survey.

'An Order 3 soil survey uses slope criteria generally based on agricultural equipment. Slope classifications should be changed to reflect the non-agricultural future of the area. Some considerations of slope based on land use:

- -mulch holds on slopes up to 25% in RUSLE equations
- -wheeled equipment can access loose soil on 25% slopes or less
- -tracked equipment can access loose soil on 25% slopes or less
- -haul trucks can access 8-10% slopes.
- -suggested slope classes: O-10, 10-25, 25-33, 33-40, 40-50, 50+% (?)

Coarse fragment contents need to be changed to reflect non-agricultural uses. MDEQ recommends salvage of all soil with up to 50% coarse fragments. The size distribution of the rock frag-ments is also important to evaluate erosion control on reclaimed slopes. We need to separate the percentage of rock fragments less than and greater than 1 inch in size.

Classify rock types as inert and non-inert; sedimentary rocks will they break down when blasted, exposed, and worked by heavy equipment; Will it absorb water and slake?

Based on my own personal survey of soil surveyors doing mine permit applications, the most common mistakes in soil surveys they have use are in identification of parent materials. Take the time to identify glacial till, residuum, colluvium, etc. Also, define what the parent material is, such as Kootenai sand-stone. More verification is needed by test holes, explain in soil description of soil complex or association; this is often controlled by the legend and can lead to bad calls. Be consis-tent with soils on similar landforms.

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Steep Slope Reclamation At Golden Sunlight Mines, Inc.
Whitehall, MT

Troy C. Smith[1]

ABSTRACT

Golden Sunlight Mine is a large open pit gold mine located near Whitehall MT. Golden Sunlight mines over 100,000 tons per day of sulfide bearing waste rock and ore. This has resulted in over 1.000 acres of tall. steep (1.5:1 horizontal to vertical slope angle) waste rock dumps. Golden Sunlight has made a bonded commitment wirh the state of Montana to reclaim these waste rock dumps as well as all other disturbed areas.

Golden Sunlight has performed extensive reclamation research in consultation with several universities and consulring firms. Based on the research results a reclamation plan for the waste rock dumps has been developed. This plan which is currently being rested includes reducing the dump slopes to a 2:1 horizontal IO vertical slope angle. developing benches in the dump to reduce the slope length: placement of a two layer rock and soil cover. followed by revegetarion. Various additional erosion control measures are also implemented.

In order to effectively work and seed these waste rock dump slopes Golden Sunlight has modified equipment specifically for this purpose. Some of the modifications include the development of a counter weight for dozers to reduce the center of gravity and increase traction. and the use of a modified snowcat to incorporate seed and fertilizer on the slopes.

Several large scale tesr plots have been in place for over four years at Golden Sunlight. These plots are now yielding data showing successful reclamation of sulfide waste rock utilizing capping materials on 2:1 horizontal to vertical slope angles.

[1] Golden Sunlight Mines Inc., Whitehall, Montana 59759

INTRODUCTION

Golden Sunlight is a large open pit gold mine near Whitehall MT. Golden Sunlight Mine(GSM) produces more than 100,000 tons per day of sulfide bearing waste rock. Due to the steep topography and the large volumes of waste rock several hundred acres of tall, steep waste rock piles have been created. This coupled with the acid producing potential of the waste rock has caused GSM to put up the largest reclamation bond in the history of hard rock mining. For this reason GSM began researching the most economical and successful methods of reclamation for these large waste rock piles.

GSM's ongoing research has identified successful methods to reclaim steep slopes in this environment. Success is a function of slope angle versus slope length, cover soil texture, vegetation. and erosion control structures. Test plots have shown that it is critical to include the entire precipitation catchment area up-gradient from the slope to be reclaimed as part of the slope. Essentially, this requires the diversion of all run-on away from the top of the slope to be reclaimed. Based on erosion rates it was determined that GSM's maximum allowable slope would be 200 vertical feet. GSM's current reclamation plan involves reducing the waste dump slopes to a 2: 1 horizontal to vertical angle, developing benches in the dump to reduce the slope length as necessary, placement of a two layer neutral oxide rock and soil cover, followed by revegetation.

RECLAMATION PLAN

Reclamation plans have been developed for all facilities within the GSM permit boundary. including the plant area. waste rock dumps. tailing impoundments, open pit, borrow areas, diversion channels, roads, monitoring wells. utility corridors, water treatment plant. and all other GSM facilities within the disturbed area boundaries.

Background

The ecosystem and plant community in the GSM permit area consist of a dry, steep slope, Great Basin-type plant community which contains grasses and shrubs with lesser numbers of juniper, limber pine, and Douglas fir. The area has been utilized by both wildlife and livestock. Mining has also occurred in the area for over 100 years.

Objectives

The objectives of reclamation are to bring the final land use and cover back to a comparable level with the pre-mine state.

Soil Salvage

Reclamation begins with the removal of soij materials from areas which will be disturbed. The primary removal method is with scrapers using tracked dozers to windrow soils off steep slopes.

All topsoil and subsoil suitable for plant growth are removed where safe to do so. Soil removal depths are staked according to previous soil surveys, and frequent quality checks are made during removal. Soil is placed in stockpiles and seeded with the seed mix shown in Table 1. Pre-mined soils and stockpiles are sampled and analyzed for texture, Ph, electrical conductivity (EC), sodium adsorption ratio (SAR), water holding capacity, and soil nutrients. Parameters for suitability are shown in Table 2.

The soil suitability parameters shown in Table 4 have been waived for coarse fragment content on the west side of the project area, where a soil shortage was noted. Soils on the west side with up to 75 percent coarse fragment content are salvaged on slopes of up to 1.5H:1.0V.

Table 1
Soil Stockpile Seed Mix

Species	Common Name	Drill Seed Rate (PLS lbs/acre)
Agropyron cristatum	*Ephraim crested wheatgrass*	6
A. smithii	*Rosanna western wheatgrass*	5
A. trachycaulum	*Pryor slender wheatgrass*	5
Melilotus officinalis	*Yellow sweetclover*	1
	Total	17

Table 2
Soil Suitability Criteria

Parameter	Limit
Texture	< 50% clay < 50% rock
pH	5-9
EC	< 8.0
SAR	< 15.0
Water holding capacity	–

Oxide Rock Salvage

All oxidized rock planned for removal is sampled in the pit according to variability, and submitted for potential acidity testing. This determines whether the material is suitable for use as an oxidized capping. Field observations of oxidation degree based on color, rock type. and visual sulfide content have shown good correlations with acid-base accounting. Combined field observations and potential acidity testing determine whether or not to save a rock unit for use as oxidized rock capping material. As oxidized rock stockpiles are being built. weekly dump crest composite samples of active stockpiles are also collected and submitted for potential acidity resting.

Based on kinetic testing and test plot data, all oxidized rock to be used for reclamation capping material must be either non-acid producing or amended with lime.

Waste Rock Dump Reclamation Research

GSM constructed test plots to evaluate reclamation success of 2H:1V versus 3H:1V slopes, and as an additional assurance to the agencies has bonded for 3H: IV slope reduction. GSM can also use the test plots to evaluate and compare any proposed changes to the permitted requirements. The first set of test plots were constructed in 1991. and additional plots were constructed in 1992.

The 1992 test plots will evaluate if there is an advantage in replacing the lime amendment with an additional six inches of oxidized cap rock. Recent research indicates that under oxidizing conditions such as at GSM. lime may become coated with iron and manganese oxides and become nonreactive. Further, the additional six inches of oxide rock capping may be more effective in limiting the upward migration of acid. Finally. the lime would be very difficult to apply uniformly on the dump slopes. The 1992 test plots will compare limed with unlimed slopes, and are more fully described in Appendix 10. The agencies have also requested that the oxidized rock used for capping be limed to neutral, if necessary, until the oxidized rock suitability criteria can be evaluated.

Kinetic testing for acid production from potentially acidic oxidized rock began in 1992. When combined with test plot data, this information will help establish the suitability criteria for the oxidized cap rock. Static test results, particularly the net acid generating(NAG) pH tests, have correlated well with the kinetic tests. In Appendix AR-93-K of GSM's 1993 Annual Report, it was recommended that oxide rock with NAG pH greater than 4.0 be deemed suitable for reclamation, that rock with NAG pH between 3.2 and 4.0 be amended with lime, and that rock with NAG pH of less than 3.2 not be used for reclamation.

The specific objectives to be achieved with reclamation of the waste rock dumps are to reduce infiltration to a level that should prevent seeps from occurring at the base of the dumps, and to permanently revegetate the dumps. The following reclamation plan will continue to be used. unless a need for a modification is revealed from test plot data or any concurrent failures. Current results from test reclamation research indicate that 2H: 1V dump slopes can be reclaimed, and may even reduce the potential for acid discharge compared to flatter slopes. Therefore, the following plan assumes a maximum slope angle of 2H: 1V. Dump slopes will be reduced further if additional data from the test plots show that 2H: IV reclamation will not be successful.

Waste Rock Dump Reclamation Plan

Waste rock dumps are constructed at the angle-of-repose (1.5H:1.0V). GSM is currently permitted to test waste rock dump reclamation on slopes reduced to a 2H: IV angle

After the dozers have reduced the slope composite samples are collected for potential acidity testing from the reduced slope and dump tops. The number of samples will be determined by the variability of the dump material. Samples will be submitted for either the modified Sobek method of acid-base accounting(ABA), or an on-site NAG pH test. If the NAG pH method is used, then a minimum of one sample in fifty will be verified with the modified Sobek ABA method.

If the waste rock dump samples have an ABA of < -20 and/or a NAG pH of < 3.2, then the upper 6 inches of the dump will be limed to neutral and a 24-inch thick minimum cap of suitable or limed oxidized waste rock will be placed over the dump. If resting shows that liming is not as effective as an extra 6 inches of oxide cap rock, then an additional 6 inches of cap rock would be placed instead of lime. If the samples have an ABA of > -20 and/or a NAG pH of > 3.2, then the dump will be treated as an oxidized cap as described below.

Oxidized rock salvaged for reclamation is sampled in the pit, and should have an AB.4 of -20 or greater. and/or a NAG pH of 3.2 or greater. Oxidized rock used for capping material will again be sampled for potential acidity prior to placement. Variability of material will determine the number of samples to be taken. Oxidized rock with lime requirements of 0 or more tons lime per 1000 tons of material will be limed to neutrality until GSM can justify an alternative plan based on kinetic or test plot data which is acceptable to the agencies. In determining lime rates, correction factors will be included for improper mixing and coarseness of lime.

After the oxidized rock cap is in place, a grid with 100 foor by 100 foot spacing will be established on the dump, and samples will be collected at each point. This same grid will be used to determine the thickness of capping materials as described under the "Treatment Uniformity" section. The samples will be visually examined, and representative samples analyzed for potential acidity. If potentially acidic areas are identified, more samples will be submitted. Those areas where more than one sample has identified lime rates of 0 or more tons lime per 1000 tons of material will either be top dressed with enough lime to neutralize the cap, or recapped with suitable oxidized rock.

After a suitable oxidized rock cap has been placed, soil will be spread. Soil depths will be 19 inches on the west and south dumps, and 24 inches on the east dumps. A composite soil sample from the in-place soil cap will be collected every five to ten acres and checked for texture, pH, EC, potential acidity, SAR, and soil nutrients.

The 2H: 1V slopes with lengths greater than 30 feet will have dozer gouges constructed in the final cover soil surface as illustrated in Figure 1.

The effectiveness of the dozer gouges for erosion control will be determined from the waste dump test plots. Based on this test data, the maximum distance between contour benches can be determined. These erosion/access benches will be designed so they slope back into the dump and divert runoff off the dump face into collector channels. At the present time, erosion/access benches are being designed at approximately 200-foot vertical intervals as necessary for construction, seeding, and maintenance.

Waste dump tops will be sloped to direct drainage away from dump slopes and into designed collection systems as also described in Appendix 6. Reclamation will otherwise follow the same guidelines as the dump slope reclamation.

When construction is complete, the area will be fertilized and seeded with the seed mix shown in Table 3. Seeding is accomplished by either broadcast seeding and harrowing with a snowcat capable of operating on 2H: 1V slopes or with a hydroseeder. When hydroseeding slopes, tackifier is used with 2000 pounds of mulch per acre.

Table 3
Waste Dump Reclamation Seed Mix

Species	Common Name	Broadcast Application Rate (PLS lbs/acre)
GRASSES		
Agropyron smithii	Western wheatgrass	5.0
A. dasystachyum	Thickspike wheatgrass	5.0
A. spicatum	Bluebunch wheatgrass	5.0
A. riparium	Streambank wheatgrass	5.0
A. cristatum	E. crested wheatgrass	4.0
A. trachycaulum	Slender wheatgrass	3.0
Festuca ovina	Sheep fescue	1.0
Poa compressa	Canada bluegrass	0.5
Oryzopsis hymenoides	Indian ricegrass	0.5
LEGUMES		
Medicago sativa	Spredor II alfalfa	2.0
Melilotus officinalis	Yellow sweetclover	1.0
Onobrychis viciaefolia	Sanfoin	1.0
SHRUBS AND FORBES		
Artemisia tridentata	Big sagebrush	0.5
C. nauseosus	Rubber rabbitbrush	0.5
Atriplex canescens	Fourwing saltbush	1.0
Linum lewisii	Blue flax	1.0
	Total	36.0

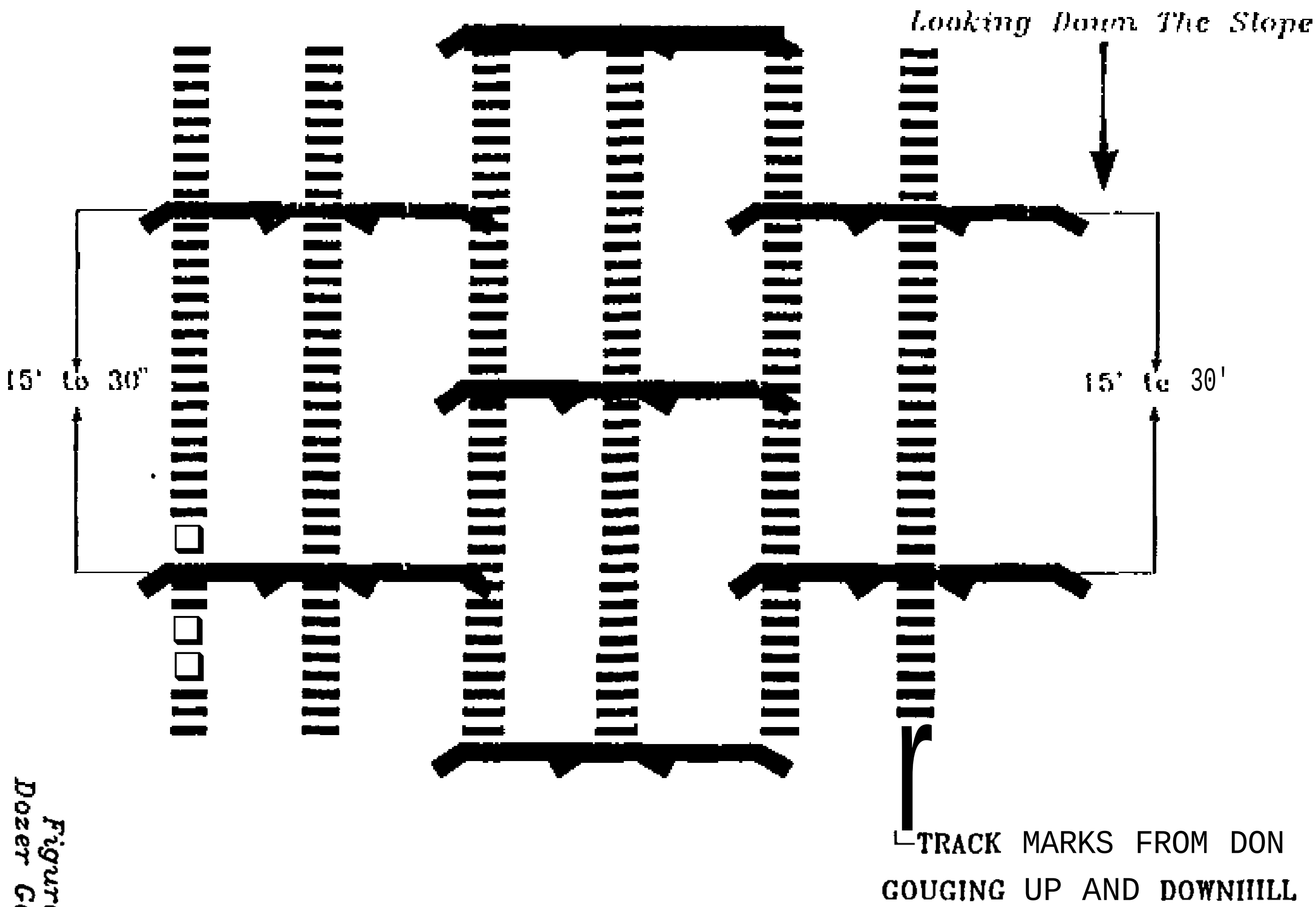

Figure 1
Dozer Gouges

When reclamation is determined to be successful, seedlings of Douglas fir, limber pine, and Rocky Mountain juniper will be planted in appropriate areas. The seedlings will be grown from seeds collected on or near GSM. Junipers will be planted at a density of 20-50 plants per acre. The tree density will vary from 10-50 trees per acre. The trees will be planted in a fashion creating windbreaks and thickets rather than being uniformly spaced. North slopes will be planted with Douglas fir, south slopes with limber pine, and east and west slopes will be mixed.

CONCLUSION

GSM has successfully implemented this reclamation plan on a sulfide waste rock dump. With the aid of counter weights dozers and snowcats have been shown to work effectively on 2H: 1V slopes. After nearly five years of monitoring, the waste dump slopes reclaimed at GSM still continue to out perform similar native slopes in vegetative production. GSM is currently proposing to amend it's permit to allow final reclamation at a 2H:1V slope angle.

The Virtual Landscape of Yellowstone National Park: Integrating spatial analysis with the process of scientific discovery to create a soils resource inventory

by Henry Shovic PhD, Ann Rodman, and Eric Compas
April 30, 1996

The two million pristine acres of Yellowstone National Park are the backdrop for an unusual and ground breaking effort. We are building an integrated landscape model, based on digital spatial data and the concepts of the science of landscape ecology. We recently completed the last major resource theme for this model. The publication of the soils inventory is the culmination of a 7 year effort and resulted in a peer reviewed and agency approved technical document. The soil survey process is one of scientific discovery, requiring an elaborate predictive system based on limited observations of a resource that is largely invisible and continuously variable. There is a well established set of methods to realize this discovery, based on extensive field sampling, development of soil forming concepts, extensive traversing of the landscape, manual delineation of map units on field sheets, with manual transfer of these delineations to a topographic base. Geographic information systems have recently been used to display final maps and for descriptive terrain analysis. Electronic data bases have been developed to organize and analyze non-spatial data. However, the majority of the process is still entirely manual. Because of limited accessibility, availability of a wealth of digital biologic and physical information, and need for a strong scientific basis we chose to replace the entire delineation process with electronic methods of spatial analysis. A point coverage was developed from 2000 field sample sites. These points were quantitatively correlated with accepted theories of soil formation to develop predictive concepts applicable to the Yellowstone survey area. We translated these concepts and the conditions under which they apply into a set of 300 rules in ARC/INFO. We applied these rules to polygon and raster coverages of landform, vegetation, climate, and soil parent material to create a polygon soils theme directly on a topographic base. We iterated the rule application process 35 times, until we had complete coverage and met quality standards. Over 83,000 possible combinations of coverage values were reduced to a set of 75 map units, each with a description of spatial variability. We used ARC to produce the final camera ready maps, meeting all cartographic standards. We solved the inherent problems of coincidence and differing spatial accuracy between themes by a combination of automated and manual but GIS supported "reality checks." Over 25,000 initial polygons were reduced to 8,000 with a series of AML's involving automated sliver and small unit removal; and field sample site verification.
Our experiment in using automated spatial analysis to replace manual methods resulted in a product that meets all scientific and agency standards for soil surveys, while completed at about ½ the cost. The soils theme is coincident with other layers, completing the giving the essential "underpinnings" to the landscape model, addressing the future management needs of our nation's premier landscape.<P>

Introduction

The two million pristine acres of Yellowstone National Park are the backdrop for an unusual and ground breaking effort. We are building an integrated landscape model, based on digital spatial data and the concepts of landscape ecology. We recently completed a soils inventory, the last major resource theme for this model. The publication of this inventory is the culmination of a seven year effort and resulted in a peer reviewed and agency approved technical document,

The soil inventory will be used for resource management planning, scientific investigations, and resource interpretation in Yellowstone National Park. It delineates soil bodies that occur together in repeating patterns on the landscape. Soil properties mapped in this survey affect vegetation, stream sedimentation, wildfire recovery, cultural and historical features, wildlife (on both a micro and macro scale), aesthetics of the landscape, construction and maintenance activities, and microclimate.

The soil survey process is one of scientific discovery, requiring an elaborate predictive system developed from limited observations of a resource that is largely invisible and continuously variable. There is a well established set of methods to realize this discovery. Local concepts of soil formation are developed based on extensive field sampling. Map unit boundaries are established by traversing of the landscape and manually delineating the map units onto field sheets. These delineations are later transferred by hand onto a topographic base. Geographic information systems have recently been used to display final maps and for descriptive terrain analysis. Electronic data bases have been developed to organize and analyze non-spatial data. However, in the majority of traditional soil mapping projects the process is still entirely manual.

The methods described above are very practical where relatively detailed soil information is needed, funding is available, and there is reasonable access to all map unit delineations. However, in our case access is difficult, the required level of detail is less than in agricultural or suburban areas, funding is limited, and a wealth of digital biologic and physical information is already available. Therefore we developed and implemented a modified set of methods that replace the manual delineation process with electronic methods of spatial analysis.

Objectives

Our objectives were to develop a soils layer for the landscape model and to provide basic soils data for use in research, resource management, and as an information source for interpretive and educational purposes. The study is classified as an Order IV soil inventory, meaning soils are classified and mapped at a scale suitable for broad resource planning. Bather than making map units with predetermined interpretations in mind, major soil properties were grouped to maximize differences between groups and minimize differences within a group. The dominant kinds of soil occurring in the survey area dictated the development of the groupings.

Methods

Since soil is normally invisible (soil is three dimensional, extending into the opaque earth, and it's surface is usually covered with plant material), it is impractical to predict soil spatial patterns by direct observation. However, soils occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. We selected 1200 sites, representing the local range and extent of conditions that influence soil development in the park, By observing the soil profiles at each location and relating their position to specific segments of the landscape, we developed concepts of how the different soils were formed. We used these observations to make predictive models of soil occurrence on the landscape. These models were based on theories of soil development, soil-site relationships observed in the Yellowstone area, and extensive site observations of soil properties on the ground.

We applied the models by translating the soil forming concepts into a set of 300 rules in a GIS. Each model was expressed in a quantitative "rule" or If-Then statement with accompanying conditions under which it is valid. The basic premise in these models is that the kind of soil occurring at a given location is predicted by knowing the quantitative or qualitative values of a set of factors, i.e. the climate and vegetation under which the soil has developed, the parent material in which it is formed, the topography, and its age. We applied these rules to polygon and raster coverages of landform, vegetation, climate, and soil parent material to create a polygon soils theme directly on a topographic base. The rules could be applied in a logical order to predict soils' spatial occurrence and distribution on a set of digitally produced maps. Most rule conditions were expressed in spatial data layers, though some required manual modification. The rules were dynamic and easily modified as new data or analysis became available. We used the sample of soil and site properties to develop and test these models.

We iterated the rule application process many times, until we had complete coverage and met predetermined quality standards. Using the GIS and the rule based system, soil maps were produced automatically during the survey process. The draft maps were used as field sheets in ground verification. After a draft map had been completed, it was overlain on a spatial model of slopes created from a digital elevation model (DEM). Slope ranges and distributions were developed and analyzed verify accuracy of mapping, and to help describe ranges of properties.

Each iteration of maps represented a stage of completion. We used the GIS to flag unmapped areas (places where no rules existed for that particular combination of soil forming factors), and analyze those combinations. Then, we resolved each case by 1) using existing sample points or taking more field samples in those areas to develop new map units or 2) correlating the areas to other map units.

Part way through the project, we switched from raster based layers in Grass 4.0 to vector coverages in ARC/INFO 7.0.3. Some of the independent soil forming layers had been created in Arc so they were already available. Every other raster layer had to undergo a "smoothing" routine in order to improve the appearance of the final maps (ii other words, an overlay of original vectors with vectorized rasters was not appealing). For the generalizing and application of the inference rules in ARC, we developed several AML's to work directly off the files used by Grass.

We edited the final draft maps using manual and computer-assisted methods to match ground observations and to meet quality and readability standards. After the final inference run was complete, we had several common overlay problems. These were: 1) *slivers;* small polygons that result from arcs representing the same feature on several layers not aligning; 2) ***small polygons***, polygons that were too small for us to reliably infer their soil types; and 3) fingers, thin, meaningless extensions of larger polygons. The small ***polygon*** concept depended upon a cut-off size, below which we could not reliably apply our inference rules. This idea is analogous to the application of a minimum mapping unit in a traditional mapping exercises. From visual inspection and field experience, we decided upon 50 acres as our minimum mapping unit, The magnitude of the task was large-the overlay process created 26,000 polygons. Of these, 20,000 fell into one of the above categories and had to be grouped into surrounding polygons. To accomplish this task, we used both automated and manual methods.

In the automated procedure, we took advantage of decision-making processes that we could implement with an AML and could be applied to the whole data set. We identified seven different types of slivers and small polygons that we could examine automatically. Four of these seven could automatically be grouped by identifying the most reliable or accurate layer, the landform layer in our case, and using it is a base for grouping polygons. Therefore, a lake boundary as delineated on the landform layer would be retained in the final product no matter how it was represented on the other layers. Another example is a sliver existing along the boundary between two larger polygons. All three have been assigned soils map unit name in the infer process, but the sliver is not a reliable delineation of its map unit. It needs to be grouped into one of the adjacent polygons. The AML examines this polygon and the adjacent ones to determine the underlying landform unit that. they belong to. The sliver is then grouped with the adjacent polygon that has a similar landform unit, In this manner, the AML "intelligently" grouped 8,000 small polygons and slivers. At the end of the process, 12,000 polygons remained. An additional 4,000 polygons, under 10 acres in size, were grouped by using the Arc ELIMINATE command. Of the remaining 8,000 polygons, 2,000 were left for manual editing. About 90 percent of the editing had been automated. These remaining edit decisions could not have been automated without losing accuracy in the final product.

The process of mapping was considered complete when 1) all areas were mapped to an appropriate level of quality and detail, 2) concepts represented by the map units were logical and fit into the surrounding landscapes, and 3) map units had adequate background documentation. All map unit boundaries were verified on the maps using remote sensing techniques, and a sampling of each map unit was visited on the ground to verify soil occurrence and distribution.

Results

The park now has a comprehensive, ground-truthed soil survey available as a document approved by the National Resource Conservation Service (NCRS), and a data layer in the GIS. The data is organized into map units that include information on soil types (classified to the family level), important soil properties, slopes, landform types, vegetation, and bedrock and surficial geology. The map unit descriptions also contain a description of the variability that exists within the map unit. Over 83,000 possible combinations of coverage values were reduced to a set of 79 map units, each with a description of spatial variability. Over 1200 sites were sampled in detail. These sites are geo-referenced and detailed site and soil information is available for each location. Over 25,000 initial polygons were reduced to 8,000 with a series of AML's involving automated sliver and small unit removal, We are using ARC to produce the 27 final, camera-ready maps in EPS format, meeting all federal cartographic standards.

Conclusions

Our experiment in using automated spatial analysis to replace manual methods resulted in a product that meets all scientific and agency standards for soil surveys, but was completed at about half the normal cost. The soils theme is coincident with other layers, giving the essential "underpinnings" to the landscape model to address future management.

* We solved the inherent problems of coincidence and differing spatial accuracy

between themes by a combination of automated and manual, but GIS supported, "reality checks."

* The data set is partially dependent upon the source layers; therefore analysis conducted with the soils layer and one of these source layers needs to conducted carefully. Correlations between the soils layer and the source layer have a potential to be a remnant of the creation procedure.

* Corrections that had to be made in the inferred soils usually were not a result of a skewed inference rule. It was usually discovered to be an error in one of the source layers or a misinterpretation of the source layer delineation,

* The intelligent automation of small polygon and sliver removal was very successful. It greatly decreased the amount of manual editing hours.

The above analysis and documentation supports our present conceptualization of the soils and their distribution in Yellowstone National Park. We published the maps and documentation now to provide a benchmark of soils knowledge as of 1996. Though this publication ends an era of pedagogic scientific discovery in Yellowstone National Park, the process of mapping soils here has just begun. The electronic nature of the survey provides an avenue for scientific and orderly updating. Since the needs of management and science change, so will this survey of soils. The digital spatial maps, physical reference samples, and accessory data bases from which the maps and descriptions came are available to provide historical data in a readily modifiable environment, thus helping to assure its fullest use and greatest longevity.

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HYDROTHERMAL SOILS OF YELLOWSTONE NATIONAL PARK

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Introduction

Hydrothermally-altered volcanic rocks and secondary mineral deposits from magmatically-heated groundwater are parent materials for over 20,000 ha of soils in Yellowstone National Park. These hydrothermal soils form a critical component of the fragile thermal ecosystems of Yellowstone and support a unique population of plants and other soil biota (Despain, 1990). Knowledge of properties and genesis of these soils is important to ecologists, microbiologists, and other scientists who study, utilize, and seek to preserve these areas.

The objectives of this paper are to provide a brief overview of the geology, hydrothermal chemistry, and properties of soils in selected acid sulfate and neutral chloride hydrothermal areas. Research on hydrothermal soils is part of an ongoing, cooperative project initiated as part of the Yellowstone National Park soil survey.

Geology and Hydrothermal Chemistry

Yellowstone National Park is part of the Middle Rocky Mountain Province (Thornberry, 1965). Study sites are located on the Yellowstone Plateau, a 6500 km’ volcanic region which has been intermittently active for at least 2.2 million years (Christiansen, 1984). The plateau is composed of glaciated volcanic materials, principally rhyolitic ash-flows (tuft) and viscous lava flows, deposited during three cycles of caldera-forming eruptions. Principal surficial stratigraphy in our study area is 630,000 yr old Lava Creek Tuff and numerous, younger (<165,000 yr old) rhyolite flows.

Tuff is an ash-sized (< 2-mm) pyroclastic deposit, exploded from volcanoes in combination with heated magmatic gasses. This mixture is not ejected high in the air, but remains near the ground surface, retaining the heat, undergoing varying degrees of consolidation, welding (induration), devitrification, and vapor phase mineralization (Ross and Smith, 1960). The latter two processes result in formation of crystalline minerals, principally SiO_2 polymotphs and feldspars in the Lava Creek Tuff. Relative to this tuffaceous unit, rhyolite flow deposits in Yellowstone are less devitrified (composed of a greater amount of volcanic glass), but have a similar suite of crystalline minerals.

A system of fractures and tectonic faults within and along the caldera perimeter serve as major conduits for deeply-circulating groundwater. This groundwater is magmatically-heated to temperatures > 200°C (Foumier, 1989), solubilizing minerals in contacted geologic units underlying the hydrologic region and absorbing volcanic gases such as H_2S.

Cooling of this groundwater as it reaches the surface results in supersaturation with respect to the solute load. The solute composition, and therefore the elemental composition of any resulting mineral deposit, depends on the traversed geologic units along fracture zones. For example, the deposit may be siliceous (e.g., siliceous sinter (geyserite) deposits of Lower and Midway Geyser Basins) or calcareous (e.g., travertine deposits of the Mammoth Terraces). In

Yellowstone National Park, the predominance of rhyolitic stratigraphic units result in a preponderance of silica-rich deposits.

Groundwater reaching the surface is typically near neutral in pH, a favorable condition for deposition of SiO_2 from silica-saturated solutions. These areas are termed neutral chloride, a coined name based on the pH and the high concentration of Cl^- in solution.

Depending on the relative abundance of magmatic H_2S in this groundwater, acidification of certain landscapes may result through the oxidation of this gas to H_2SO_4 by *Thiobacillus* and other S-oxidizing bacteria in the soil vadose zone above the water table. This results in development of acid sulfate chemistry, precluding the abundant deposition of siliceous sinter found in neutral chloride areas by inhibiting silica polymerization and through the formation of silica-sulfate solution complexes (Foumier, 1985).

These two chemistries, acid sulfate and neutral chloride, represent two endpoints in rhyolitic-based hydrothermal areas of Yellowstone. Both chemistries represent accumulations of silica; acid sulfate by the loss of alkali and alkaline earth elements resulting in concentration of remaining siliceous minerals and residue, and neutral chloride from abundant silica precipitation. The exact chemistry which controls an area is variable between these chemical endpoints and may vary over time depending on relative H_2S in groundwater and water table levels of an area.

Study Sites

As a part of the field and laboratory pedon characterization program for the park soil survey, 10 pedons in four hydrothermal areas were sampled. Sample sites represent acid sulfate (Norris Annex and Solfatera Plateau), neutral chloride (Nez Perce Creek), and travertine or $CaCO_3$ (Mammoth Terraces) chemistries. Ongoing laboratory investigations are currently focused on acid sulfate and neutral chloride areas.

The Norris Annex site is located directly east of Norris Geyser Basin (44" 43' 41"N, 110" 41' 49"W). Centered within this site is a small hydrothermal basin. Soils within the basin and surrounding landscape have developed in glaciated Lava Creek Tuff and have undergone acid sulfate alteration. Two pedons were sampled. One pedon is located on the basin sideslope at a location where stunted lodgepole pines (*Pinus contorta* Dougl. ex. Loud var. Latifolia Engelm. ex Wats.) (Dom, 1992) and small areas ofjuniper moss (*Polytrichum juniperinum* Hedw.) are capable of establishment. At lower elevations within the basin, temperature and chemical restriction prevent vegetational growth. The second pedon is located on the upland, interfluval position to the south. Lodgepole pine at this location appears similar in size and density to other non-hydrothermal rhyolitic areas in the park, though this site has limited development of understory vegetation. The understory vegetation is estimated at 10-15% coverage and consists ofjuniper moss and lichen (*Cladina nitis* (Sanbst.) Hustich).

The Solfatera Plateau site is located 12 km east of the Norris Annex along the Canyon-Norris Road (44" 42' 41"N, 110° 33' 11"W). Soils in this acid sulfate area have a parent material composed of the 110,000 yr old Solfatera Plateau Unit, a vitropyritic rhyolite flow. This hydrothermal area is composed of multiple small basins and three pedons were sampled along a 4 m pit dug perpendicular to the contour of a selected basin. This pit traversed a landscape boundary represented by a change in soil color and a progressive loss of vegetation downslope. Vegetation is moss, panicgrass (*Panicum acuminatum* Sw), hairy golden-aster (*Heterotheca* spp.), and other small forbs.

The Nez Perce site is along Nez Perce Creek, located 3 km northeast of the Lower Geyser Basin (44" 34' 19"N, 110° 48' 18"W). This neutral chloride alluvial area is composed of soils forming in siliceous deposits that are either hard, platy materials or soft, slightly thixotropic deposits. Pedons were sampled to characterize soils developed in both materials. Vegetation is lodgepole pine in moderately well to well drained soils on stream terrace positions, and tufted hairgrass (*Deschampsia cespitosa* (L.) Beauv.), alkali cordgrass (*Spartina gracilis* Trin.), slender wheatgrasss (*Elymus trachycaulus* (Link) Gould ex Shinners.), and Halls sedge (*Carex parryanna* Dewey var. *unica* Bailey) on poorly drained soils.

Properties of Hydrothermal Soils

Acid Sulfate Soils

Acid sulfate soils are characterized by an extremely acidic pH, ranging from 5.3 to 2.1, and soil temperatures ranging from ambient to 78°C. Acidification and acid leaching are the major processes in these soils, removing bases and other plant nutrients, and accelerating rates of mineral alteration and dissolution relative to non-hydrothermal soils. The most extreme areas of acidity are principally aligned with fracture zones, which serve as conduits of water, heat, and gases. These zones generally coincide with basin floors, areas of principal water movement and greatest subsidence. Basin floors and sideslopes are characterized by the lack or presence of sparse, stunted vegetation and accelerated rates of erosion. In higher landscape positions, weathering occurs from both acidic water held in pores and vapor phase alteration.

Soils in acid sulfate areas are weakly developed, with most pedogenic activity in the upper 20-30 cm. Hydrothermally alteration continues below the depth where pedogenic processes are active. Soils have ochric surface horizons and develop cambic subsurface horizons on more stable, less acidic upland landscape positions. Pedons at these sites classify as Typic Troporthents or Dystric Cryochrepts (Soil Survey Staff, 1994), and similar soils in acid sulfate map units include the great groups of Dystropepts and Cryorthents (Rodman et al., in press). Soils are bleached white from loss of Fe oxide coatings on mineral grains, though surface horizons are generally darkened by organic matter. Horizon textures are sandy loams and loamy sands and soils have low water holding capacity. Organic matter is the major source of cation exchange capacity and extractable bases, and greatly increases water retention..

Soils forming from tuff and volcanic flow parent materials have similar suites of minerals in both the sand and clay fractions. The sand fraction is generally composed of quartz, cristobalite, tridymite, volcanic glass, and feldspar. Devitrification occurred to a greater extent in tuff deposits relative to volcanic flow materials at the Solfatera site. This has resulted in lower amounts of glass in hydrothermal soils from tuff.

Feldspars and volcanic glass are most susceptible to hydrothermal alteration in these soils. Other minerals, such as pyroxenes, biotite, or hornblende, ifpresent, would undergo alteration or dissolution as well. These latter minerals exist in very low concentrations in these parent materials and soils.

The clay fraction is composed of cristobalite and kaolinite, with lesser amounts of goethite and alunite. Cristobalite is a primary mineral from the original volcanic deposition. Kaolinite, alunite, and goethite are secondary minerals which form through alteration of feldspars. Kaolinite has been identified as both sand-sized pseudomorphs from feldspar and as yellow to red, oriented, laminar deposits in voids associated with Fe oxides. These two secondary minerals are present only in horizons with a pH > 3.2, suggesting the relative instability of these weathering products under hydrothermal alteration at a lower pH.

Neutral Cbloride Soils

Silica concentrations in groundwater are *often* similar in both acid sulfate and neutral chloride areas. While deposition of silica is minor or absent in acid sulfate soils, the near neutral pH of neutral chloride areas favors deposition and accumulation of siliceous organic and inorganic deposits.

Groundwater in neutral chloride areas typically emerges from hot springs. This heated water may flow from the mouth of the spring in a dispersed, fanlike pattern forming a spring apron, or channelized in a narrow flow. Silica precipitates from this groundwater as a non-crystalline mineral, opal-A (Jones and Segnit, 1971). Precipitation initiates on mats of phototropic bacterium which provide nucleation sites (Schultze-Lam et al., 1995), or by homogeneous nucleation in solution (Fournier, 1985). This non-crystalline silica forms hard, platy morphologic forms. These deposits tend to slowly build up along the opening and sides of a hot spring. Deposition results in an increasingly small spring opening, eventually forming a dome and completely encapsulating the spring.

Along stream terraces of Nez Perce Creek, older hot spring deposits are weathering into shallow, skeletal soils, with channery siliceous rock fragments. These soils classify as Lithic Cryochrepts. The great group classification of other similar soils included in these map units are Udorthents and Eutrochrepts (Rodman et al., in press). Textures in the sampled pedon are loamy sands and sand loams, and the soil pH ranges from 5.0 at the surface and increases to 6.9 in the Cr horizon at 19 cm. Mineralogy and micromorphology of these soils suggest that alluvial or colluvial deposits from non-hydrothermal rhyolitic soils are mixed with the original parent material in the fine earth fraction.

Behind and on the sides of existing hot springs, and overlying former hot spring deposits, are hydric soils saturated with groundwater at ambient temperature. Scanning electron microscope observations suggest that both inorganic and biogenic silica deposits accumulate, combining to form soft, low density aggregates of diatoms, plant opal, and inorganic flakes of opal-A. The matrix of this soil is white, with upper horizons darkened by organic matter accumulation. The sampled pedon has a solum depth of 36 cm, contacting an R horizon at 51 cm. This R horizon is a white, platy siliceous material suggesting this present soil overlies a former hot spring deposit.

This pedon classifies as a Typic Cryaquept, and other similar soils in the map unit are Tropaquepts (Rodman et al., in press). The texture of upper horizons is silty clay loam or silty clay. The pH ranges from 6.6 to 6.8 and the NH_4OAc-base saturation is at or near 100% for all horizons. The mineralogy is predominantly opal-A in the clay and sand fractions, though small amounts of quartz and feldspar are found in the sand fraction, likely alluvial deposition from non-hydrothermal soils.

Conclusions

Hydrothermal soils in Yellowstone National Park are complex entities with diverse origins and properties. This diversity of properties is principally related to the surficial stratigraphy, the geologic strata through which the magmatically-heated groundwater travels, the inclusion and subsequent oxidation of H_2S, and the differences in landscape position within a particular area.

Examples of this diversity is clearly exhibited in comparing acid sulfate and neutral chloride soils. Both groups of soils represent silicification, but by different processes. Acid sulfate soils developed in existing geologic deposits undergoing acid degradation with little to no secondary mineral deposition, while neutral chloride soils form in silica minerals deposited from groundwater.

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SOIL QUALITY AND HEALTH-SOME APPLICATIONS TO FOREST ECOSYSTEMS'

Robert T. Meurisse'

INTRODUCTION

Concerns about sustaining the productivity and health of forest ecosystems have been the subject of much research, debate, and federal actions (Perry, et. al. 1989; Gessel, et. al. 1990; Everett, et. al. 1994.) Forest management practices and their impacts on the environment are scrutinized daily by the media. The National Forests are managed under principles of multiple use and sustained yield "without impairment of the productivity of the land." Soil health and quality are embedded in statute for the National Forests of the United States. Restoration of stressed sites, and processes is an integral component of sustaining forest ecosystem health (Everett, 1994.) Understanding the role of soils is crucial to understanding stress processes within ecosystems and establishment of measurable soil quality standards is a means of expressing desired soil conditions (Meurisse and Geist, 1994.) It is national Forest Service policy to have soil quality standards to ensure sustainability and long-term productivity of forest ecosystems. The several Regions have developed and implemented standards, or measures, of soil quality since the 1970's.

Definitions: The terms, soil quality and soil health, often are used interchangeably. However, there are some subtle differences between them. Soil quality can be defined as: "the capacity of a specific soil to function, within natural or altered land use boundaries, to sustain or improve plant and animal productivity, water, air quality, and human health and habitation." (NCSS SQ Committee, 1995) Health is defined as "freedom from disease or ailment; the general condition of the body or mind with refemce to soundness or vigor (Am. College dictionary). So, I define soil health as "the condition of the soil with reference to its inherent quality and ability to perform vital ecosystem functions." The subtlety is in the capacity to function versus the condition of the soil relative to its inherent qualities.

Vital Soil Functions: Vital soil functions are to: (1) Sustain biological activity, diversity, and productivity; (2) partition water, energy and solute flow; (3) filter, buffer, immobilize, and detoxify organic and inorganic materials; (4)store and cycle nutrients and other materials; and (5)support structures and protect archeological treasures. Therefore, we can say a soil is unhealthy if the soil quality standards are exceeded so that the ability to perform the vital functions is impaired.

WHY ARE WE CONCERNED ABOUT SOIL QUALITY OR SOIL HEALTH?

Soil and Civilizations: Several recent symposia and publications have focused on issues pertinent to soil quality and health. "For humankind, soil is the essence of life and

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[1] Paper presented at West Regional NCSS Conference, Bozeman, MT, June, 1996

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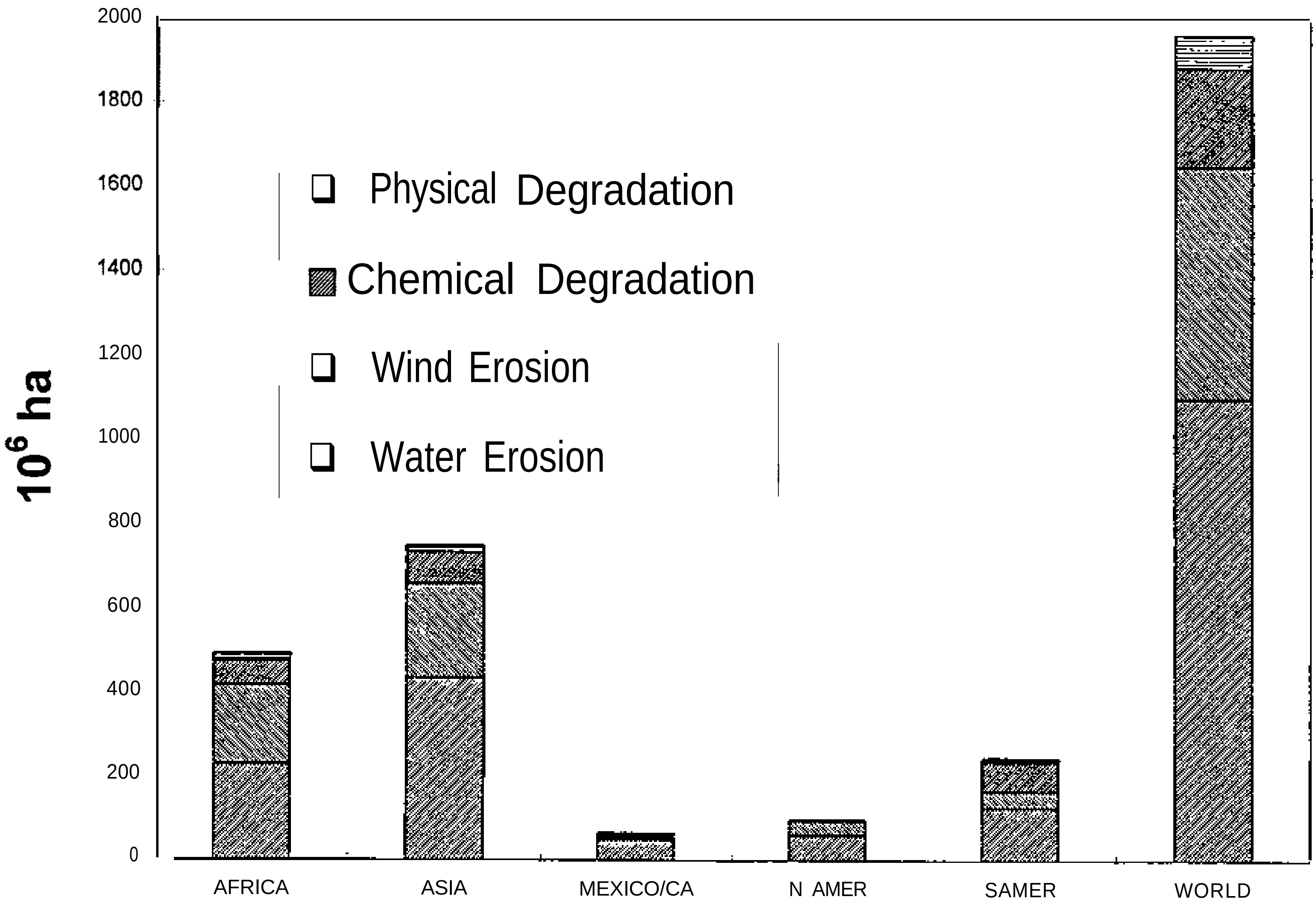
health." This opening sentence of the Preface to the SSSA Publication, Defining Soil Quality for a Sustainable Environment, captures the significance of the soil resource for sustainability of human life and economic well being (Doran, et. al.1994). In the Forward to this same publication, President Darrell Nelson states that for soil quality to become part of the mainstream of soil or environmental science programs, "there must be acceptance of the definition of the term and quantitative indicators must be developed." I concur. Definition is important for communication and establishment of quantitative measures is critical for monitoring conditions. The importance of sound soil and water management in the development and advancement of civilization is further explored in SSSA Publication 41, titled 'Soil and Water Science: Key to Understanding our Global Environment." In particular, Hillel (1994), describes the historic relationship between soil, water and civilization. The protection of soil quality through the wise use of soil resources is critical to the sustainability of civilization.

Soil Degradation: Sustainable land use and resilience was the subject of a symposium in Budapest (Greenland and Szabolcs, 1994). Figure 1 illustrates the extent of soil degradation from erosion, and physical and chemical causes from major regions of the world (Szabolcs, 1994). Nearly two billion ha. is degraded worldwide. Most is from erosion. South America, Africa, and Asia have several hundreds of millions of hectares in degraded condition. Most is from water and wind erosion. Although Mexico and Central America and North America are among the least of all Regions, many millions of ha are degraded. In North America, there is no measurable amount shown for physical and chemical degradation. Yet, studies have shown that many areas have reduced productivity and quality largely because of erosion and physical degradation from soil compaction (O'Laughlin and Pearce, 1984; Froehlich and McNabb, 1984; Follett and Stewart, 1985; Sullivan, 1987; Berg, 1988; Geist, et. al. 1991). So, these may be underestimates. Most of the degradation in forest systems is due to physical degradation, namely soil compaction (Sullivan, 1987; Froehlich and McNabb, 1984) and erosion (Megahan, 1981; O'Laughlin and Pearce, 1984; Berg, 1988).

Forest health and productivity: Forest health and ecosystem health have emerged as major concerns in the United States. Usually, the forest health discussion has focused on insects and diseases that have increased mortality in the western and southern parts of the country. These often are only symptoms to more underlying stresses regulated by soil/climate systems. Concerns have been raised about the long-term productivity and sustainability of forest ecosystems. Several symposia and conferences have focused on the multiple facets of this issue (Perry, Meurisse, et. al. 1987; Gasboro and Slaughter, 1987; Gessel, Lacate, Weetman and Powers, 1990; Harvey and Neunschwander, 1991; McFee and Kelly, 1995). Soil quality, health of forest ecosystems, and sustaiability of ecosystem processes, including standards, monitoring methods and management practices have been central to these discussions.

Special Concerns for Mountain Ecosystems: Conserving mountain ecosystems and cultures demands special attention (Denniston, 1995). Mountains span one fifth of the landscape and are home to one tenth of humanity. Mountain cultures and ecosystems

Figure 1 . Soil Degradation in Regions of the World
From: Szabolcs, 1994



face three primary threats from the expanding world economy: land scarcity fueled by inequitable ownership patterns and control of public resources, intensive resource extraction, and mass tourism and recreation. Denniston characterizes mountains as "vertical islands of cultural and biological diversity surrounded by seas of biological impoverishment and cultural homogeneity." Mountain ecosystems are of particular concern because the soils there often are less well developed than on more gentle slopes and are subject to intense storms that can accelerate erosion. Mountain soils also may be less resilient than deeper, better developed soils on lands of low relief and lowlands with older geomorphic surfaces. Mountain ecosystems usually are managed for forestry, range, watershed and recreation activities. More than half of humanity receives its water supply from mountain watersheds. Thus, mantenance of soil quality is particularly important in mountain ecosystems.

Development of quantitative soil quality measures, assessment of soil health conditions and application of sound management practices is essential for sustainable development and survival of civilizations. Mountainous forest and rangeland ecosystems play unique and important roles in the sustainability of civilizations. Soil health is crucial for achieving ecosystem sustainability and soil quality standards must be appropriate for these conditions.

SOIL QUALITY-FOREST HEALTH-ECOSYSTEM HEALTH-WATERSHED HEALTH CONNECTIONS

There is a close relationship between soil quality and health and the quality and health of forests, watersheds and ecosystems (Figure 2). There is much discussion, debate and disagreement about forest and ecosystem health and watershed health. Forest health usually is considered in terms of insects and diseases and their effects on tree mortality. This is particularly a concern in much of the mountain west and in parts of the south. Recent infestations of spruce budworrn, mountain beetle, southern pine beetle, and other insects have caused much mortality. Some root diseases are also a major concern. There is increasing evidence that some of this mortality is accelerated by other stresses on the system (Mika, et. al.1992). The stresses may be due to drought and nutrients, but detrimental soil conditions from management activities often are major contributors to the stresses (Everett, et. a,. 1994). For example, soil compaction, displacement and severe bums, result in conditions that reduce available moisture and nutrients for sustained plant growth.

Soil microorganisms play a critical role in the functions of ecosystems. They are particularly important for nutrient cycling, carbon mineralization and energy flow, nitrogen fixation, and nutrient and moisture supply through mychorrizal symbiosis (Richards, 1987; Amaranthus, et. al. 1990; Allen, 1991). Habitat provided by variable soil conditions influences the species and populations of soil biota. Significant changes in the habitat from management practices can greatly alter the species and their abundance.

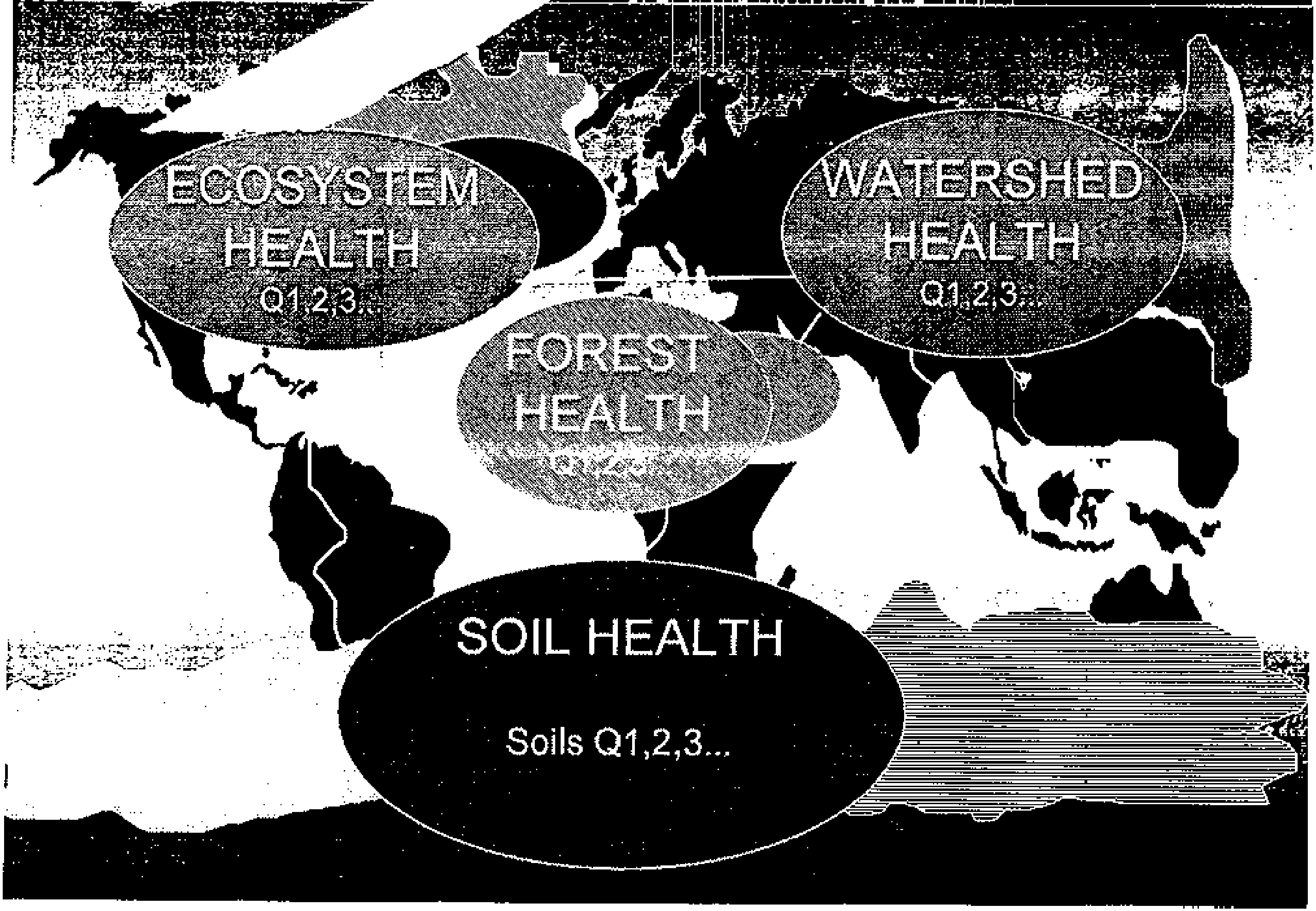


Figure 2. Relations[illegible]alth [illegible]shed health

There is an evolving body of literature defining ecological linkages between soil processes, plant growth, and community dynamics in the rhizosphere (Molina and Amaranthus, 1991). Mychorrizae affect soil structure by producing humic compounds. Interrupting flow of organic materials to mychorrizae can cause a deteriortion in soil structure and aggregate stability, and reduce forest regeneration and root growth (Amaranthus, et. al., 1990). Healthy populations of mychorrizal fungi and other soil microbes are essential for the growth and survival of tree seedlings, particularly on droughty and nutrient-poor sites.

Similarly, watershed health has a direct linkage with soil health. When soil compaction exceeds about 12 percent of a watershed, significant changes in peak flows have been reported in Western Oregon (Harr, 1976). Accelerated erosion from poorly designed or improperly applied practices decreases water quality and productivity (Megahan, 1981; O'Laughlin and pearce, 1984; Berg, 1988). Properly functioning watersheds are dependent on properly functioning, healthy soil systems.

The connections between forests, ecosystems and watersheds are dynamic and complex. They are highly variable in their qualities and in their conditions or health. Fudamentally, all are underlain and regulated largely by the quality and health of the soil ecosystem and its complex, dynamic web of properties, processes and functions. These connections are illustrated by the irregular lines and shapes in Figure 2.

SOIL QUALITY STANDARDS ON NATIONAL FORESTS

Soil quality standards have been established by the Forest Service for the National Forests since the late 1970's. The general concepts and standards are described by (Griffith, Goudey and Poff, 1990). Specific standards vary by region. The Pacific Northwest Region developed the first comprehensive set of quantitative soil quality standards and a procedure for measuring soil physical conditions. These are described by Meurisse (1987) and Geist et. al. (1991). Sullivan (1987) presented some of the most complete data that illustrates the use of the sampling methods and the effects of some management practices on soil conditions.

The most common measures of soil quality used on the National Forests are various physical properties. There are others such as erosion, organic matter, and degree of burning. A general description of the common measures follows.

> Physical measures: bulk density, porosity, soil displacement, infiltration, rutting and puddling.
>
> Erosion measures: These are more indirect and include soil loss tolerance, some specified percentage of topsoil loss, effective soil cover, and some percent of forest floor removal.
>
> Organic matter measures: X percent loss in surface layers, amount of organic matter less than some specified quantity, amount of large woody debris, and large woody debris sufficiency.

Detrimental burning is a measure of loss of 0 horizons and signs of oxidation, change in soil color at the surface together with the next cm depth blackened.

Specific quantitative standards, or thresholds, determine detrimental conditions. The detrimental conditions are presumed to be "unhealthy" soil conditions because they are impaired in their ability to perform one or more of the vital functions. In most cases, functions of concern are productivity and diversity, water quality and changes in water and energy flows, and effects on nutrient and carbon cycles.

SOME EXAMPLES OF SOIL QUALITY AND HEALTH ISSUES IN FOREST ECOSYSTEMS

A few brief examples of specific relationships between soil quality and productivity, biological diversity, water quality, hydrologic function, and soil borne diseases are described. Also, the concept of soil resiliency and its application to soil health evaluation is discussed.

Productivity and forest health- The effects of soil compaction and related loss of soil structure on tree establishment and growth is well documented (Froehlich and McNabb 1984). The direct effects of displacement and erosion, also are evident, The relationship between nutrient depletion and availability is becoming clearer for many tree species (Weetman, et. a!., 1992; Mika, et. al. 1992). There appear to be some direct links between potassium availability and tree mortality from insects and diseases, The ratio of nitrogen to potassium may be significant. Soil organisms are increasingly the subject of study for their effects on forest soils and forest health. Preliminary results from sampling soil arthropods and other mesofauna in compacted soils, reveal some changes in numbers of some species (K. Bennett, personal communication). The significance for tree growth or diseases is not known.

Soils have a high degree of biological diversity (Richards 1987; Allen 1991; Molina and Amaranthus, 1991). A high percentage of all organisms make their home in the soil. Some estimate thst as much as 90 percent of all organims are below ground. Recent studies found 200 mychorrizal types on one study site in southwestern Oregon (M. Amaranthus, personal communication). About 50 truffel species were found at the site. Other studies suggest that sporocarp (mushroom) production may be reduced in compacted soils. Ectomychorrizal fungal types and numbers may be affected by soil compaction and organic matter removal (M. Amaranthus, personal communication).

Hydrologic Function-Hydrologic function and water quality are impaired when soils are compacted and eroded. The literature is replete with studies that document effects from silivicultural practices, land use and fire on soil and water resources (Megahan, 1981; O'Loughlin and Pearce, 1984; Berg, 1988).

Soil Borne Diseases-Soil borne diseases may be increased when soil health is impaired by compaction and changes in soil nutrient supply. Surveys and personal observations have revealed black stain in Douglas-fir and in ponderosa pine in compacted soils. Black stain reduces the quality and comercial value of wood products.

Soil Resilience-The concept of resilience is fundamental to assessing soil quality or soil health. Resilience is defined variously as the ability to rebound or recover from some condition or stress. Szabolcs (1994) defines resilience as follows:

$$SR = BC_{ph} + BC_{ch} + BC_{b} + \int_{t1}^{t2} dPSF/dt + \int_{t1}^{t2} dAF/dt$$

Where: SR =Soil resilience
BC_{ph} =Physical buffering
BC_{ch} =Chemical buffering
Bc_{b} =Biological buffering
PSF =Pedological soil fluxes
AF =Anthropological soil fluxes

Such an approach to resilience can contribute not only to its interpretation, but to its modelling and estimation through further studies. The concept of resilience is crucial to characterization of soil health. Thus, interpretations of soil resilience need to be made. Some of the important dynamic factors that contribute to resilience are organic carbon, soil structure, soil organisms and soil nutrients. Other intrinsic properties include moisture and temperature regimes, depth, partcle size distribution and permeability.

SOME PRESCRIPTIONS FOR SUSTAINING AND IMPROVING SOIL HEALTH DURING FOREST MANAGEMENT OPERATIONS

The discussion about soil health is incomplete in the absence of prescriptions to conserve soil resources while managing forests for a variety purposes. A key to managing the soil resources to sustain their health, is to have knowledge of the soils and their behavior in response to management practices. Clearly defined, quantitative soil quality standards are essential. Then, design practices to meet the standards and implement a sound monitoring program that includes management feedback.

Prevention of damage should be a primary consideration. For harvest and site preparation, the goal is to reduce the amount of area impacted. This can be done by operating when soils are in a favorable moisture state, or when frozen or covered with snow. Use logging methods that minimize ground impacts and minimize the number of entries. Designate skid trails and re-use them in future entries.

Some practices that minimize adverse effects from fire include doing broadcast burning within prescription, selective use of underbuming within prescription to reduce fuel loads, crushing residues in lieu of burning, and selectively piling for burning. Improvement of soil conditions where soils have been degraded or where inherent qualitites are low can be accomplished with management practices. Subsoiling is a common practice to restore compacted soils. Winged susbsoilers can be effective. Forest fertilization can be an important practice where response information and soil deficiencies are known. A variety of nitrogen-fixing species are known and can be managed so that soil quality is improved where nitrogen is deficient. Appropriate application of these practices, and others, is fundamental to achieve soil and ecosystem health.

FOREST SOIL AND ECOSYSTEM PROCESSES RESEARCH

There are several significant research projects actively investigating various aspects of soil quality in relation to tree nutrition, productivity and forest ecosystem health. One of the longer running studies is the Stand Management Cooperative and the portion that formerly was the Regional Forest Nutrition Research Project at the University of Washington. It is a cooperative effort with several industry organizations and U.S. Forest Service and Bureau of Land Management. This project has investigated the relationship between soil fertility, tree nutrition and tree growth. Nitrogen is a limiting nutrient in many soils of the Pacific Northwest and significant response to fertilizer additions is experienced (Chappell, et. al. 1992). The Intermountain Forest Tree Nutrition Cooperative, at the University of Idaho, also has studied response of interior species to nitrogen. More recently, the investigations have included the broader aspects of forest health. Results suggest a relationship between soil nitrogen and potassium and tree mortality (Mika, et. al. 1992). Management practices that diminish nutrient supplies from *severe* bums or from soil displacement, can impact tree growth and mortality from insects and diseases because of increased stress.

The USDA Forest Service is conducting a National Long-term soil productivity study of soil compaction and organic matter removals at three levels each (Powers, Alban, et. al. 1990). Preliminary results seem to confirm previous studies that decreased soil quality from compaction and loss of organic matter impair tree growth.

The Pacific Northwest Research Station and Region are conducting an integrated, long-term ecosystem productivity study. A series of integrated research sites is established in Western Oregon and Washington. This study has some unique and innovative characteristics. This large scale study, of 15 ha. treatments, integrates physical, biological and social sciences. It is designed to provide managers, scientists and the public with a comprehensive and integrated understanding of the ability to manage forests for sustained ecological, social and economic values and is planned to continue for 200 years. The study includes effects of early, mid and late successional stages on productivity and soil processes and properties. It also has three levels of organic matter for each successional treatment. This study will examine fundamental soil and ecosystem processes including carbon sequestration and cycling, soil organisms and net primary productivity.

RESEARCH, DEVELOPMENT AND APPLICATION NEEDS

In order to have a broader understanding of the extent of soil degradation and causes of it, an assessment of soil conditions is needed. While there are individual studies, monitoring projects, and observations, there is not a comprehensive assessment of soil conditions. This is especially true of forest ecosystems.

Measures of soil quality need to be developed and tested for three distinct groups. Land owners and managers need to have general, qualitative and quantitative measures that are easily observed or measured. Technical advisors require somewhat more inclusive, quantitative, measurable standards for monitoring soil conditions. Research scientists need to consider a variety of quantitative measures including physical, chemical and biological properties and processes. Soil organisms, microbila biomass, enzyme studies and other biological measures should be tested to determine effects of management practices on population distributions, numbers, and processes. Much of the research to date has been fragmented and lacks a comprehensive knowledge base for setting policy about soil quality or soil health issues. An integrated and coordinated research, development, monitoring and applications effort is needed to maximize effectiveness of scarce resources. The NRCS Soil Quality Institute is a beginning for this approach.

Sustainable healthy forest ecosystems and watersheds are intricately linked with healthy soil conditions. An understanding of the basic soil ecosystem properties and processes is essential to sustaining soil quality and soil health. Life and civilization depends upon sustaining the quality of soils and their ability to perform their vital functions.

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Soil Quality & NRI Pilot Project

Presented by
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Soil quality is not a new, it has been around for some time. The term "soil quality" is usually used by the scientific community, whereas "soil health" is preferred by the farmer or land manager (Karlen et al., 1995). In the soil quality/soil health literature, the terms are generally used synonymously, and also will be for the purpose of this presentation. Historically, soil quality meant suitability of a soil for a specific use (Warkentin, 1977). Today, the meaning of soil quality has been adapted for current needs and new knowledge gained of soils.

A generally accepted definition of soil quality is one that was developed by an ad hoc committee of the Soil Science Society of America (Karlen et al., 1995): "The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation." The phrase "specific kind of soil" recognizes that soils are diverse and defined by the soil forming factors and processes. The "capacity of a soil to function" is referring to what the soil does. Soils perform many functions within a soil ecosystem. Three major soil functions or goals that define soil quality are to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. From these three function or goals, five specific or vital functions are defined, they are: (1) sustaining biological activity, diversity, and productivity; (2) regulating and partitioning water and solute flow; (3) filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric depositions; (4) storing and cycling nutrients and other elements within the earth's biosphere; and (5) providing support for socioecomic structures and protection for archeological treasures associated with human habitation (Karlen et al., 1995). The capacity of a soil to perform these functions will very with soil type, kind of land (e.g., rangeland, agricultural land, wetland) and land use.

The capacity to function (soil quality) can be viewed with respect to soil in two ways: (1) as it relates to a soils inherent or natural capacity to fimction (inherent soil quality); this is defined by the soil forming factors and processes that developed the soil. Therefore, different soils will have different capacities to function, and thus, different qualities. Soils are compared against each other for their capacity to fimction under a specific use.

The second view relates to the changing or dynamic capacity of a soil to function as influenced by land management and use. This relates to soil quality changes over time as a result of human influences and land management. Under this view, quality is compared to a standard state or reference condition. This reference condition could be its natural state, or some baseline condition; the key is that a reference condition is established. Quality can be monitored in comparison to this reference condition (on the same soil) over time to determine if the soil is being sustained, aggraded or degraded. Then corrective action can be taken to reverse a declining situation. Another way for assessing soil quality is to establish standard values for the reference soil condition, and then measured values are compared to the standard values.

To evaluate soil quality, certain concepts need to be kept in mind. The first, is that soil quality goals need to be established; these are generally to maintain plant productivity, environmental quality, and human and animal health. Second, based on the goals, specific soil functions should be defined that evaluate these goals. Third, appropriate indicators are then established that "'point to" or indicate if the soil is functioning effectively, of course, within the limits of its inherent capacity. To evaluate soil quality from a set of indicators, an index is usually developed and used.

Soil quality indicators should encompass the biological, chemical, and physical attributes of the soil. Other indicators besides soil attributes are aspects of the crop, such as yield, plant vigor, root development, etc; or offsite impacts such as ground water quality or surface water quality (Acton and Gregorich, 1995). Remember environmental quality is also a goal of soil quality. Indicators of soil quality should also be sensitive, easily measured, reliable, and reproducible (Doug L. Karlen, personal communication).

It would not be economical or feasible to measure all soil attributes to assess its quality, so a core set of attributes called a minimum data set (MDS) are selected, that collectively indicate the quality or effective functioning of the soil (Larson and Pierce, 1991). Several minimum data sets have been proposed (Larson and Pierce, 1991; Arshad and Coen, 1992; Doran and Parkin, 1994). The most recent MDS proposed is that described in table 1.

A soil quality index can be used to assess the quality of a soil. Several methods for computing a soil quality index have been proposed (Pierce and Larson, 1993; Smith et al., 1993; Doran and Parkin, 1994; Karlen et al., 1994a). The soil condition index of NRCS is currently being resurrected and updated as a useful tool to evaluate soil quality or condition. Another index that shows promise is the soil tilth index, which was developed by the Soil Tilth Laboratory in Ames, IA (Singh et al., 1992). A systems engineering approach was used to develop a soil quality index from a MDS (Karlen et al., 1994a, 1994b). This approach will be used in the Natural Resources Inventory (NRI) pilot study to assess the quality of the soils.

<u>NRI Pilot Project Summary</u>

A pilot study of the NRI was initiated in 1996 to (1) determine the feasibility of using the NRI sampling frame to assess soil quality, (2) test indicators of soil quality, (3) assess the temporal and spatial variability of indicators, (4) assess soil quality on an MLRA and soil series bases, and (5) develop a blueprint for future NRI assessment of soil quality. Cooperators in the project include the National Soil Survey Center, National Soil Tilth Laboratory, Oregon State University, Soil Quality Institute, NRI & Analysis Institute, NRI Division of NRCS, and several Agriculture Research Service Laboratories.

The pilot study will be conducted in four and possible five Major Land Resource Areas (MLRA) of the United States; these are (1) MLRA 9, Palouse and Nez Perce Prairies (2) MLRA 67, Central High Plains (3) MLRA 77, Southern High Plains, (4) MLRA 105, Northern Mississippi Valley Loess Hills, and (5) MLRA 136, Southern Piedmont. In MLRAs 67, 77, and 136, soil quality will be assessed on a soil series bases, while in MLRAs 9 and 105, it will be assessed on an MLRA basis without regard to soil type.

Within each MLRA of the pilot study, the goal will be to sample 100 Primary Sampling Units (PSU). Within each PSU, two out of the three PSU points will be sampled. At each PSU point, soils will be sampled at two depth; 0 to 1 and 1 to 4 inch depths. If there is a mixed plow layer, than just one depth, from 0 to 4 inches, will be sampled. The maximum total number of samples will be 400 from each study area or MLRA.

Measurements taken at each point will include (1) site characteristics (Table 2), (2) Bob Grossman's 'Near Surface Point Soil Quality" evaluation (Table 3), and (3) soil quality indicators from a MDS (Table 4). In addition to the above, in MLRA 9 only, addition biological properties will be measured; these are total active bacteria and fungi, VAM root colonization, nematodes, protozoa, and soil enzyme analyses (beta-glucosidase and arylsulfatase).

A reference condition for most of the soil quality indicators measured will be established for soils that function similarly or are genetically similar. From these reference values scoring functions and an overall index will be developed to evaluate the quality of the soils in the study areas.

Table 1. Minimum Data Set (MDS) of soil attributes to assess soil quality (after Doran and Parkin, 1994).

<u>Physical</u>

Texture
Depth of soil, topsoil, & rooting
Infiltration & bulk density
Waterholding capacity

Chemical

Soil organic matter
pH
Electrical Conductivity
Extractable N, P, & K

<u>Biological</u>

Microbial biomass C & N
Potentially mineralizable N
Soil respiration (water content & temperature)

Table 2. Site characteristics recorded for the 1996 NRI pilot project.

Identify soil type - auger hole
Landscape position - surface config.
Surface relief - tillage
Visual erosion features
Rock fragments - surface cover %
Land use/crop history
Soil rooting barriers
Irrigation

Table 3. Near surface point soil quality evaluation (Bob Grossman, NCSS).

Pedon description to 30 cm depth
horizon, depth, % clay & sand, water state, most consistence, structure (shape, grade, size), and macropores
Measure crust expression
Measure bulk density
zone of maximum density

Table 4. Soil quality indicators measured in NRI 1996 pilot project.

Organic C	Aggregate stability
Organic C & N	Potentially mineralizable N
CEC	Particulate organic matter
Ext. Al & bases	Microbial biomass
pH	Basal respiration
EC&SAR	Herbicide residue
Texture	PAH

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Precision Agriculture, Remote Sensing, NASA's Mission to Planet Earth, the Internet, Public Access Resource Centers and the Soil Survey

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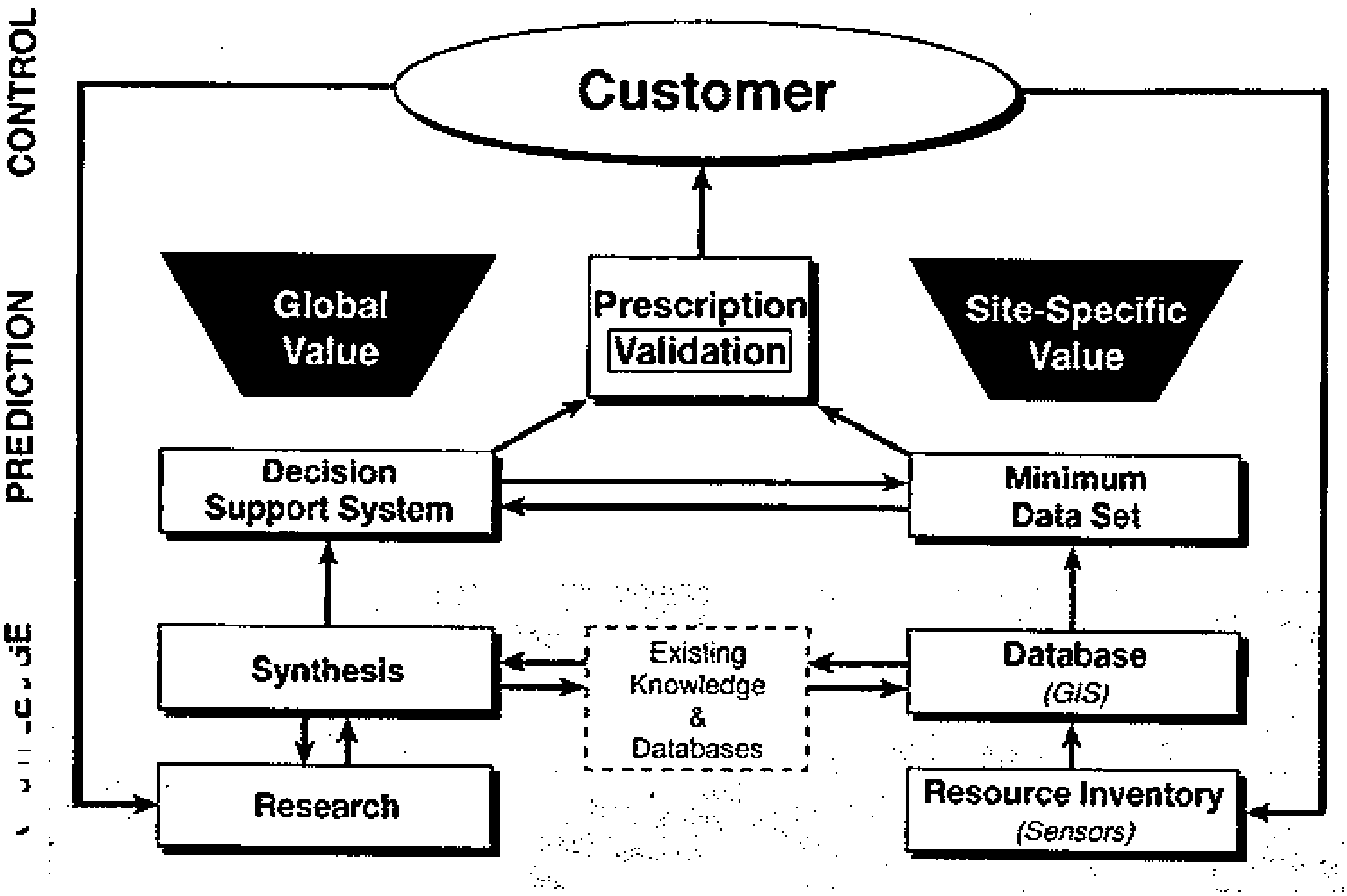
ABSTRACT

Precision agriculture and site-specific crop management are part of a conversion to agriculture practices in which fertilizers, herbicides and other treatments are applied precisely where and when they are needed according to soil conditions. Global positioning system receivers allow accurate navigation of field implements and creation of crop yield maps. Digitized aerial photographs and remote sensing products from space can help producers explain the wide range of yields shown on maps. These products enhance soil survey information as a basis for digitized field management maps. Previous public and commercial sources of remote sensing products for agriculture did not provide services that generated a sustained demand by crop producers, often because relevant data were not processed quickly enough to affect important decisions. Public Access Resource Centers (PARCs) could provide soils data, weather information and a nearly uninterrupted electronic flow of remote sensing data from NASA's Mission to Planet Earth MODIS and other sensors that could monitor crop conditions for producers and their advisors. This early warning/opportunity system would provide a low cost way to discover unexpected conditions that merit examination on the ground Spectral reflectance values could indicate an opportunity to improve crop quality, for example, by increasing protein content through supplemental application of nitrogen fertilizer. High-spatial resolution digital aerial photographs or data from new commercial satellite companies would supplement soils information as the basis for applying the nitrogen site-specifically. These detailed (I to 4 m resolution) data are too expensive to acquire often and must he limed so as lo represent differences in water supply characteristics and crop yield potentials. The importance of soil surveys, remote sensing products, and agronomic research will not he fully realized until they are merged to provide the knowledge, predictions, and the specific prescriptions that crop producers need to control operations and improve site specific outcomes

Fig I was developed from discussions with G.Uehara and others during a "brain storming session at the NCSS conference in Bozeman, June, 1996. The figure illustrates the importance of merging agronomic research with resource inventory 10 obtain the knowledge, predictions and prescriptions that producers need 1" control operations and benefit from site-specific management,


CONTROL
PREDICTION
Customer
Global Value
Prescription
Validation
Site-Specific Value
Decision Support System
Minimum Data Set
Synthesis
Existing Knowledge & Databases
Database
(GIS)
Research
Resource Inventory
(Sensors)

Evaluating Management Impacts on Long-Term Soil Productivity: A Research and National Forest Systems Cooperative Study

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Abstract

limber harvesting and mechanical site preparation can reduce site sustainability if they excessively disturb or compact the mineral soil or remove the surface organic matter. Volcanic ash-influenced soils with low undisturbed bulk densities and rock content are particularly susceptible. This paper outlines the Forest Service's National Long-Term Soil Productivity Study and gives local results from northern Idaho.

Background

Sustaining the wood-growing capacity of commercial forests is a fundamental goal of forest management in North America. Rotations are shortening, residue use is' increasing, and site preparation is intensifying in many regions. Removing more organic matter increases the loss of nutrients and organic materials important to soil resiliency and microbial activity. More mobile machinery is used each year in harvesting and site preparation, thereby increasing the risk of soil compaction. Do such practices threaten the long-term productivity of the land? Scientific evidence, though rare and fragmented, suggests this may be so. Thus, sustained, long-term productivity of forest land is emerging as a legal and scientific issue. As the world's largest forest management and forest research agency, the US Forest Service has lead responsibility for tackling this issue.

Regulations

The Multiple Use-Sustained Yield Act of 1960 binds the Forest Service to achieve and maintain outputs of various renewable resources in perpetuity without permanent impairment of the productivity of the land. Section 6 of the National Forest Management Act of 1976 (NFMA) charges the Secretary of Agriculture with ensuring research and continuous monitoring of each management system to safeguard the land's productivity.

Justification

Our ability to maintain the soils productive capacity faces increasing public challenge through Forest Land Management Plan (FLMP) and timber sale comments and appeals. Results from this cooperative study will provide creditable responses to these challenges, and will address related research needs identified in FLMP's across the nation. Initially, existing soil quality monitoring standards will be compared with interim findings and can be adjusted to reflect the most recent research results. The fact that the Forest Service is aggressively addressing the problem shows "good faith" intentions, and should further alleviate challenges concerning soil productivity. More substantive information will be available to deal with the next round of planning.

Joint effort

Our technological ability to disturb soil is advancing much faster than our assessment of its impact on fundamental resources. The oldest designed experiments in the U.S. rarely included the degree of soil disturbance possible with today's equipment. While case studies show that the productive potential of a site can be degraded by losses of organic matter and total soil porosity, the most definitive work has been done outside the U.S., and has centered on sandy soils and mesic to xeric moisture regimes. Work on finer-textured soils and in cooler and moister climates tends to be short-term, limited in scope, retrospective, and often confounded. Because of this, results from existing research can not always be extended broadly to tackle the questions facing National Forest Systems.

A new approach, which crosses traditional lines of study, is needed to understand how management practices affect soil processes and potential productivity across a broad spectrum of sites. This cooperative study alters site organic matter and total soil porosity over a range of intensities encompassing those possible under management. This creates a network of comparable experiments producing nil to severe soil disturbance and physiological stress in vegetation over a broad range of sites and climates. Establishing and monitoring this network directly addresses the needs of National Forest Systems, and creates a research opportunity of unusual scope and significance. The work fosters close cooperation between Research and National Forest Systems, and opens the door for important collaboration with university researchers (for more information about study design see Powers and others 1990).

Long-Term Soil Productivity Study in Idaho

The Intermountain West has extensive areas of forested land on volcanic ash soils (Geist and others 1989). These areas are highly productive, but prone to compaction because they have a low volume weight (weight-to-volume ratio) and relatively few coarse fragments in the soil profile (Geist and Cochran 1991). Their undisturbed bulk density is about 0.70 g/cm^3, porosity 77 percent, coarse fragments 20 percent, and available water 25 percent (see Geist and Cochran 1991).

Once these sites have been disturbed through timber harvesting activities and site preparation, porosity (Dickerson 1976; Moehring and Rawls 1970) and hydraulic conductivity (Gent and others 1984) declines. Relatively little information exists, however, relating the quantity of residual organic matter and the intensity of site preparation to compaction levels in the soil profile before and after harvesting.

Site Description

This study was conducted on a bench adjoining the Priest River at the Priest River Experimental Forest, Priest River, ID. The study area receives about 83.8 cm of precipitation annually, with a mean annual temperature of 6.6 °C. The habitat type is classified as *Tsuga heterophylla/Clintonia uniflora* (Cooper and others 1991). The soil has a silt loam surface layer 28 to 38 cm think, derived from Mount Mazama volcanic ash. The subsoils is 50 to 75 cm thick. It is a silty clay loam derived from glacial lacustrine sediments. These are underlain at depths of 60 to 100 cm by gravelly to very gravelly sands and sandy loams deposited by alluvial processes. The soil is a medial, frigid Ochreptic Fragixeralf (Mission series). Before harvest, the site consisted of a well-stocked stand of about 30-year-old western white pine (*Pinus monticola* Dougl. ex D. Don), western hemlock (*Tsuga heterophylla* (Raf.] Sarg.), Douglas-fir (*Pseudotsuga menziesii* var. *glauca* [Beissn.] Franco), and western larch (*Larix occidentalis* Nutt.). In the past, the site was part of the Priest River Arboretum.

This site was divided into nine 0.8-ha plots surrounded by a 200-m buffer. Trees were directionally felled and skidded along a central skid trail or from the plot boundaries to prevent compaction during harvesting. The treatments followed a three-by-three factorial design as follows:

COMPACTION LEVEL	ORGANIC MATTER LEVEL	
no compaction (C,)	Bole only removal	(OM_0)
no compaction (C,)	Bole and crown removal	(OM_1)
no compaction (C,)	Bole, crown, & litter removal	(CM:)
medium compaction (C,)	Bole only removal	(OM_0)
medium compaction (C,)	Bole and crown removal	(OM_1)
medium compaction (C,)	Bole, crown, & litter removal	(GM:)
severe compaction (C,)	Bole only removal	(GM,)
severe compaction (C,)	Bole and crown removal	(OM_1)
severe compaction (C,)	Bole, crown, & litter removal	(OM_2)

Compaction-free plots did not have any equipment on them during harvesting or site preparation. Moderate compaction was achieved by driving a Grappler log carrier over the plots twice. Extensive compaction was obtained with four passes with a D-6 Caterpillar tractor. On compacted plots with surface organic matter, debris was removed with the first tractor pass to prevent organic and mineral components from being mixed. The organic matter was then evenly redistributed on the plots. Soil moisture during compaction averaged 25 percent (Page-Dumroese 1993).

In each 0.8-ha plot, 16 locations were established on a 20-m grid. At each grid point, soil profiles were examined to measure bulk density (at O-10 cm, 10-20 cm and 20-30 cm depths), soil strength, soil nutrients, pH, ectomycorrhizal colonization, and organic matter. Understory vegetation samples (grasses, forbs, shrubs, and litter) were taken to estimate biomass and nutrients. Downed woody transects were installed to measure total surface woody debris. Three overstory trees in each plot were taken to estimate biomass and nutrient distribution. One-half of each 0.8-ha plot had competition controlled.

Results and Discussion

Figure 1 shows the effects of harvest method and site preparation on soil bulk densities. When harvest activities were restricted to the designated skid trail, the soil densities were no greater after harvest than before. However, as site preparation intensity increased through encompassing more of the site, increasing the number of passes by equipment, and leaving less surface organic matter, bulk density increased from 0.60 to 0.81 g/cm^3. Even after site treatment, the average bulk density was still much lower than that of many coarse-textured soils in this region, which can average greater than 1.0 g/cm^3. However, bulk density did increase greater than 20 percent with four vehicle passes. Large increases in bulk density have been reported to a depth of 5 cm with the first vehicle pass (Kroger and others 1984; Miles and others 1981).

After three years seedling height growth (Figure 2a and 2b), biomass (Figure 3a and 3b), and root volume (Figure 4a and 4b) give mixed results. Each species responds differently and each measured variable different interpretations. For example, if height growth were the only variable measured, then western white pine does best in post-harvest treatments that moderately compact the soil and remove surface organic matter (with no herbicide treatment). On the contrary, Douglas-fir height growth is best after moderate compaction, total removal of the surface organic matter, and herbicide application. If biomass were the only variable measured, western white pine seedlings should be planted in non-compacted soil with no organic matter removal or herbicide. However, Douglas-fir biomass is greatest after high compaction and total organic matter removal. Looking at all the measured variables is more difficult to interpret. Short-term results may indicate that compaction or organic matter removal may not impair growth. The caveat of this study is that long-term seedling response will be quite different from short-term findings and no single measure should be used.

There was a marked reduction in non-mycorrhizal root tips for both Douglas-fir and western white pine seedlings in moderate and severe soil compaction treatments (Figure 5) (Amaranthus and others 1996). Soil compaction decreases the ability of seedlings to capture site resources and may adversely affect reforestation success, especially on sites where the period for seedling establishment is limited. Non-mycorrhizal vs mycorrhizal root tips may be the best bio-indicator of seedling success (Amaranthus and others 1996). Diversity of ectomycorrhizae may equip the tree and forest to adapt to changes in season, habitat, pollution, or climate change and improve the ability of both Douglas-fir and western white pine to grow well over decades and centuries.

Early results do not show clear treatment differences but the compacted treatments seem to have better “average” seedling growth. However, the compacted treatments suppressed competition. Therefore, growth gains may be related to changes in competition rather than changes in soil physical properties. As seedlings in the compacted plots grow, their height increment will likely slow due to less soil volume available for them to exploit. Above ground growth masks belowground processes, as shown with the non-ectomycorrhizal tips. Site assessments should take into account both aspects and over time provide accurate evaluations of relative impacts.

This National Long-Term Soil Productivity Study began as a partnership between Forest Service management and research. It has now developed an international scope. Test sites have immense demonstration value for training current and new generations of natural resource specialists. They also provide a valuable tool for learning more about intensive management which allows us to maximize outputs of tolerant stands already under management, perhaps taking pressure off intolerant areas.

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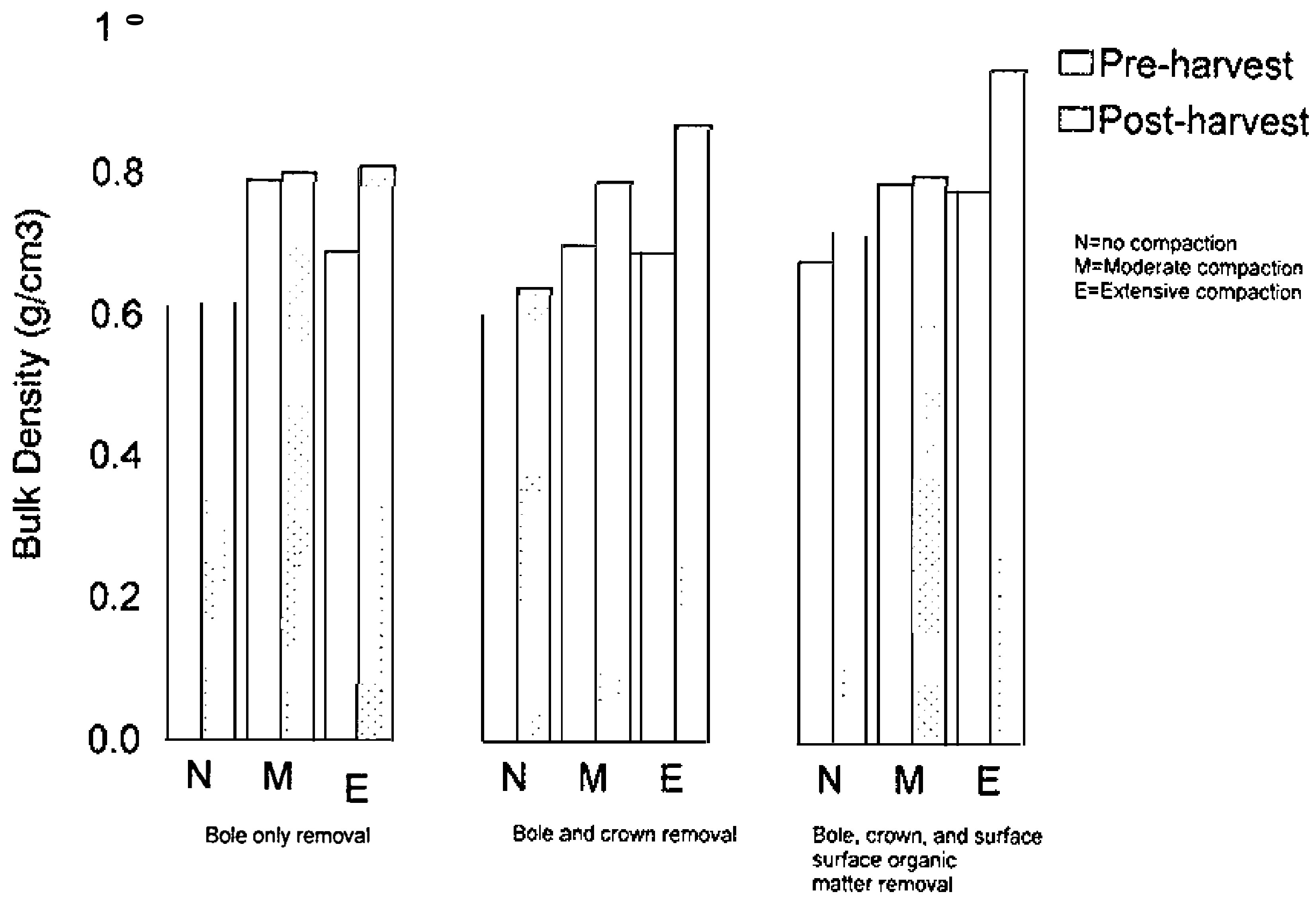

1. The effects of timber harvesting and spreparation on soil bulk density, averaged for three soil depths.

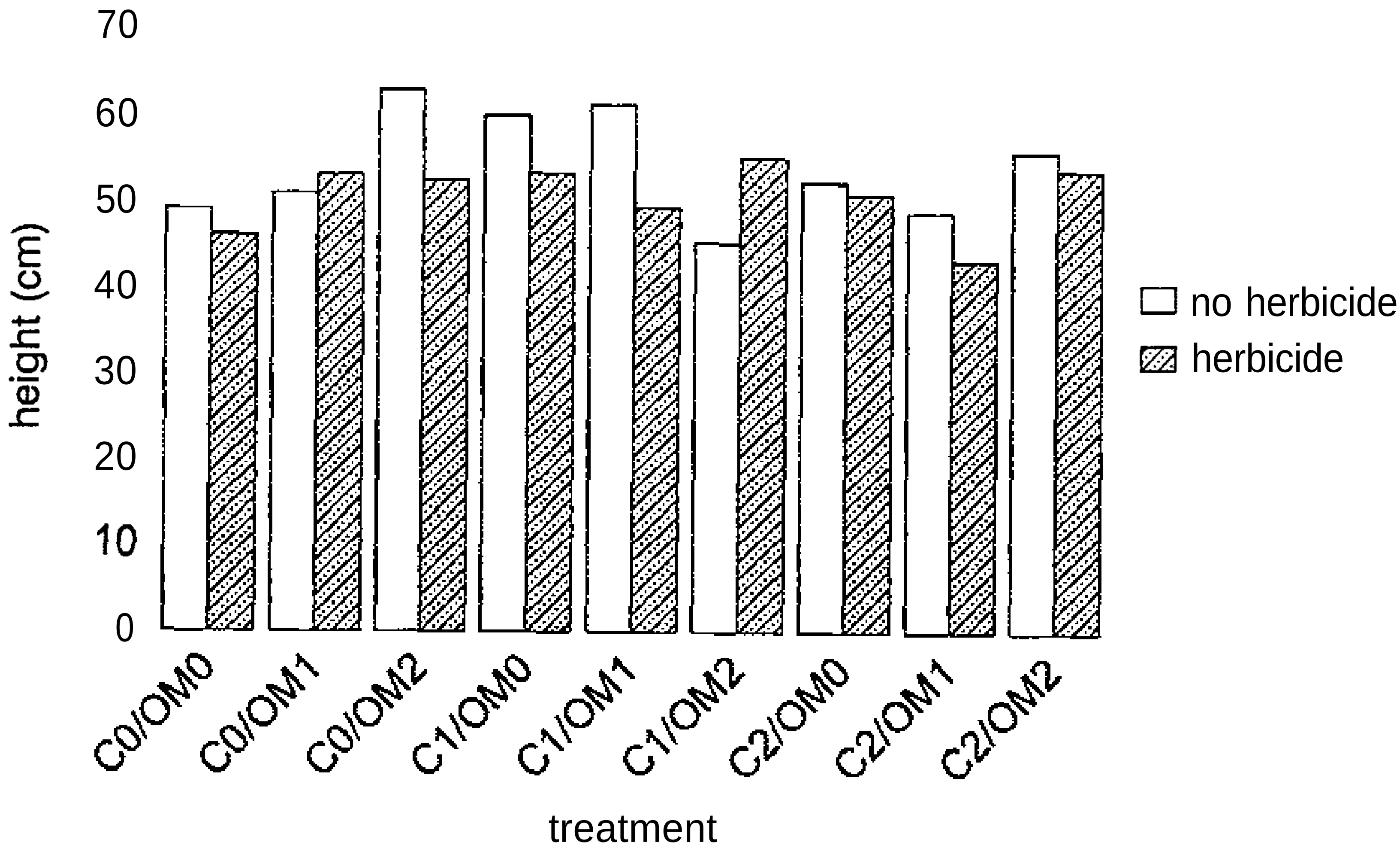

Figure 2a. Average height of 3-year-old western white pine as affected by compaction and organic matter removal.

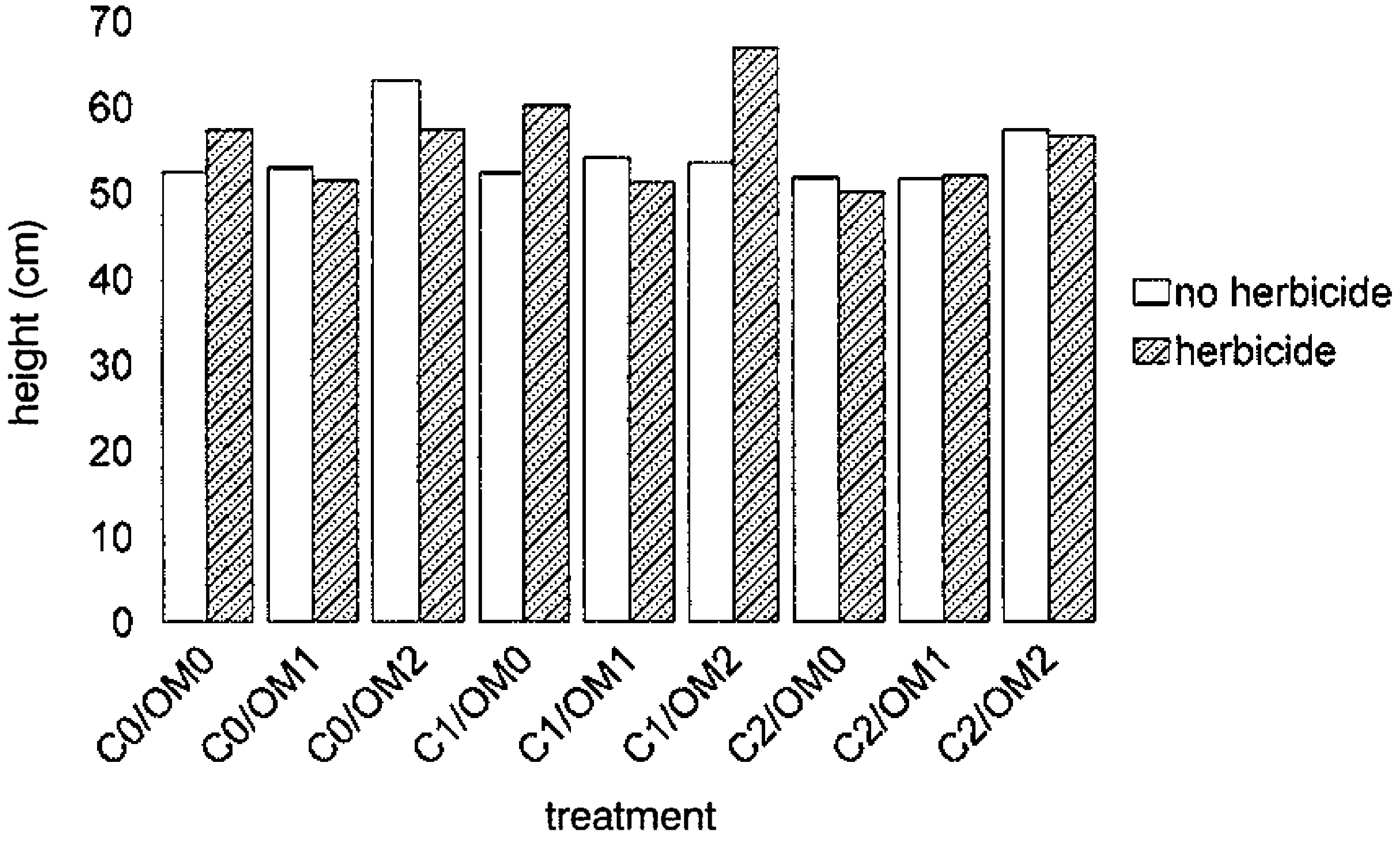

Figure 2b. Average height of 3-year-old Douglas-fir as affected by compaction and organic matter removal.

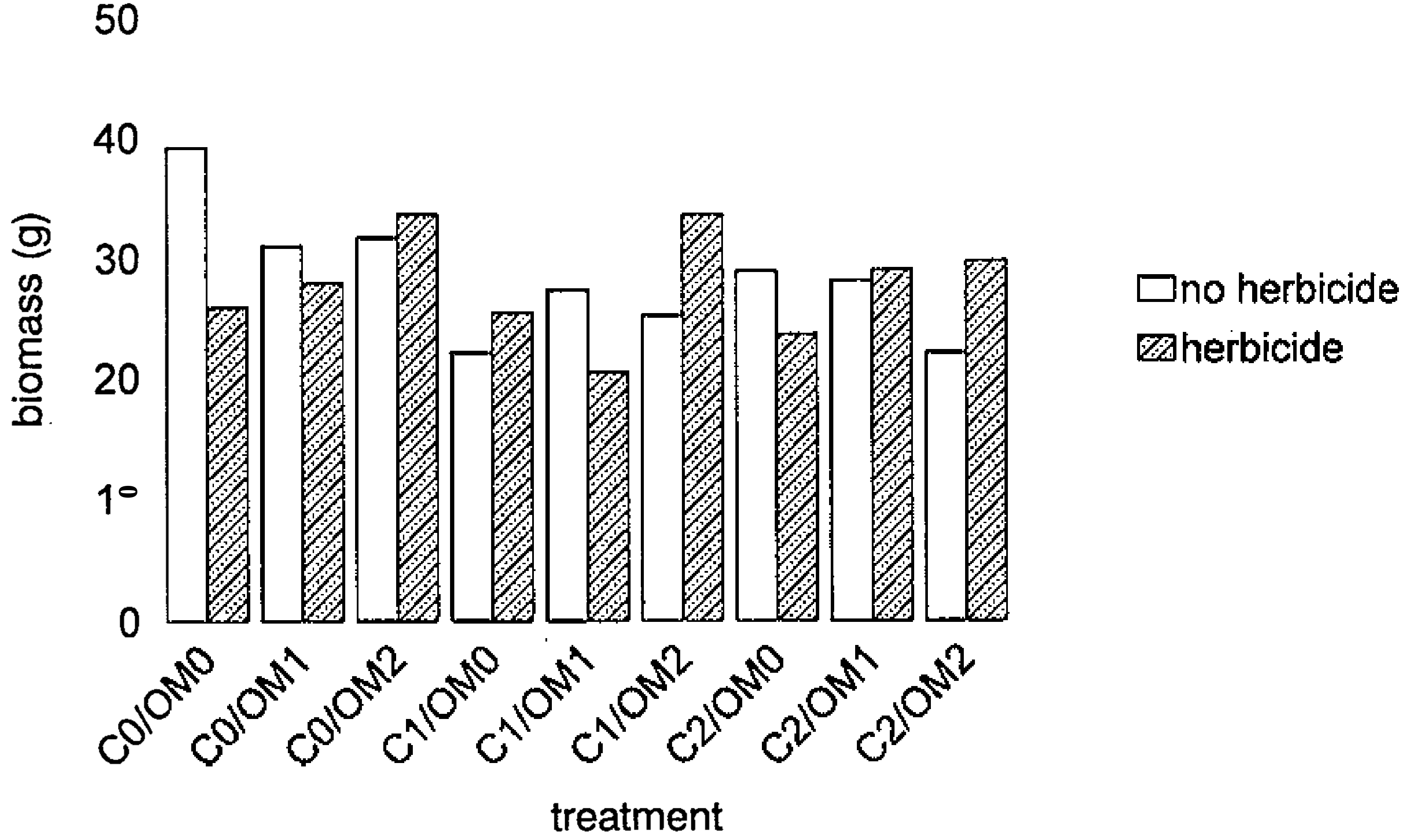

Figure 3a. Average biomass of 3-year-old western white pine as affected by compaction and organic matter removal.

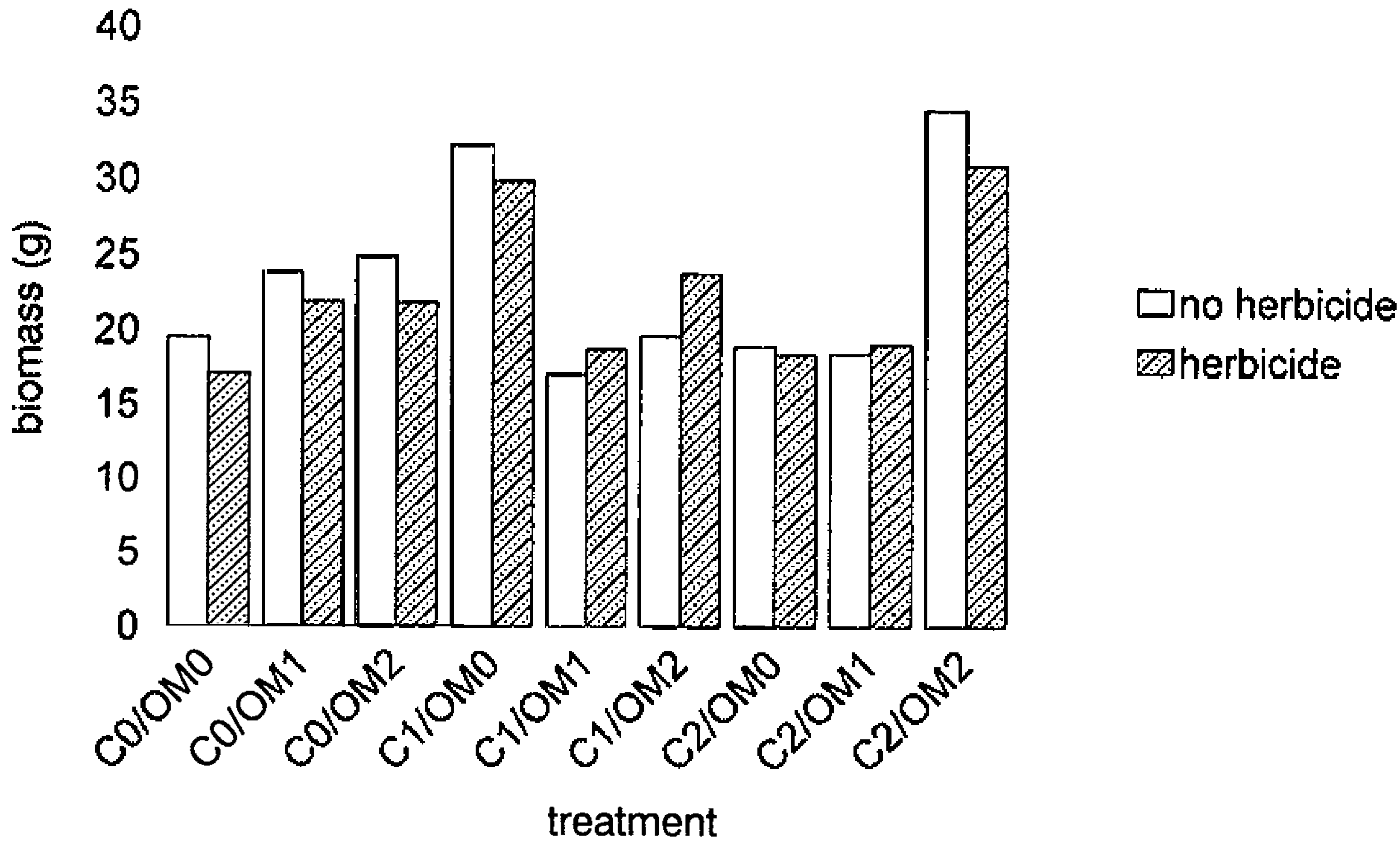

Figure 3b. Average biomass of 3-year-old Douglas-fir as affected by compaction and organic matter removal.

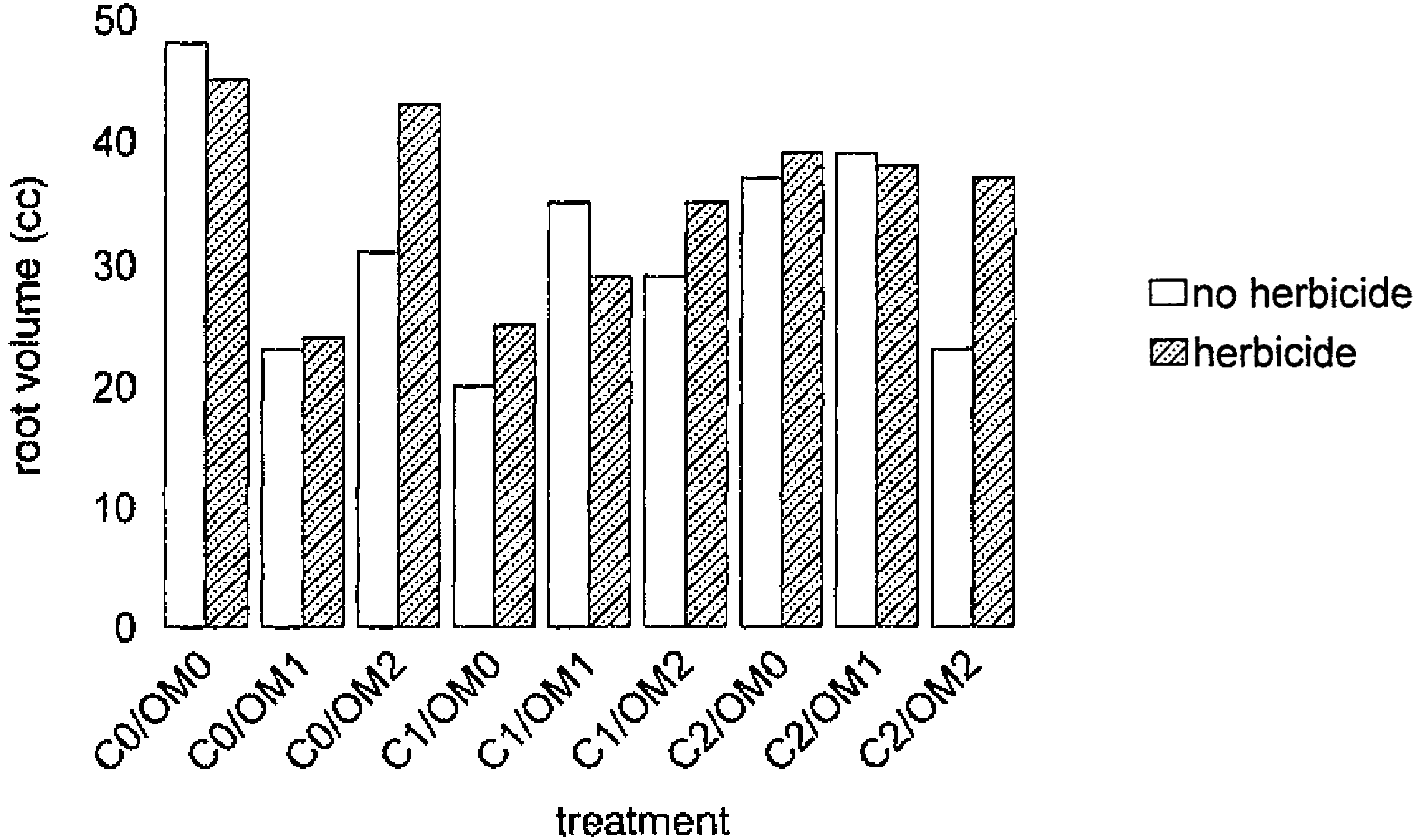

Figure 4a. Average root volume of 1-year-old western white pine as affected by compaction and organic matter removal.

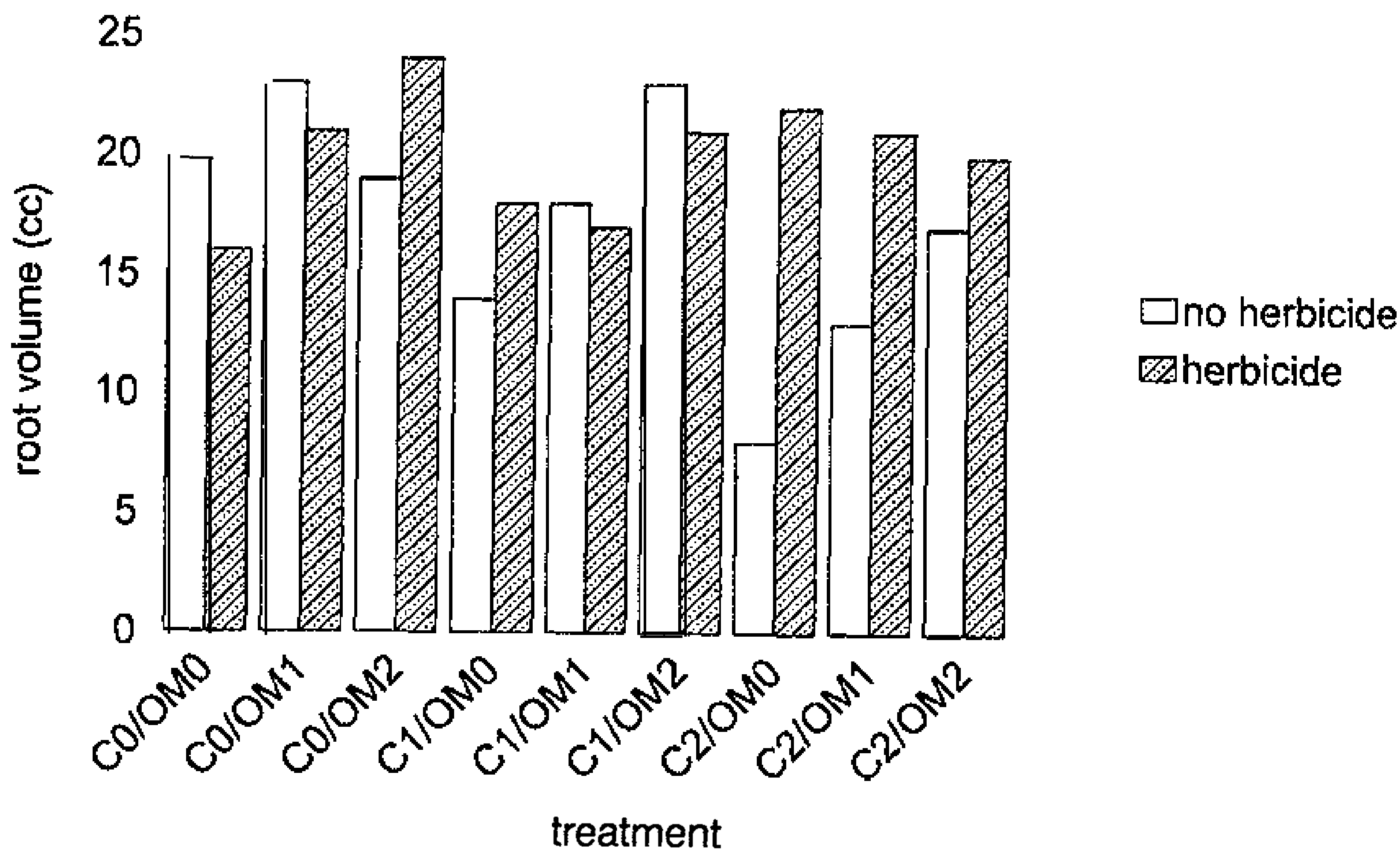

Figure 4b. Average root volume of 1-year-old Douglas-fir as affected by compaction and organic matter removal.

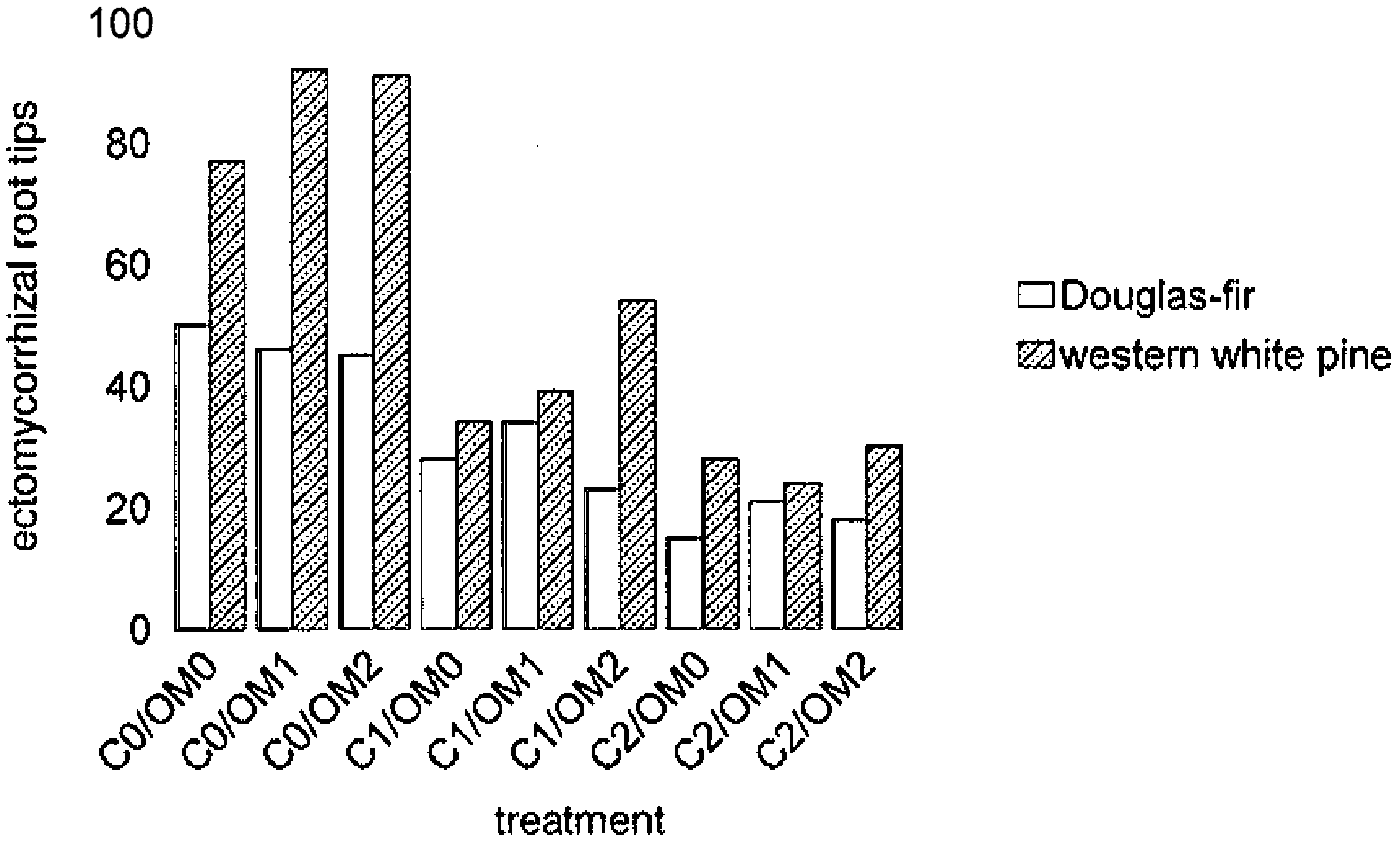

Figure 5. Average non-ectomycorrhizal root tips on 1-year-old Douglas-fir and western white pine as affected by compaction and organic matter removal.

Introducing SOLO:
an interactive expert system for SOil quality monitoring and LOng term ecosystem sustainability

What is SOLO? SOLO is a computerized collection of representative documentation on soil monitoring and ong term ecosystem sustainability. linked together electronically by topic, author, key word, or key concept. The information may be surveyed by activating push-buttons on the computer screen.

Yhy is SOLO being created? From a desire to consolidate and cross-reference all Regional soils nformation in a single library for electronic access, and to make that information available to Forest Service ersonnel in an organized, easily searchable, predigested format, SOLO was conceived to aid in decision-naking processes involving forest planning. habitat quality maintenance, and mitigation of soil disturbance, rhether human-induced or natural.

What kinds of information will SOLO contain? The main body of information in SOLO will contain abstracts and summaries of published and unpublished studies, analyses, reports, articles, papers, and data iles, as well as generalized scientific assessments, learned opinions, gut feelings and anecdotes which are elevant to assessing and maintaining soil quality in a forest environment. Each item will be selected based on s applicability and/or its importance to the topic. A few articles of general importance will be included in their entirety.

low is the information in SOLO organized? A system of menus, submenus and maps is employed to rganize the information geographically. as well as by land type, habitat type, ecozone, disturbance type or ssociated guideline, arena of influence, and effects related to a particular event or activity. Also included are iiscussions of methods for site selection, sampling, analysis and data interpretation, plus options for mitigation r avoidance of disturbance. Each item is referenced in a general bibliography and categorized by source. opic and discipline.

How can SOLO be used? SOLO is intended for use by forestry, soils, hydrology, engineering and land use professionals in planning and management of activities which will affect ecosystems, or in prevention or amelioration of the effects of natural disturbance events. The information in SOLO may be accessed via several pathways, e.g., activity or event, disturbance type, geographic location, or land type, habitat type, or soil property affected.

When will SOLO be available? SOLO is being developed in two phases:
Phase 1 is the programming of the user interface and document framework, which is complete for the material 'hat is currently in the information base. A working version of Phase 1 will be available in November, 1995. to an advisory group, for testing and review.
Phase 2 is the compilation, parsing and linking of the larger body of information to be contained, and the expansion of the framework to accommodate it. A first release of Phase 2 is planned for the summer of 1996. It will be distributed to key personnel at Forest Supervisor's Offices throughout the Region.

Because forest soil research continues indefinitely, SOLO is a dynamic, evolving product which may never be "complete" in the definitive sense. New information will be incorporated as it becomes available, and feedback from users may dictate occasional changes in the system. Maintenance of SOLO's information base will be accomplished at the Regional level, by a person or persons as yet unnamed. New versions will be released on an occasional or need basis, depending on the volume and quality of the changes.

For more information, contact:
Tom Rice, INT Moscow, (208) 883-2308 (DG) T.Rice:S22L04A

OPERATOR'S MANUAL: SoLo Hypertext Document

Ia. Introduction to SoLo

The Region One Soil Quality Monitoring electronic document (SoLo) is an attempt to create a user interface for easy systematic access of information on the standards and guidelines for soil quality, associated detrimental effects of forest activities 'and methods for mitigation of those effects, as well as procedures and practices to avoid unacceptable soil disturbance.

As a result of its evolutionary development, SoLo is really a collection of 3 smaller documents. The first document, LEARN, was created to demonstrate the capabilities of hypertext as a tool for development of the desired product. The focus at the time was toward a general knowledge base centered on landscape ecology. LEARN consists mainly of a series of brief, off-the-cuff discourses on landscape ecology and soil productivity, with some pertinent charts, graphs and references included.

The second document ("SoilBook") represents the true beginnings of what is now SOLO. It is an electronic version of the paper document which represents Chapter 2 of the Region 1 Soil Management Handbook. That paper was formulated at a meeting of Region 1 soil scientists in April, 1992. The electronic form uses hypertext methods to allow non-linear, yet structured perusal of the contents of the original paper.

The third major component, titled "SoLo," is a more typical hypertext interface. Consisting of a series of screens, each of which presents a men" of "pushbuttons," SoLo provides the user with a choice of purpose-oriented pathways to the information. In SOLO, the contents of the SoilBook are repeated, but are broken into topics, or "chunks," and linked and cross-linked to allow access by a design similar to brainstorming or free association. The original information is enhanced by the inclusion of graphics, predominantly electronically scanned maps and window-like backgrounds, which provide more avenues for searching of the information.

Ib. Introduction to hypertext

Hypertext, and its offspring, hypermedia, are computer tools for organizing information, whether textual, graphical, auditory or visual. "Hyperwriting" software allows the creation of "electronic" or "digital" documents, wherein various types of information appear as individual topics or "chunks," divided and arranged according to the contextual relevance of the subject matter to the theme of the document, and strategically connected by a convenient system of cross-referencing "links."

These links are similar in concept to the flipping of pages in a paper text volume to find previous or subsequent information on a key word or concept. The links allow the reader a choice to proceed sequentially through the text or in a non-linear fashion, for information on a specific topic or topics. They provide immediate access from one topic to another, and allow a reader to trace a thought or concept through a document without having to sort through all of the included information.

II. Installation

SoLo is distributed on 2 computer disks. Disk 1 contains the HyperReader (tm) software and font-files, plus batch files and initialization files which will make getting started easier. Disk 2 contains the SoLo document(s) and the associated graphics and text files.

To install SoLo, first create a new directory called SoLo on your C drive (C:\SoLo).

Change to the SoLo directory.

Copy disk 1 to the C:\SoLo directory.

If you prefer to run SoLo on the hard disk (for faster operation). copy the Contents of disk 2 to the C:\SoLo directory.

III. Startup

If you are running SoLo on the hard disk, type "SoLo"at the C:\SoLo> prompt and press ENTER.

If you are running SoLo on a floppy drive, place disk 2 in drive A or B;

If disk 2 is in drive A, type "SoLoa" at the C:\SoLo> prompt and press ENTER

If disk 2 is in drive B, type "SoLob" at the C:\SoLo> prompt end press ENTER

The propel- configuration will be copied to the initialization file, end the SoLo documents will be loaded. The title screen should appear on your monitor.

IV. Configuration problems

The HyperReader software provides a menu system to help with navigation, configuration, etc. If there is an immediate problem with navigation once you have opened the document (or a blank title screen), you may need to change the directories settings. To activate the menu line, click at the top of the screen, or press F10. Go to the, "Options" menu, click or press ENTER, select "Directories," click or press ENTER. A dialogue box will appear. with the current search paths/directories listed, and the "Documents" line highlighted. Type the path to the document files (a:\, b:\ or c:\SoLo) on the line. Then activate the "All directories same as first" button (click or press Alt+A), to change all search paths, click "OK" or press ENTER. If there was a problem before, you should see a change in the title page.

V. Navigation

Once you have "entered" a hyperdocument, you have several options for navigation: pushbuttons, word links, hot keys, and menu choices. To begin, let's concentrate on the pushbuttons.

(* Of course, you may exit at any time by pressing Alt+F4. Upon request to exit, you will be presented with the option of leaving a "bookmark." Just like in paper texts, a bookmark allows you to reopen the document at the same point from which you exited. Choose either "Yes" or "No." *)

On the title screen, there are two pushbutton links: "User's Guide" and "Table of Contents." If you have a mouse, you can activate a link by moving the cursor over the link and clicking the left mouse button. Without a mouse, you can select a link using the TAB key, and then activate the link by pressing ENTER or F1. To *return from* a link, click the right mouse button, or press ESC.

(* Notice that the cursor arrow changes to a small hand when it is Over a link. This will help you recognize active links within the document. ●)

The User's Guide describes the SoLo document and offers basic instructions on how to navigate within the document, much as this Operator's Manual does. It also explains the use of the menu options, text links, and hot keys. The HELP system provides more information.

The "Table of Contents" button/link move8 to another screen, which presents a menu Of pushbuttons. These provide a variety of pathways to the information in the document. You may query the information by Guideline, by Method, by Problem, by State, by Zone or by Forest, or find out about the 3 types of

Monitoring, or look at Key Terms or other subjects by activating the corresponding button.

Or you may follow the generic links at the bottom of the page: the NEXT and PREVIOUS buttons, which will take you along pre-set paths through the menu screens. At any time, activating the CONTENTS button will return you to the Table of Contents screen, allowing you to reorient yourself if you become lost in "hyperspace."

After stepping into the document for a while, you may retrace each step by continually pressing ESC or clicking the right mouse button.

You may also activate the built-in hypertext HELP system by activating the HELP button. Remember, you return from HELP using the ESC key or the right mouse button, just like in any other link.

Or you can EXIT the document with the EXIT button. Again, you will be prompted for a bookmark upon exiting.

** The "SOIL MANAGEMENT HANDBOOK" button will load the SoilBook document 'described in the introduction above. The screen format in each of the 3 component documents is slightly different, but the principles of navigation are the same.

Feel free to explore all the documents. You will come across some buttons whose links are not active. There is nothing "broken" here; the links simply have not been made.

Likewise, some of the topics are blank. Nothing is wrong; no information has been entered. SoLo is still very much a prototype.

Some topic screens have a white "checkmark" in the upper left corner. If you click on that checkmark, a "Reader's Note" will pop up, containing some comment about the information in that particular topic. You may edit those Notes, delete them, or create your own. This Reader's Notes option allows 2-way communication between co-authors or author and reviewer. Editorial comments can be saved as Reader's Notes on a floppy disk copy of the document, and sent to the correspondent for consideration. The correspondent can move from note to note within the document by pressing Alt+F2.

If you have comments or questions about any screen(s) or topic(s) in the SoLo document, please add Reader's Notes, save the document to a floppy disk, and mail it to T.Rice, Forestry Sciences Lab, 1221 S. Main, Moscow ID 83843.

INTERAGENCY PARTNERSHIP SUCCESS STORY
OWL MOUNTAIN

SCOTT DAVIS, BUREAU OF LAND MANAGEMENT, COLORADO

The beginnings of the Owl Mountain Partnership occurred in Nevada in 1991. Several land management agencies and interest groups held a livestock and big game symposium to explore long-term opportunities and benefits which might be attained through cooperative efforts. The Seeking Common Ground Work Group was formed with the goal -- "To improve and manage rangeland resources to enhance the long term benefits for livestock, big game, and other multiple uses and to effectively communicate the success".

In 1992, the Habitat Partnership Program requested and received $55,000 from Seeking Common Ground to identify and implement habitat improvement projects that would attract and hold big game animals on public or private land where conflicts do not occur. Expansion occurred with agencies and local community members establishing a committee to resolve a number of resource conflicts.

The mission was to serve economic, cultural, and social needs of the community, while developing adaptive long-term landscape management programs, policies, and practices that ensure long-term sustainability. Owl Mountain would serve as a prototype decision-making process using the principles of ecosystem management. "Eco" comes from the Greek word "oikos" meaning home and ecology is the study of the relationships of organisms (includes people) to one another and their environment. The key to success is to ensure that the community and government work together and that each takes on responsibility of sustainable resource management.

Success will be determined as the following goals are met:

1. Creation of trust and teamwork to achieve ecosystem health and resolution of conflicts which serve the economic, cultural, and social needs of the community;
2. Development and implementation of an adaptive ecosystem management plan across all ownerships, based on issues and needs; and
3. Documentation of an implementation process to communicate knowledge gained from this prototype.

The area consists of 375 square miles in north central Colorado. Approximately two-thirds is under federal ownership and one-third private. It includes over 25 ranching operations and over 300 different land owners.

Eight landowners have combined their grazing management of 1000 acres by constructing fences and water developments, and by establishing riparian zones and a rest rotation grazing system. The land now falls under the agricultural tax bracket with all landowners getting paid for grazing. The grazing system allows for grazing one-year during the growing season, one-year outside the growing season, and one year of no grazing (rest) to allow for re-growth and a better balance for cattle and elk and overall sustainability.

Other completed projects includes, establishment of grants and scholarships for local high school to write and print a newsletter and brochures, completion of a breeding bird atlas survey, a baseline vegetative inventory, and construction of stackyards to protect hay on private lands from being used by elk.

On-going work includes water quality sampling (sediment) to meet requirements of the Clean Water Act, placing the county soil survey into a digital form in GIS, and a study to look at biological aspects of the soil. This might help determine habitat-diversity changes which might be correlated to declining sage grouse populations.

Understanding soil organism diversity and responses to disturbance will help lead to overall sustainability. A systems approach can measure the net effect of a multitude of organisms in a cost efficient manner. The systems studied include: decomposition of plant material, plant productivity and diversity, and myccorhizal inoculum potential. Decomposition gives an indication of the amount of plant material being returned to the soil. Mycorrhizae levels give a general measurement of soil stability. Previous studies in the region have shown dramatic drop off in plant diversity and production if mycorrhizae levels drop below 10%. Two years of data are being analyzed for 3 sites (grazing-ungrazed; sagebrush-grass site treatedwithherbicide; and a riparian exclosure). We hope that by combining soil ecosystem data with plant diversity and biomass data that we will find enough information to determine ecosystem health and sustainability.

A Qualitative Procedure to Assess Rangeland Health

Introduction

Rangeland managers and the public are in a debate about the condition of our nations rangelands. Issues of these conditions continue to be fueled over issues such as grazing fees and state versus federal management of western rangelands. Range managers have struggled to develop cost efficient and accurate assessment procedures since the public rangelands were first allocated.

Early rangeland inventory techniques included combinations of quantitative and qualitative data gathering to identify livestock carrying capacity and stocking levels. An Interagency Range Survey Committee developed a procedure based on ocular estimates of cover and vegetation composition to determine livestock forage production in 193 7. Included in this procedure were qualitative procedures to determine soil erosion status (Wagner 1989). Early monitoring procedures e.g. Deming Two-phase and Parker Three-Step included a 'scorecard approach" using indicators to determine "site-soil stability" and usefulness of forage for livestock grazing (Wagner 1989).

The Bureau of Land Management used 'soil surface factors" to determine erosional status of large acreages of public lands in the 1970's (USDI 1973). By 1980 the emphasis in public land monitoring and inventory had shifted to the collection of quantitative data e.g. the Bureau of Land Management's Soil-Vegetation Inventory Method (Wagner 1989).

Interest in the use of qualitative assessment procedures surfaced again in the 1990's. The Bureau of Land Management published a Technical Reference (TR 1737-9) in I993 that utilized a qualitative checklist to assess the functioning condition of riparian areas (USDI 1993). The National Research Council published a book on Rangeland Health (Committee on Rangeland Classification 1994) that included a matrix of indicators to qualitative& assess rangeland health.

Concurrently, a committee of the Society for Range Management developed an approach to identify thresholds of soil stability for sustainable management flask Group on Unity in Concepts and Terminology 1995). The Western Regional Research Coordinating Committee-40 on Rangeland Research reviewed monitoring and inventory techniques of the various federal land management agencies and concluded that cost effective and efficient assessment techniques were needed (Range Improvement Task Force 1994).

These recent publications sewed as the impetus and direction for initiation of an interagency Workgroup whose task was to develop and field test an assessment procedure for rangeland health that relied entirely on qualitative measurements or judgments. This Workgroup benejitted greatly from reviews of historic qualitative assessment techniques and the recommendations on new approaches provided by the Society for Range Management, National Research Council, and the Range Improvement Task Force.

What is Rangeland Health?

The 1994 National Research Council publication, "Rangeland Health, New Methods to Classify, Inventors: and Monitor Rangelands" defined rangeland health as,

> *"the degree to which the integrity of the soil and ecological processes of rangeland ecosystems are maintained"*

Stated differently, healthy rangelands are present when ecological processes are functioning properly to maintain the structure, organization, and activity of an ecosystem over time. The end product is an ecological system that is capable of sustaining the capacity of rangelands to satisfy values and produce commodities.

Ecological processes include the water cycle (the capture, storage and release of precipitation) energy flow (conversion of sunlight to plant then animal matter) and nutrient cycling (the flow of nutrients such as nitrogen and carbon through the physical and biotic environments). Ecological processes functioning within a normal range of variation will support appropriate kinds and proportions of flora and fauna. Direct measure of the efficiency of the ecological processes is difficult due to the complexity of the interrelationships. Therefore, vegetation attributes are often used to estimate the functional status of ecological processes.

Purpose

Certain public land issues become controversial due to the inability of participants to agree if _a problem even exists. If the basic procedures to foster the visualization, communication and resolution of rangeland health issues are available: then people with diverse backgrounds can work together to find common ground. A qualitative procedure to assess rangeland health is proposed as an effective communication and assessment tool to arrive at local resolution of rangeland health issues. This procedure is also proposed as a tool to identify areas where rangeland health is satisfactory, at risk or unsatisfactory without establishing cause or trend of the condition.

INDICATORS

Unfortunately ecological processes are difficult to observe or monitor in the field due to the complexity of most rangeland systems. To characterize the health status of a selected landscape, indicators are used to assess the condition of selected plant and physical environment attributes. An indicator is a component of a system whose characteristics (presence or absence, quantity, distribution) are used as an index of those attributes that are too difficult, inconvenient, or expensive to measure, Historically, resource inventories and monitoring by land management agencies focused on vegetation attributes (production, composition, density, etc) and soil stability. Such assessments are inadequate to determine rangeland health because they do not reflect the complexity of the ecosystem. There is no one indicator of ecosystem health; instead a suite of key indicators should be used for an assessment (Karr 1992).

The Qualitative Assessment of Rangeland Health procedure includes four categories:

1. Cover by vegetation lifeform and ground cover for site protection (see attached **Cover Worksheet).**
2. Species abundance relative to dominant plant cover (see attached **Species Abundance Worksheet).**
3. Physical environment status based upon 10 indicators (see attached **Physical Environment Worksheet).**
4. Biotic environment status based upon 8 indicators (see attached **Biotic Environment Worksheet).**

A **Rangeland Health Site Documentation worksheet (attached) is** also completed to record location of assessment, ecological site(s), and other relevant landform features and site uses.

In this Qualitative Assessment Procedure, physical and biotic indicators are evaluated in the field and an appropriate descriptive category is selected for each indicator. The descriptive categories roughly correspond to functioning (healthy), at risk, and improperly functioning (unhealthy) condition.

Physical Environment Rating

In the physical, i.e., abiotic environment, indicators are used to assess soil and watershed stability. Soil stability and proper watershed function are important because they promote normal capture, storage and release of water. Indicators of soil and watershed condition are listed in the attached **Physical Environment Worksheet.** ***Information on the Cover Worksheet should be reviewed prior to completing the*** **Physical Environment Worksheet.**

Biotic Environment Rating

In the biotic environment, indicators are used to assess the integrity, structure, and function of the flora, fauna, and ecological processes. Most indicators in the biotic environment are focused on vegetation attributes since they are the most easy to observe during the short period of time allocated to conducting the qualitative assessment. Biotic indicators are listed in Biotic **Environment Worksheet** ***Both the*** **Species Abundance and Cover Worksheets** ***should be reviewedprior to completing the*** **Biotic Environment Worksheet.** ***The physical and biotic indicators on the worksheets represents the minimum requirements to subjectively assess health status in most ecosystems. Indicators can be added or deleted for unique situations in an ecosystem.***

Ecological Reference Areas

Before assessing the health of specific landscape units, some understanding of the structure, function, and dynamics of the local landscape is required. To obtain this understanding, field personnel use Ecological Reference Areas (ERA) for training and as comparison areas for site evaluations. An ERA is a landscape unit in which ecological processes are functioning and the vegetation complex has adequate resistance to and resiliency from major disturbance. This concept is similar to that proposed by the Western Regional Research Coordinating Committee-40 on Rangeland Research of using well-managed rangelands and appropriate relict areas on given ecological sites as benchmarks for assessments (Range Improvement Task Force 1994).

At each ERA, an interdisciplinary team takes photographs and records baseline information on system attributes and indicator status by completing all worksheets and conducting quantitative cover studies. This information is used for training, future comparisons, and developing photo guides for assessment of landscape units with similar site potentials.

Interpreting Indicators

The critical link between observational measurements of indicators and determining the health status of a landscape is the interpretation process. The indicators are evaluated and a final status determination of physical and biotic status is made. This procedure relies upon the collective experience and knowledge of the interdisciplinary team to rate the indicators and make the final physical and biotic rating.

This process produces separate ratings for the physical and biotic environment for each landscape unit. The physical environment utilizes the same final rating of:

1) Functioning, 2) At Risk, and 3) Improperly Functioning.

The biotic environment is classified into three categories following the wording in the Rangeland Health publication (NRC 1994):

2. Biotically: a) Healthy, b) At Risk, and c) Unhealthy

Determination of the physical and biotic status is based upon a "preponderance of evidence" approach. The relative significance and rating of each indicator are determined by an interdisciplinary team to arrive at the physical and biotic status of a landscape unit.

The Improperly Functioning and Unhealthy ratings are further subdivided into "reversible" and "irreversible" categories. This classification allows the separation of landscape units that will recover with management changes in a 20-30 year period with those that will require artificial restoration involving high labor and material costs. An example of an irreversible, unhealthy ecosystem is the cheatgrass monocultures in Idaho's Snake River Plain. The system is biotically unhealthy and would require competition control i.e. herbicide or mechanical control of cheatgrass and reseeding with perennial vegetation to move it back to a healthy rating.

Applications

This process is intended to provide resource managers and the public with a tool to determine the health status of selected rangeland landscapes in a relatively short period of time. The primary purpose is to serve as a communication tool to help educate and train BLM's many customers and stakeholders as well as its own managers and resource specialists.

The assessment procedure does not establish the cause of at risk or unhealthy rangelands; it simply identifies where a problem exists. This procedure is not intended nor designed to replace quantitative monitoring, serve as a trend indicator, or provide data that can be aggregated for a national report on rangeland health.

SUMMARY

Qualitative assessments of rangeland health provide land managers with timely information on site stability and biotic integrity. Early warnings of resource problems allow application of remedial management actions before site degradation proceeds to a nonfimctioning or unhealthy situation. However, more research is needed to quantify indicator attributes and identify thresholds for physical and biotic status. Once this information is available the assessment of rangeland health will become more of a "science" and less of an "art".

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Rangeland Health Site Dooumontatlon

State ________ District/Region ________

Management Unit ________ Watershed ________

Major Land Resource Unit ________

Identification Number or Name (if applicable) ________

Location: Legal T. ___ ,R.___ , Sec._ , ___1/4, ___ 1/4.

Latitude ______ , Longitude ________

UTM Coordinates ________

Observers: ________ Date: ________

SITE CHARACTERISTICS

Ecological Site ________

Soil Map Unit Name ________

Geology or Parent Material ________ Aspect ________

S l o p e Elevation ______ft. Topographic position ________

Climate: Annual Precipitation

Recent climate: 1)Drought___, 2) Normal_, or 3) Wet Period

BITE USES

Describe wildlife and livestock use in the area of the assessment ________

Describe evidence of recent disturbance (wildfire, recreation, grasshoppers,etc. ________

COMMENTS ________

Cover Worksheet

ESTIMATED **LIFEFORM** AND **GROUND** **COVER (%)**							
COVER **CLASSES**	0	1-5	6-15	16-30	31-50	51-75	75-100
LIFEFORMS							
I - GRASS							
Annuals							
Native Perennial							
Exotic Perennial							
II - FORB							
Annual							
Perennial							
III - SHRUBS							
IV - TREES							
V - SUCCULENTS							
GROUND COVER							
I - **LITTER**							
II - BARE GROUND							
III - **ROCK/GRAVEL**							
IV - CRYPTOGAMS							
V - **VASCULAR PLANTS**							

All Ground **cover** In Categories **I.-IV.** are estimated from **Interspace** areas only. Category V. **Is** an estimate **of** total **vasoular** plant **cover.**

COMMENTS-

Species Abundance Worksheet

The dominant species are ranked (l-3) according to abundance on the site (l-4, section I) and by lifeform (l-3, Section II). Abundance is determined based upon cover. Noxious weeds are also identified by species(Section III).

Seotlon I- Dominant Speoies on Site

1. ______________________

2. ______________________

____

4. ______________________

Seotlon II- Dominant speoies by lifeform

Annual Grasses.

____

____

____

Annual Forbs.

____

____

____

Perennial Grasses

____

2. ______________________

3. ______________________

Perennial Forbs

____

____

____

Shrubs and Trees (succulents)

1. ______________________

2. ______________________

3. ______________________

Seotlon III- Noxious weeds

____

____

3. ______________________

Comments ______________________

____

Physical Environment Worksheet

Relative to **Ecological** Reference **Area(s)-ERA**

Indicator	Plus	Intermediate	Minus
1. Flow Patterns	Few, slight deposition	Well defined, small with intermittent deposits	Numerous with soil deposits common
2. Surface Litter	In place or slight movement	Moderate movement, bigger litter displaced	Extreme movement, occurs with each event
3. Soil Movement - Water	None to slight	Moderate, slight terracing & some short pedastals	Significant movement with each event, rocks and plants on pedastals, some roots exposed
4. Soil Movement-Wind	None to slight	Wind scoured depressions evident, small aeolian deposits around plant clumps	Wind scoured depressions common with large aeolian deposits around plant clumps
5. Soil Crusting & Surface Sealing	None to minimal with "soft" physical and/or chemical crusts	Physical and/or chemical crusting obvious with reduced infiltration occurring	Hard physical and chemical crusts widespread on bare ground, strongly reducing infiltration
6. Compaction Layer	None to minimal. not restrictive	Thin, weakly restrictive to roots and water	Extensive with > 1" width, strongly restrictive
7. Rills	If present, rare and widely spaced	Occasionally present, < 3" deep	Very common at 5' or less intervals, up to 6" deep
8. Gullies	None to few, if present gullies are healing (veg. on sides & bottom	Few present, active erosion (incised sides) on <10% of length	Numerous with active erosion on 20% or more of length, some headcutting evident
9. Cover- Amount (veg, litter, rock etc.)	Adequate (> %) to protect site from accelerated erosion.	Marginal (around %) for site protection, accelerated erosion starting	Inadequate (> %) for site protection, accelerated erosion evident
10. Cover-Distribution	Well distributed with bare ground areas small	Bare ground areas larger, more numerous and less uniform in distribution	Bare ground areas numerous over large areas, most cover is under trees or shrubs, if present

Current site->__		
#1		#1
Test Site---->#2		#2
#3		#3

Rating: 1.Functioning___ 2.At Risk 3. Improperly Functioning: a) Reversible b) Irreversible

Biotic Environment Worksheet

Relative to **Ecological** Reference **Area(s)-ERA**

Indicator	Similar to ERA(s)	Marginally Similar to ERA(s)	Dissimilar to ERA(s)
1. Community Diversity	Good representation of lifeforms and #'s of species	One or two lifeforms poorly represented, #'s of species 30% of expected (ERAs)	Lifeforms dominated by one class. #'s of species < 50% of expected (ERAs)
2. Community Structure & Root Distribution	Good diversity of height, size and distribution of plants including roots (vertical distribution)	Marginal diversity of height. size end distribution of plants and their roots	Plant community dominated by 1-2 lifeforms with poor height. size and distribution of species and their root systems
3. Exotic Plants	Absent or sparse, pose little threat of expansion	Present along roads or scattered in plant community, pose threat of further expansion	common in plant community with areas of exotic plant dominance
4. Photosynthesis period	Length and distribution similar to ecological reference area	Length and distribution is marginal compared to ecological reference area	Length and distribution dissimilar to ecological reference area
5. Plant Status	Majority of plants are productive and alive	Signs of mortality in important species. production of remaining plants declining	Dead or decadent plants readily evident. production of remaining plants is poor.
6. Seed Production (if applicable)	Numbers of seedstalks and seed production adequate for stand maintenance	Plants stressed resulting in reduced seedstalk and seed production	Seed and seedstalk production inadequate for stand replacement during favorable recruitment periods
7. Recruitment (sexual and asexual)	Evidence of recruitment (seedlings, juveniles or vegetative spread) in last 5 years	Recruitment in last 5 years is spotty and not fully representative of each lifeform	Minimal evidence of recruitment in last 5 years community dominated by dead or decadent plants
8. Nutrient Cycle	Mechanisms (leguminous plants. cryptogamic crust, litter, etc) are adequate for plant maintenance)	Mechanisms are marginally adequate for plant maintenance and lifeform representation	Mechanisms are inadequate to maintain plant community lifeforms

Current site--> ______________________________

ERA(s)--------> ______________________________

Rating: 1. Functioning___ 2. **At Risk**____ 3. **Improperly** Functioning: **a) Reversible**____ **b) Irreversible**

(Healthy) **(Unhealthy)**

Comments on Indicators

1. Flow Patterns

2. Surface Litter

3. Soil Movement- Water

4. Soil Movement- Wind

5. Soil Crusting & Surface Sealing

6. Compaction Layer

7. Rills

8. Gullies

9. Cover- Amount

10. Cover- Distribution

National Soil Information System (NASIS)

Implications for the Inventory Field Soil Scientist

Mike Hansen, MLRA Soils Staff, Bozeman, MT

NASIS is widely considered a sophisticated, flexible, well engineered piece of software. This discussion will not be focused on the software itself, but instead concentrate on the impacts of NASIS concepts on the way we do business as field inventory soil scientists. A question asked often by the soil mapper is: What does the move to NASIS mean for me?

In a very brief discussion, I will attempt to outline the revolution in NCSS soil inventory that NASIS is bringing about, especially for soil scientists weaned on the soil-5, soil-6 data system..

Major points of interest:

-- All components, both major (most always present) and minor (former inclusions) are represented fully in the database. Their properties are reported and available for interpreting.

-- Limitations as to the number of horizons allowed for a component are gone. Horizons may be labeled with official horizon designation. Horizons are not combined into layers in the database.

-- There is no system limit to the number of components in a map unit. The purpose and intensity of the survey define the limits of how many interpretive components are needed or allowed.

-- Aggregated soil component data is reflected in many cases as a high, low and representative value. (Examples include: elevation, precipitation, component percent composition, horizon thickness...)

-- Several legends of different vintages or intensity can be maintained in the database for the same survey area.

-- Correlation can be truly a two-way street, as map units correlated off the legend may be maintained in the database for future reference or evaluation.

-- Field observations are aggregated to components based on the purpose of the survey, as outlined in the Memorandum of Understanding (MOU). Soil Taxonomy is used as a guide, not as a restriction in this process. Soil Taxonomy in concert with desired interpretations form the sideboards on partitioning observations.

-- Field sampling must be porportional to the variety of components in a map unit, not porportional to the area each may represent. This is critical to providing site data to support all components, both major and minor (former inclusions) in the database.

-- The interpretation generation process utilizes fuzzy logic to more accurately model results.

-- Interpretations are highly flexible. National sets can be tailored into local sets reflecting local conditions or properties. New criteria can be tested and validated against the data for uses not previously addressed or to make more sophisticated existing interpretations.

-- Electronic manuscript generation is facilitated with map unit descriptions being the first to be prototyped (June, 1996).

-- Nasis is very site data hungry. Limited observations are not "matched" to a existing concept (SIR). It takes significant site data, representing the entire map unit to be able to partition/group these observations into components based on the purpose and intensity of the survey.

Recent Changes
to

Soil Taxonomy

Bob Ahrens and Bob Engel

Changes to the Family

Particle-size classes and their substitutes

- Previously, Ultisols were the only mineral soil order that did not distinguish fine and very fine families. Experience has shown that this separation is meaningful and should be used uniformly in all taxa with the same exceptions applying to all soils. This change will affect the family classification of many Ultisols.

Mineralogy

1. Kandi and kanhap great groups of Alfisols and Ultisols are now included in mineralogy classes previously used only for Oxisol taxa. This will combine all soils with low activity clays into the same group of mineral classes since the clay activity definition for oxic and kandic horizons is the same.
2. Because Andisols are defined in part by poorly ordered or amorphous material, crystalline mineral names used for taxa in other orders are not appropriate for Andisols. Instead amorphic, ferrihydritic, glassy, and mixed classes are introduced for a better depiction of soil material. The criteria were developed by pedologists in New Zealand. More weathered Andisols are in ferrihydritic or amorphic glasses and less weathered Andisols in the glassy class.
3. Whole-soil (fine-earth fraction). New mineralogy classes were introduced and a definition changed to classes based on the whole-soil (tine-earth fraction).

   A. Magnesic replaces serpentinitic and the definition is expanded to include Magnesium rich minerals The name serpentinitic implied only the mineral serpentine

   B. Glauconitic is based on the amount of glauconite pellets both volume and weight percent limits are given.

   C. Isotic includes those soils that have appreciable amounts of poorly ordered minerals, but do not meet the criteria of the substitutes for particle-size classes. These soils have unique properties including high 1500 kPa to clay ratios. One of the criterion uses pH values by NaF because this test is a simple index of andic soil materials. However, free carbonates in the soil can result in high NaF pH values, so calcareous soils are excluded from the isotic class.

D. Parasesquic includes some soils that were previously in the oxidic class. The oxidic definition did not provide meaningful separations. The parasesquic class has no required clay to iron ratio but the total Fe203 equivalent plus gibbsite must be greater than 10 percent The definition does not require any limits on quartz or weatherable minerals.

4. The following classes based on the less-than 0.002 mm fraction have been changed.
   - **A.** Halloysitic requires more than 50 percent 1:1 minerals plus allophane and more halloysite than any other single mineral
   - **B.** Kaolinitic requires more than 50 percent 1: 1 minerals and more kaolinite than any other single mineral.
   - **C.** The montmorillonitic class has been renamed smectitic. Montmorillonite, beidellite and nontronite are the dioctahedral expanding 2:1 minerals in the smectite group. All have been detected in the clay fractions of soils. In fact montmorillonite and beidellite commonly occur together. The group name smectite (smectitic) is more appropriate since species are rarely differentiated. The definition has been simplified and clarified to require only more smectite than any other single kind of clay
   - **D.** The definition of vermiculite also has been changed to require only more vermiculite than any other single kind of clay mineral.
   - **E.** Chloritic classes are deleted from Soil Taxonomy. This should present no classification problems since no chloritic families have been established.
5. The following changes were made to the classes based on the 0.02 to 2.0 mm fraction.
   - **A.** The definition of micaceous is changed to include pseudomorphs of mica in mineral grain counts. In some soils, appreciable mica has weathered to kaolinite but the mica platy or flake morphology has been maintained. Physical properties such as shear strength are affected by these platy particles.
   - **B.** The paramicaceous class was established to include those soils that have properties resulting from significant mica and mica pseudomorph content, but they do not make the greater than 40 percent limit. Low shear strength is still an important property of soils that meet the criteria of paramicaceous.

Cation Exchange Activity Classes

Ratios of tine-earth cation exchange capacity at pH 7 to percent clay are used to define classes of cation exchange activity. These classes are used as a component of the family name in mixed and siliceous mineralogy classes of loamy, loamy-skeletal, clayey-skeletal, clayey, fine, and very tine particle-size classes in all taxa except Oxisols and kandi and kanhap great groups of Alfisols and Ultisols. These classes by definition are subactive.

Family Keys

All of the components of the family with the exception of the contrasting particle-size classes **have been** arranged in the form of a key. The key must be followed to correctly classify a soil. The "key" format should eliminate some of the confusion that has existed in the past with some of the components of the family.

Application

A number of soil series will need to be reclassified because of NSTH 18. The components of the family name are listed below in the same sequence in which the components appear in the family name.

Particle-size classes, mineralogy classes, cation exchange activity classes, calcareous and reaction classes, soil temperature classes, soil depth classes, rupture resistance classes, Classes of coatings, and classes of cracks.

Cation exchange Activity Class follows the mineralogy class in the family name. For example, Fine, mixed, active, mesic Typic Hapludalfs. The control section for cation exchange activity classes is the same as that used to determine the particle-size and mineralogy class. For soils with strongly contrasting particle-size classes, where both named parts of the control section use a cation exchange activity class, the class associated with the particle-size class that has the most clay is named. For example, in a pedon with a classification of loamy over clayey, mixed, active, calcareous, thermic Typic Udorthent, the cation exchange class, active, is associated with the clayey part of the control section. Note that commas replace the parentheses around the calcareous class. For soils with strongly contrasting particle-size classes, the mineralogy for both named particle-size classes or their substitutes are given, unless they are the same. For examples, ashy over clayey mixed, active, mesic Typic Vitraquands or clayey over loamy-skeletal, smectitic over mixed, superactive, thermic Vertic Ustochrepts. In the first case active refers to the clayey part and in the second example superactive refers to the loamy part, because no class is used with smectitic mineralogy.

Paralithic Contact

A paralithic (lithic like) contact is a contact between soil and paralithic materials where the paralithic materials have no cracks or the spacing of cracks that roots can enter is 10 cm or more. It differs from the densic contact and the lithic contact in that the material forming a densic contact slakes when air dried fragments are submerged in water and the material forming a lithic contact is in a strongly cemented or more cemented rupture resistance class (rock fragments).

Paralithic Materials

Paralithic materials are relatively unaltered (do not meet requirements for any other named diagnostic horizons or any other diagnostic soil characteristic) materials that have a very weakly cemented to moderately cemented rupture resistance class. Cementation, bulk density, and the organization is such that roots cannot enter except in cracks. Paralithic materials have at their upper boundary a paralithic contact if the paralithic materials have no cracks or if the spacing of cracks that roots can enter is 10 cm or more. Commonly these materials are partially weathered bedrock or weakly consolidated bedrock such as sandstone, siltstone, or shale. Paralithic materials can be used to differentiate soil series if the materials are within the series control section. Fragments of paralithic materials, 2.0 mm or more in diameter, are referred to as pararock fragments.

Densic Contact

A densic contact (L densus thick) is a contact more between soil and densic materials that has no cracks or the spacing of cracks that roots can enter is 10 cm or. It differs from both the lithic contact and the paralithic contact in that air dried fragments of the material forming a densic contact slake when submerged in water.

Densic Materials

Densic materials are relatively unaltered (do not meet requirements for any other named diagnostic horizons or any other diagnostic soil characteristic) materials that have a noncemented rupture resistance class. The bulk density or the organization is such that roots cannot enter except in cracks. These are mostly earthy materials such as till, volcanic mudflows, and some mechanically compacted materials such as mine spoils. Some noncemented rocks can also be densic materials, if they are dense or resistant enough to prevent roots from entering except in cracks. Densic materials have at their upper boundary a densic contact if the densic materials have no cracks or the spacing of cracks that roots can enter is 10 cm or more. Densic materials can be used to differentiate soil series if the materials are within the series control section.

Ortstein - Summary of Properties

Ortstein has all of the following:

1. Consists of spodic materials, and
2. Is in a layer that is 50 percent or more cemented, and
3. Is 25 mm or more thick.

Fragipan - Summary of Properties

To be identified as a fragipan, a layer must have all of the following characteristics:

1. The layer is 15 cm or more thick and
2. It has evidence of pedogenesis within the horizon or, at a minimum, on the faces of structural units; and
3. It has very coarse prismatic, columnar, or blocky structure of any grade, has weak structure of any size or is massive. Separations between structural units that allow roots to enter have an average spacing of 1 0 cm or more on the horizontal dimensions; and
4. Air-dry fragments of the natural soil fabric, 5 to 10 cm in diameter, from more than 50 percent of the horizon slake when they are submerged in water; and
5. It has, in 60 percent or more of the volume a firm or firmer consistence, a brittle manner of failure at or near field capacity, and roots virtually absent.

Fragic Soil Properties

Soil aggregates with fragic soil properties must:

1. Have evidence of pedogenesis within the aggregates or at a minimum on the faces of the aggregates; and
2. Slake when air-dry fragments of the natural fabric, 5 to 10 cm in diameter are submerged in water; and
3. Have a firm or firmer consistence and a brittle manner of failure when soil water is at or near field capacity; and
4. Restrict the entry of roots into the matrix when soil water is at or near field capacity.

An example of how fragic soil properties are used in SOIL TAXONOMY:

IAKC. Other Endoaqualfs that have fragic soil properties;

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; or
2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Endoaqualfs

Lamellae - Summary of Properties

A lamella is an illuvial horizon less than 7.5 cm thick formed in unconsolidated regolith more than 50 cm thick. Each lamella contains an accumulation of oriented silicate clay on or bridging the sand and silt grains (and coarse fragments if any are present). Each lamella is required to have more silicate clay than the overlying eluvial horizon.

Lamellae occur in a vertical series of 2 or more and each lamella must have an overlying eluvial horizon (An eluvial horizon is not required above the upper most lamella if the soil is truncated).

Lamellae - Summary of Properties

Lamellae may meet the requirements of either a cambic or an argillic horizon. A single lamella is a cambic horizon if the texture is very fine sand or loamy very fine sand or finer. A combination of two or more lamellae will meet the requirements of an argillic horizon if there is 15 cm or more cumulative total thickness of lamellae that are 0.5 cm or more thick and that have a clay content of either:

Three percent or more (absolute) higher than in the overlying eluvial horizon (e.g. 13 percent versus 10 percent) if any part of the eluvial horizon has less than 15 percent clay in the fine earth fraction, or;

Twenty percent or more (relative) higher than in the overlying eluvial horizon (e.g. 24 percent versus 20 percent) if all part of the eluvial horizon have more than 15 percent clay in the fine earth fraction.

Future plans

7th edition of the "Keys" summer 1996

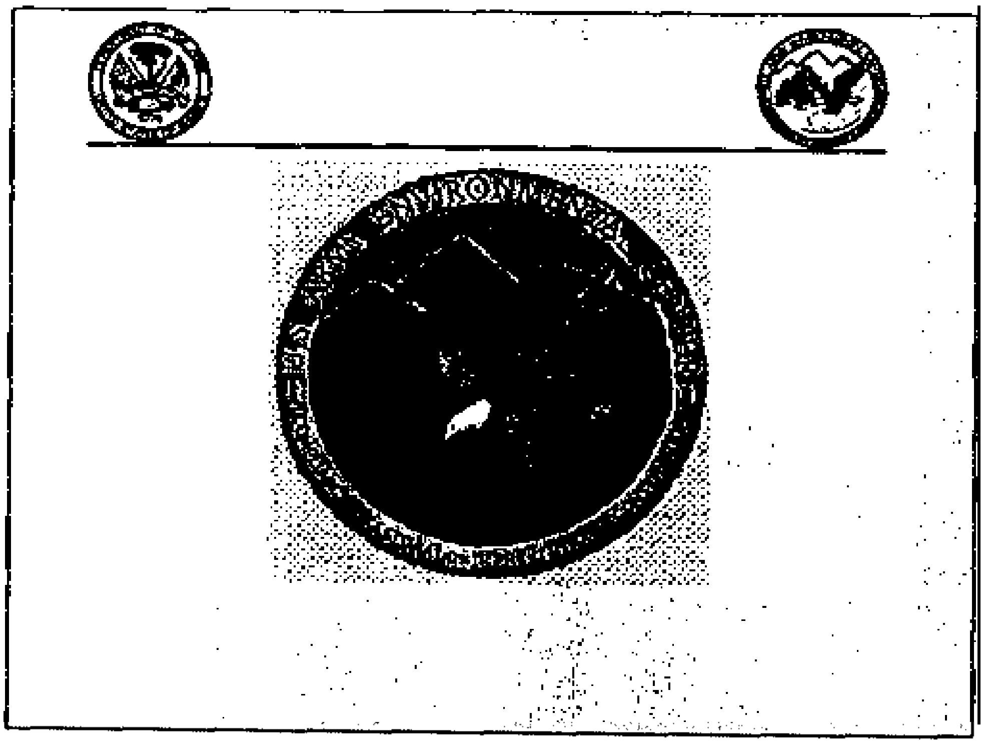
New Edition of the "Green Book" summer 1998

Active International Committees

Permafrost Affected Soils (COMPAQ

Moisture and Temperature Regimes (ICOMMOTR)

Anthropedogenic(ICOMANTH)



The United States Army Environmental Center, as an operating activity of the Army Staff, and under staff supervision of the Director of Environmental Programs, provides a broad range of military funded environmental program management and technical support services to Headquarters, Department of the Army, Major Commands, and installations.

The Army Environmental Center is the largest environmental unit in the three services.

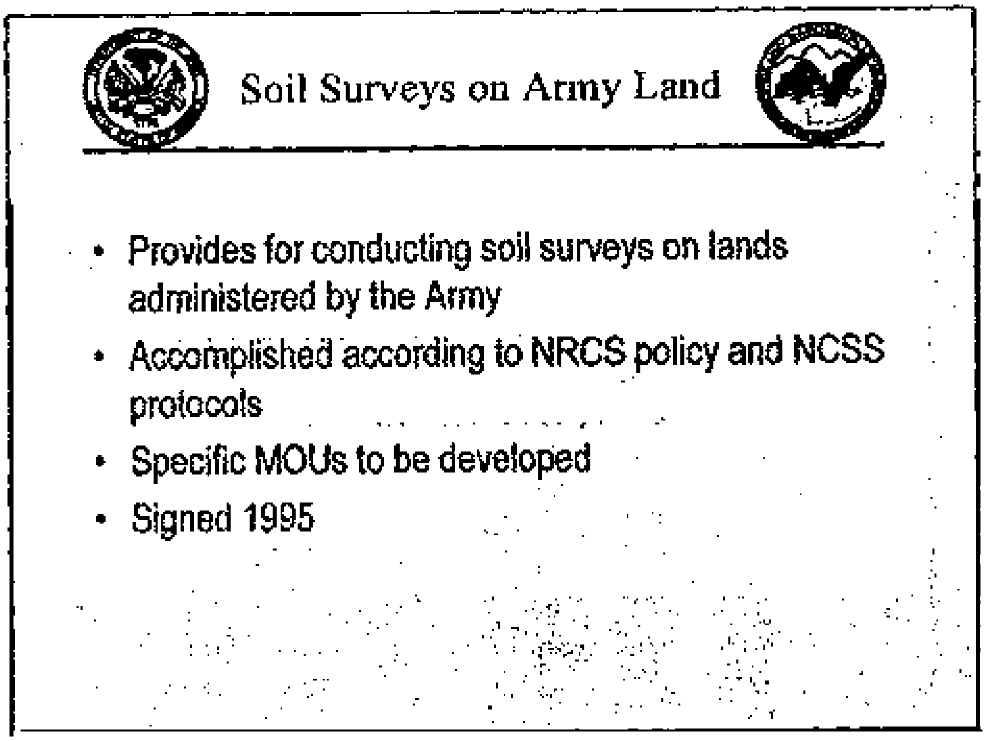
AEC/NRCS Agreements

Memorandum of Understanding between the U.S. Army Environmental Center & the Natural Resources Conservation Service to establish watershed and environmental enhancement

- IAG - Assign a Resource Conservationist
- IAG - Soil Surveys of Army Installations
- IAG - Assign a Soil Scientist
- IAG - Assign a Plant Materials Specialist

The Army Environmental Center has many agreements with federal agencies. These are the ones that are important to the Natural Resources Conservation Service.

The MOU serves as an umbrella agreement that allows for and encourages supplemental interagency agreements.



Interagency Agreement between the U.S. Army Environmental Center and the Natural Resources Conservation Service for the Conduct of Soil Surveys on Lands Administered by the U.S. Army

Soil Survey Activities

Fort Bliss. New Mexico and Texas : MOU

Fort Wainwright, Alaska: photography

Fort Hood, Texas: update of Bell County, Texas

Department of Army Installations Soil SurveY Status

- Develop a database of soil survey activity for major Army installations with significant training activity (DAISSYS).
- Coordinate the necessary activity between the two agencies to initiate appropriate levels of soil survey assistance

SIKES ACT

Title 16, Chapter 5C, Sub-chapter I, 16 USC Sec. 670a, Cooperative Plan for Wildlife Conservation and Rehabilitation.

Approved 15 September 1960.

Commonly referred to as the Sikes Act.

Sikes Act - Language

The Secretary of Defense shall carry out a program of planning for, and the **development, maintenance,** arid coordination of, wildlife,. fish, and game conservation and rehabilitation on military installations. Under the program, the Secretary shall **prepare and implement for each military Installation in** the, **United States an** Integrated **natural resource management plan** mutually agreed upon **by the Secretary of Defense, the. Secretary of the Interior,** and **the appropriate State agency designated by the** State in **which the installation was located except that the Secretary (DoD) is not required to prepare such a plan for a military Installation if the Secretary determines that preparation of such a plan is not appropriate.**

The wording in bold are proposed changes to the current law.

Shall replaces ‘is authorized to’

Integrated natural resources management plan replaces ‘cooperative plan’.

The last emphasis gives the Secretary (DoD) some flexibility in determining which installations need plans.

Definition - Military Installation

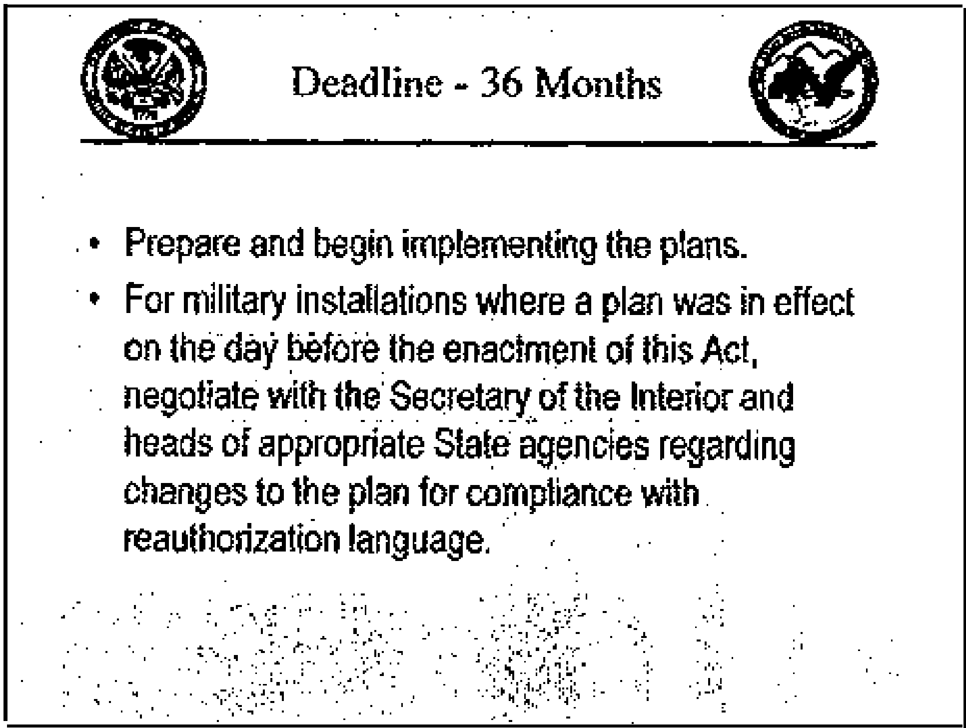
- Any land or interest in land owned by the United States and administered by the Secretary of Defense or the head of military department; and
- Includes all public lands withdrawn from all forms of appropriation under public land laws and reserved for use by the Secretary of Defense or the head of a military department.

Definition - Integrated Natural Resource Management Plan

- An integrated plan based on ecosystem management that shows the interrelationships of individual components of natural resource management (e.g.., fish and wildlife, forestry, land management, public access) to mission requirements and other land use activities affecting an installation's natural resources.

Definition - Natural Resources

- All elements of nature and their environments of soil, air, and water. Which consist of the following two general types:
  - **Earth Resources:** Nonliving resources, such as minerals and soil components
  - **Biological Resources:** Living resources, such as plants and animals

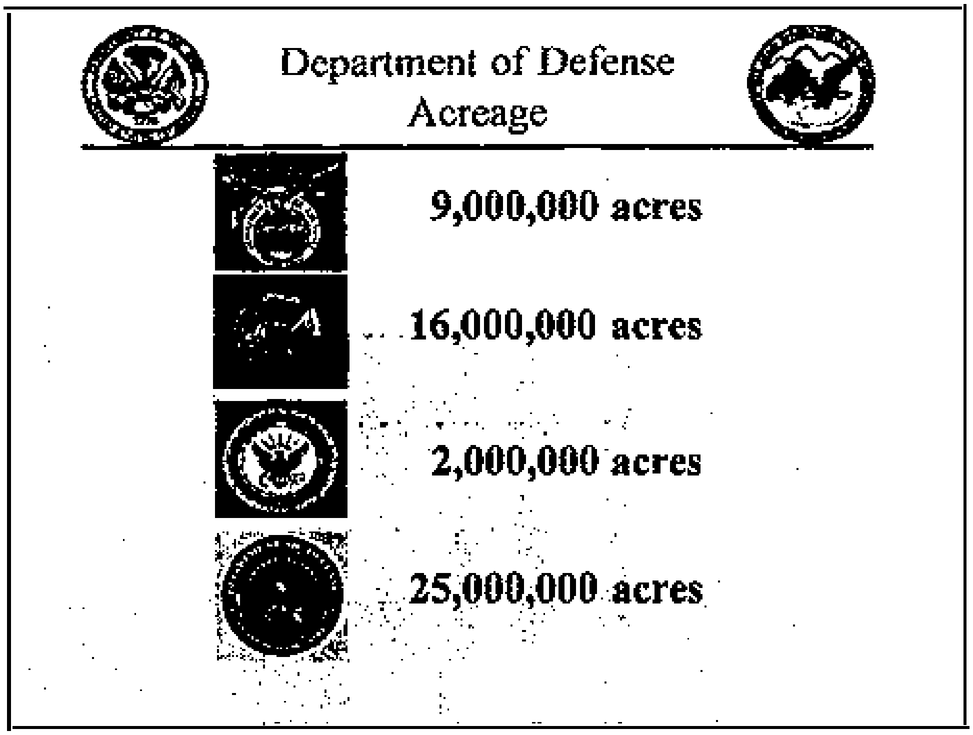


Basically, what this means, is that there is no automatic Grandfather clause.

Initial studies have determined that most of the 'cooperative plans' are single species and are not integrated. These will not meet the requirements as set forth in other sections of the Sikes Act.

Impacts

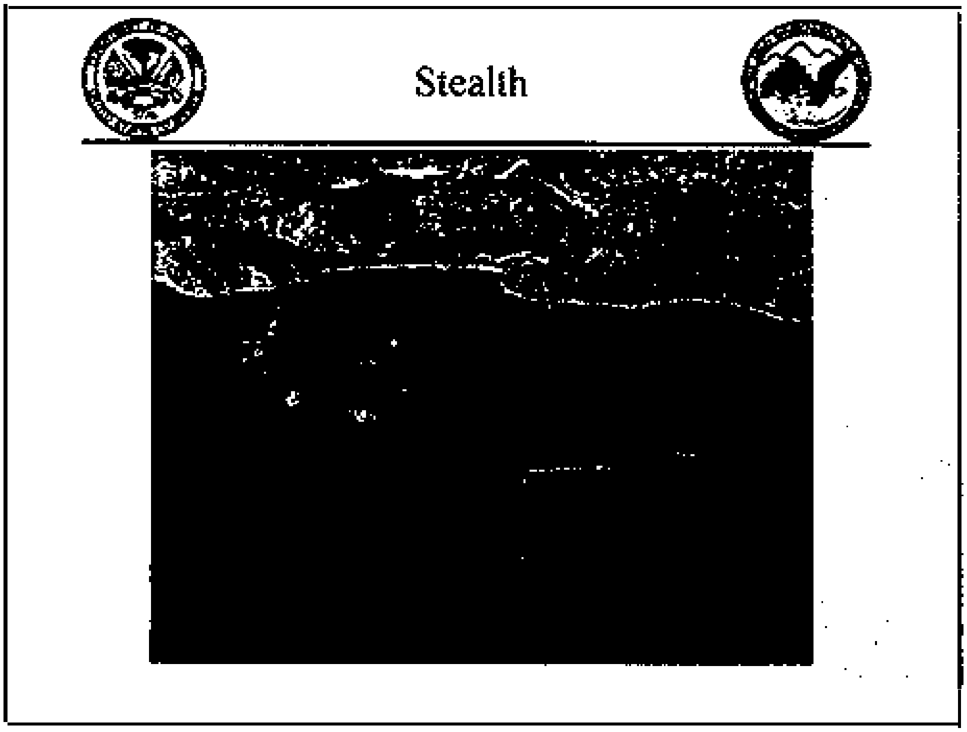
- Every installation with more than 50 acres will need an INRMP
- In most cases, the level of existing natural resource inventory is not adequate.
- An order 2 survey is required.



I have no information concerning specific Navy or Air Force installations. I do have a list, more or less complete, of Army installations.

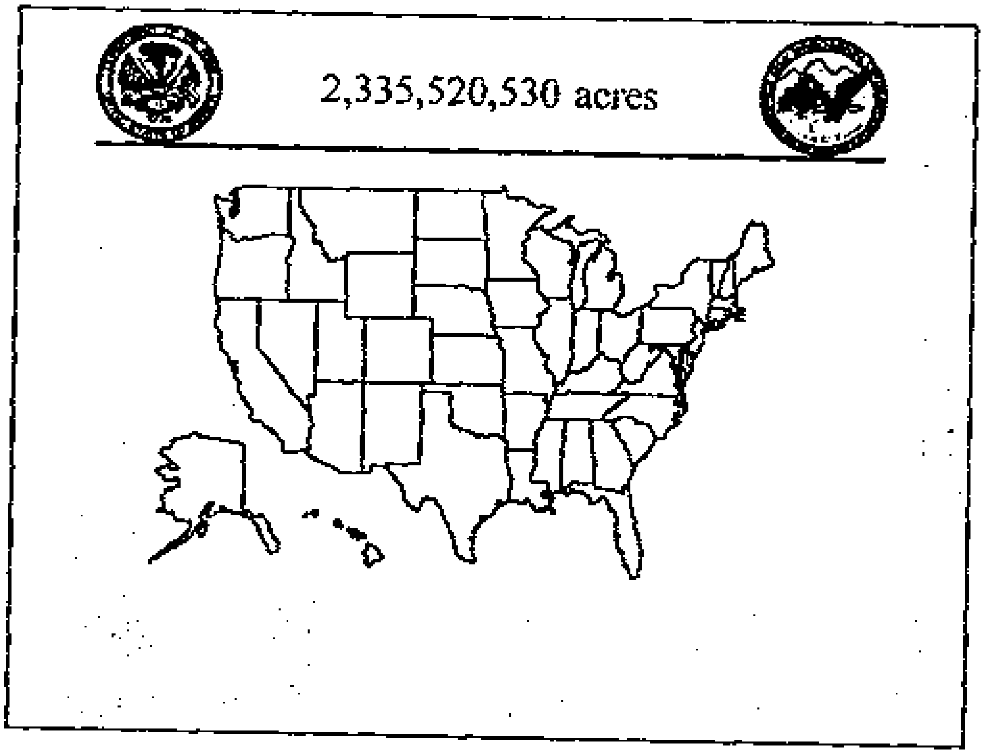
The bottom line of the Sikes Act Amendment is that all of a sudden there are nearly 25 million acres of land that will need to be mapped sometime within the next 3 to S years. All of these acres will need to be at an order 2.

The real problem is not that there is 25 million acres to map. Neither is it the fact that there is only about 4 years in which to do this. For all practical purposes, the real problem is that they are stealth acres.

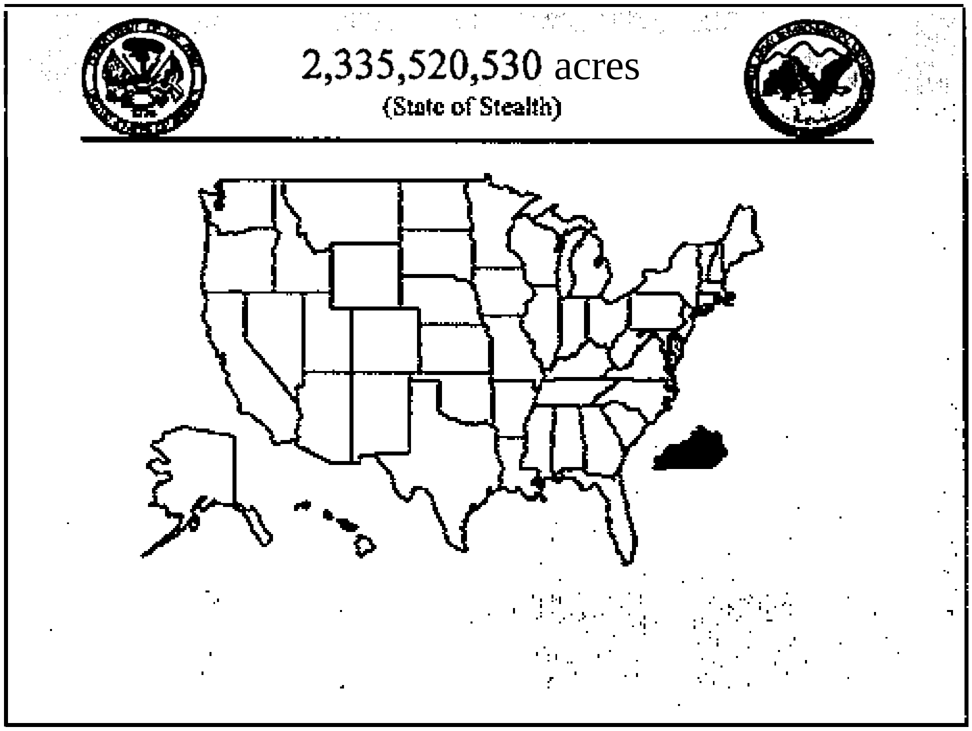


In all likelihood, you know exactly when your non-federal acres are scheduled to be mapped. That is, they show up on the the soil survey radar.

For the most part DoD land has been ignored and we only cared about it when installations came calling. Like the stealth fighter, by the time one sees it, it's too late to plan a reaction.



The scenario could happen something like this. One day, NRCS National Headquarters knows that there are 2.3 billion acres in Soil Survey Schedule and that all are scheduled to be something (initiated, completed, published, etc.) by sometime (6/96, 12/99, 3/00, etc.).

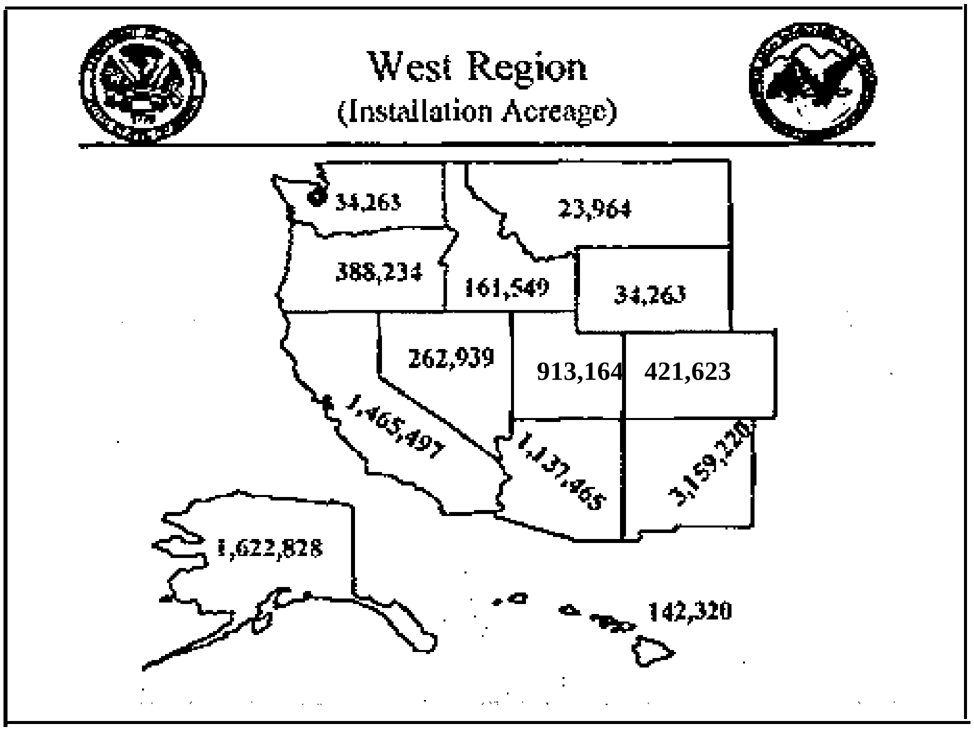


Then, the next day (after the Secretary of Defense calls and asks for soils data) there are still 2.3 billion acres in Schedule. However, there are 25 million that aren't scheduled for anything or need to be rescheduled, with a date of 1999.

That's like having another state the size of Kentucky show up with only some old mapping, some farm plan mapping, and some National Resource Inventory- Primary Sampling Unit's,

In the past, most states were able to deal with these stealth acres because they had some soil scientists working in the area on survey's that didn't have mandated end dates. However, with current budgets, the states have turned to reimbursable agreements. This means that if a survey area doesn't get plugged into the planning process several years before it is time to do it, the states won't have the resources.

For example, Texas and New Mexico. They were told 30 September 1995, that Fort Bliss (1.2 million acres) needed to be mapped within the next **5** years, with several hundred thousand acres being mapped by 1998. Texas and New Mexico are going to staff the survey with new hires.



It has been determined that the acreage figures in this slide are valid for Army installations. If they err, it is on the low side. These figures do not include Air Force and Navy installations.

YELLOWSTONE NATIONAL PARK FIELD TOUR

for **the**

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

June 2 - 7, 1996

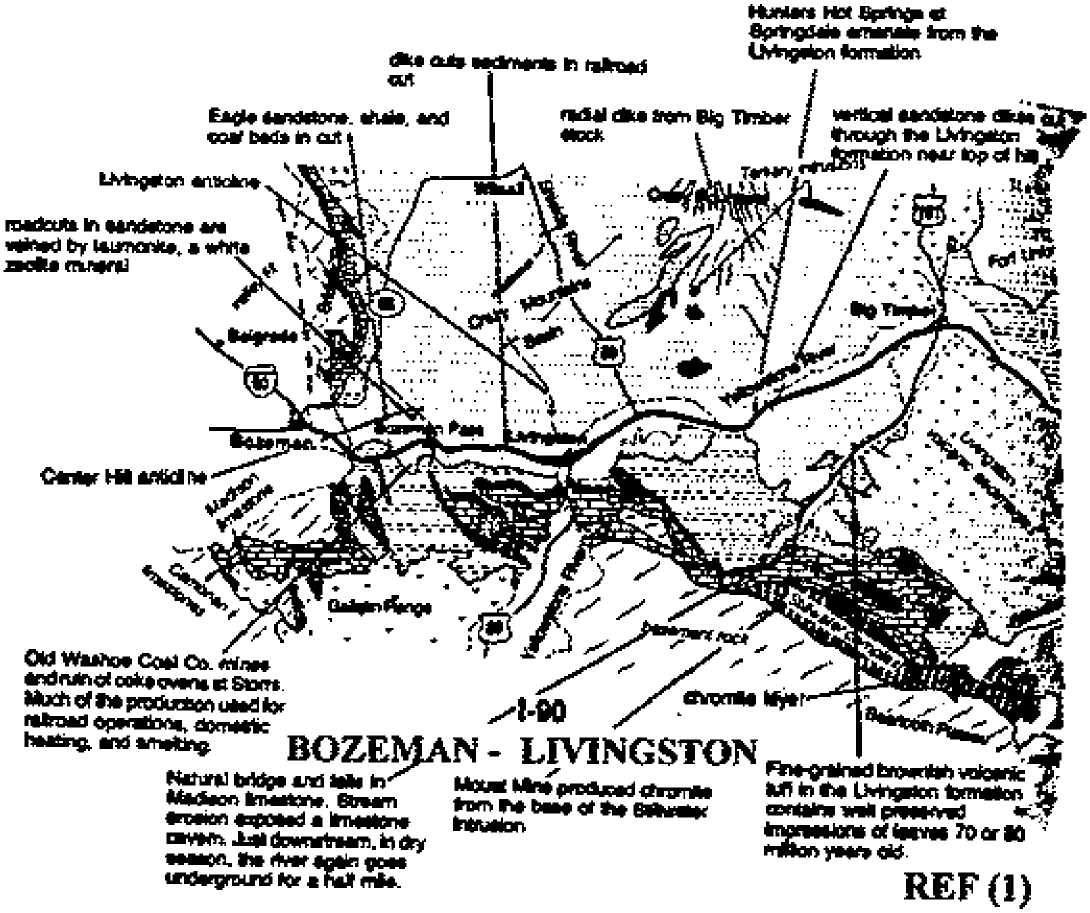
Best Western Grantree Inn
Bozeman. Montana

SOILS OF YELLOWSTONE NATIONAL PARK

Field Guide prepared for tour of the Western Regional Work Planning Conference

June 5.1996

Compiled and organized by:
Henry Shovic
Ann Rodman
Eric Compass
Mike Wilson



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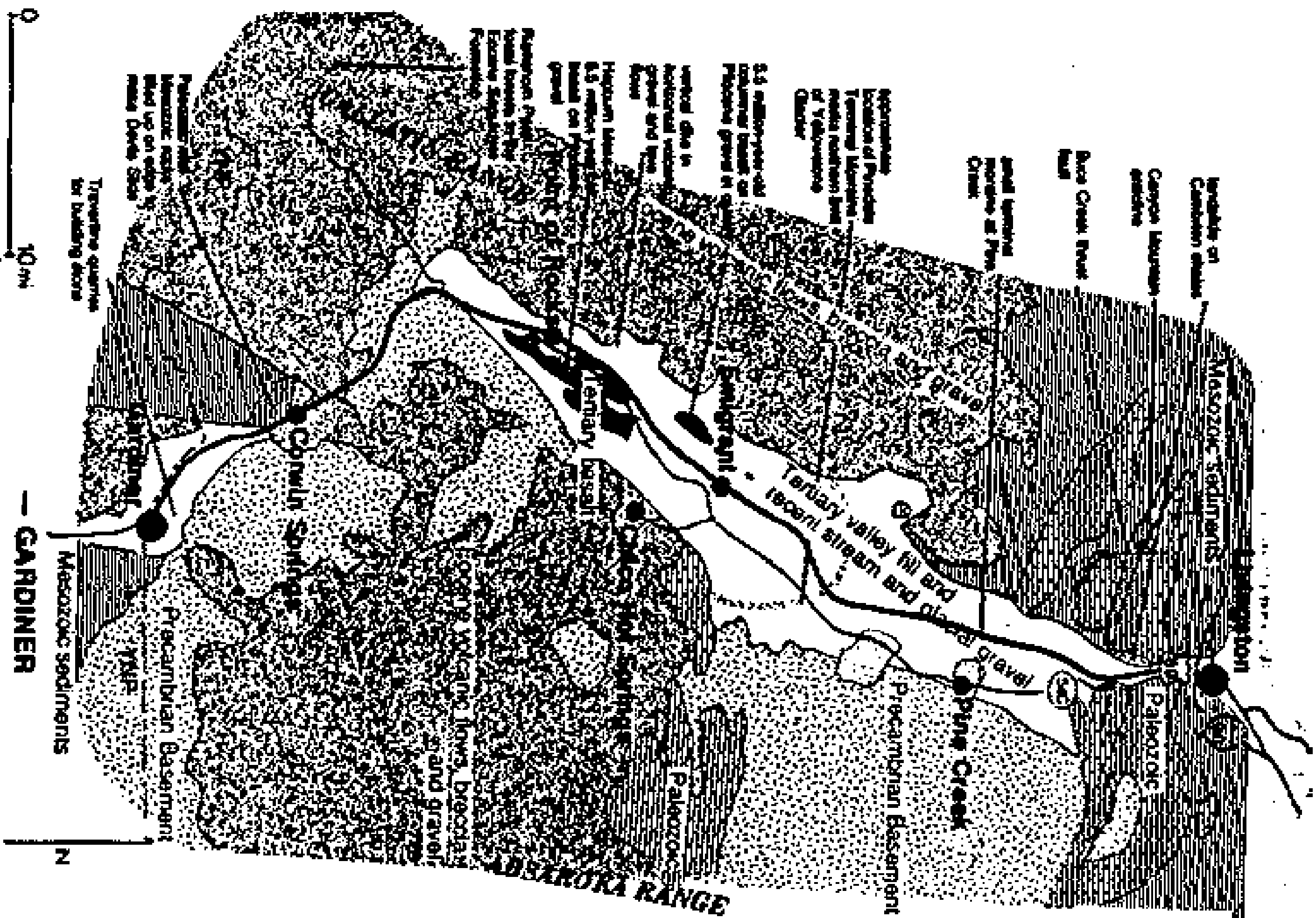

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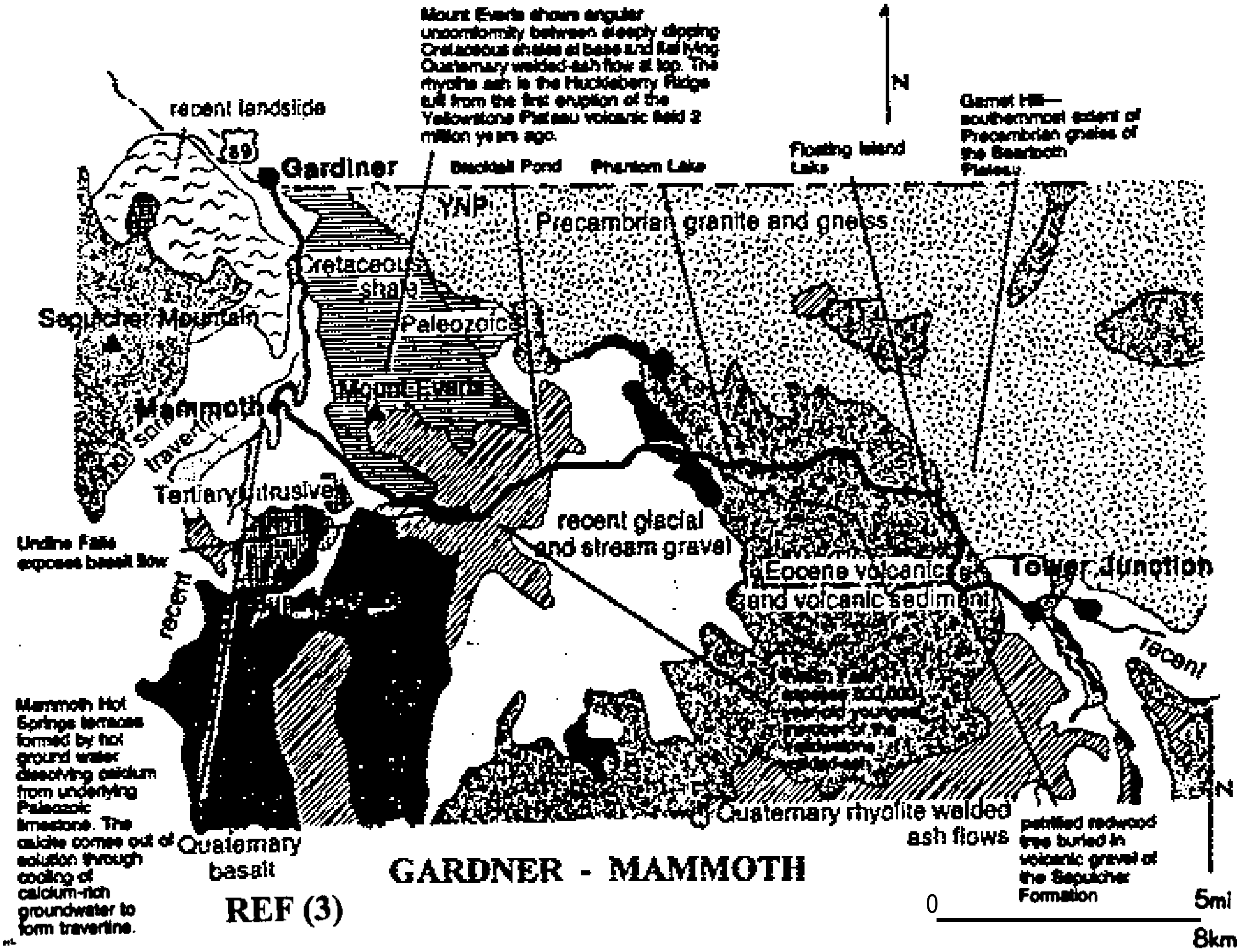

GARDNER - MAMMOTH

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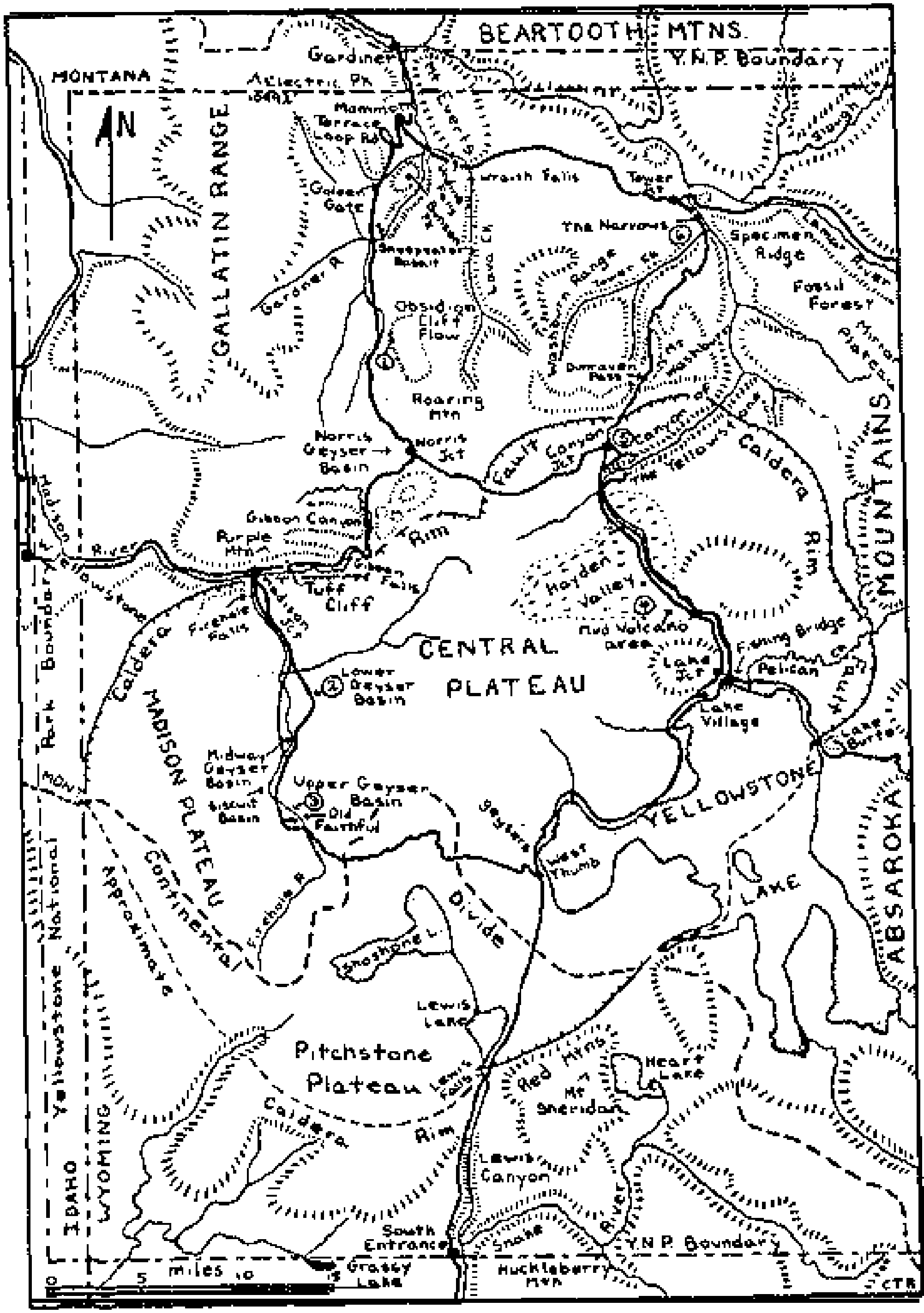


REF (4)

MAP SYMBOLS

- Recent, glacial, stream gravel, lake silts, hot spring deposits
- Landslides
- Basalt flows
- Rhyolite welded-ash
- Rhyolite flows
- Tertiary valley fill
- Tertiary basalt and andesite flows
- Eocene volcanic gravel (Absaroka Volcanic Supergroup)
- Intrusive rock
- Mesozoic sediments
- Paleozoic and Mesozoic sediments
- Paleozoic sediments
- Precambrian basement all rock types

AGE	ERA	PERIOD	EPOCH	Representative formation Names of rocks exposed in the Yellowstone Country
.01	Cenozoic	Quaternary	Recent	Hot springs, landslides, stream, glacial, lake deposits
1.6			Pleistocene	Rhyolite, welded ash, basalt of 2nd & 3rd volcanic cycles
5		Tertiary	Pliocene	Huckleberry Ridge Tuff of 1st volcanic cycle
24			Miocene	Six Mile Creek Formation
27			Oligocene	Renova Formation
58			Eocene	Absaroka Volcanic Supergroup Willwood Formation
66			Paleocene	Fort Union Formation
144	Mesozoic	Cretaceous		Evanis Formation Eagle sandstone, Telegraph Creek Formation, Cody Shale Various sands and shales near Cody
208		Jurassic		Morrison Formation Ellis Group
245		Triassic		Gypsum Springs Formation Chugwater Formation
286	Paleozoic	Permian		Phosphoria Formation
320		Pennsylvanian		Tensleep/Quadrant Sandstone Amsden Formation
360		Mississippian		Madison Group
408		Devonian		Three Forks Shale Jefferson Dolomite
438		Silurian		No rocks in Yellowstone Country
505		Ordovician		Bighorn Dolomite
570		Cambrian		Snowy Range Formation Pilgrim Limestone Park Shale Meagher Limestone Wolsey Shale Flathead Sandstone
47	Precambrian			Granite, gneiss, schist, amphibolite gabbro dikes, pegmatite of crystalline basement

REF (3)

CYCLE	VOLCANIC UNIT	AGE (millions of years)
Third Volcanic Cycle	Plateau Rhyolite	
	Central Plateau Member (forms Pitchstone, Madison, and and Solfatara plateaus)	0.07-0.2
	Mallard Lake Member	0.15
	Shoshone Lake Tuff	0.16
	• Obsidian creek Member	0.09-0.32
	* Roaring Mountain Member (makes Obsidian Cliff)	0.08-0.4
	Upper Basin Member	0.28-0.6
	Osprey Basalt	0.2
	Madison River Basalt	0.1 -0.6
	Swan Lake Flat Basalt (flow at Sheepeater Cliff)	0.2 -0.6
	Falls River Basalt	0.2 -0.6
	LAVA CREEK TUFF	0.6
	Undine Falls Basalt	0.7
	Mount Jackson Rhyolite	0.6
Second Volcanic Cycle	Island Park Rhyolite	1.3
	MESA FALLS TUFF	1.3
	Basalts of warm River	0.6 -1.2
First Volcanic Cycle	Lewis Canyon Rhyolite	0.9
	Basalt of the Narrows	1.5
	HUCKLEBERRY RIDGE TUFF	20
	Junction Butte Basalt	2.2

* Lava flows outside the caldera

REF (3)

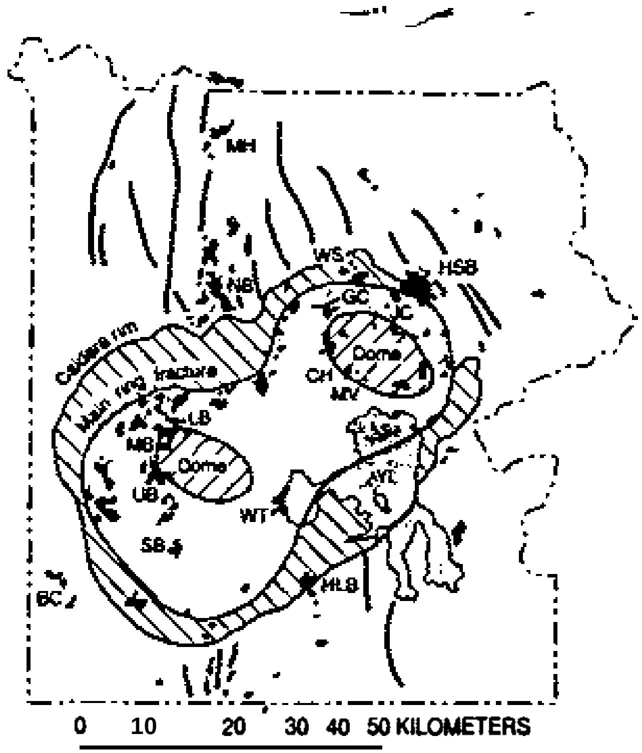


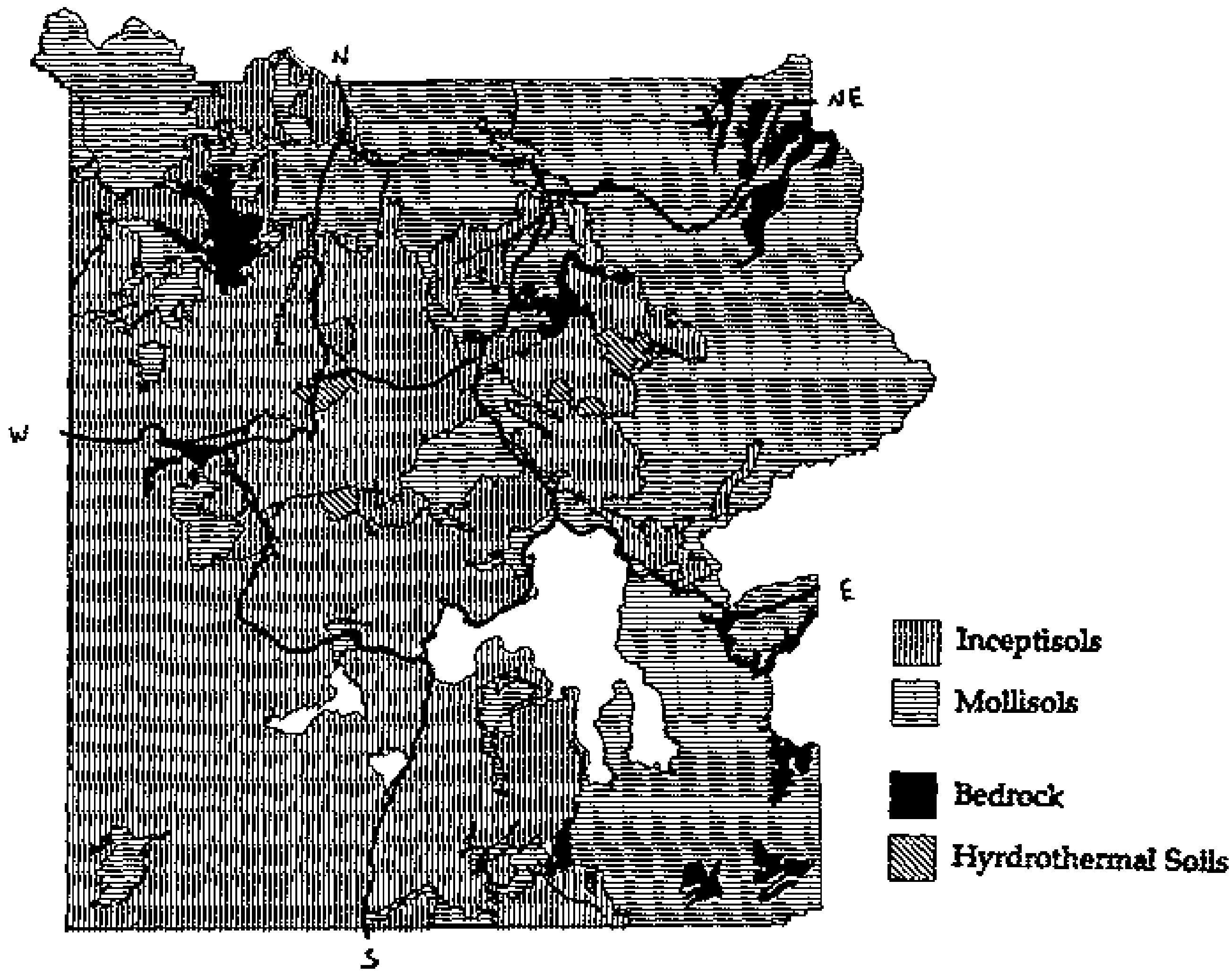
Figure 2. **Map of Yellowstone National Park, Wyoming, showing 0.6-Ma Yellowstone caldera, two resurgent domes, active and recently** active **hydrothermal features (solid black),** major **faults (solid lines** outside **caldera region), and locations** of **selected named thermal areas. Letter codes show approximate locations of major thermal areas mentioned** in text: BC, **Boundary Creek; CH, Crater Hills; GC,** Grand Canyon: HLB. **Heart** Lake Basin; HSB. **Hot Springs** Basin: JC. **Josephs Coat** Hot **Springs;** LB, **Lower Geyser Basin;** MB. Midway Basin; MH. **Mammoth** Hot **Springs; MV, Mud Volcano; NB, Norris Geyser Basin; SB, Shoshone Basin; UB, Upper Geyser** Basin; WS, **Washburn Hot** Springs; **WT, West Thumb; YL, Yellowstone** Lake **(stippled area). Outline** of **Yellowstone National** Park **shown** for **reference. (Figure revised and redrawn after Christiansen, 1984.)**

REF **(2)**

M 3

Yellowstone National Park

Location of areas dominated by Inceptisols or Mollisols



Parent material	Most common subgroups	Most common families
rhyolite	Typic Cryochrept, Dystric Cryochrept, Typic Cryumbrept	lo-sk, sa-sk, co-lo
andesite	Typic Cryoboroll, Typic Cryochrept, Pachic Crvoboroll	lo-sk, fi-lo, co-lo

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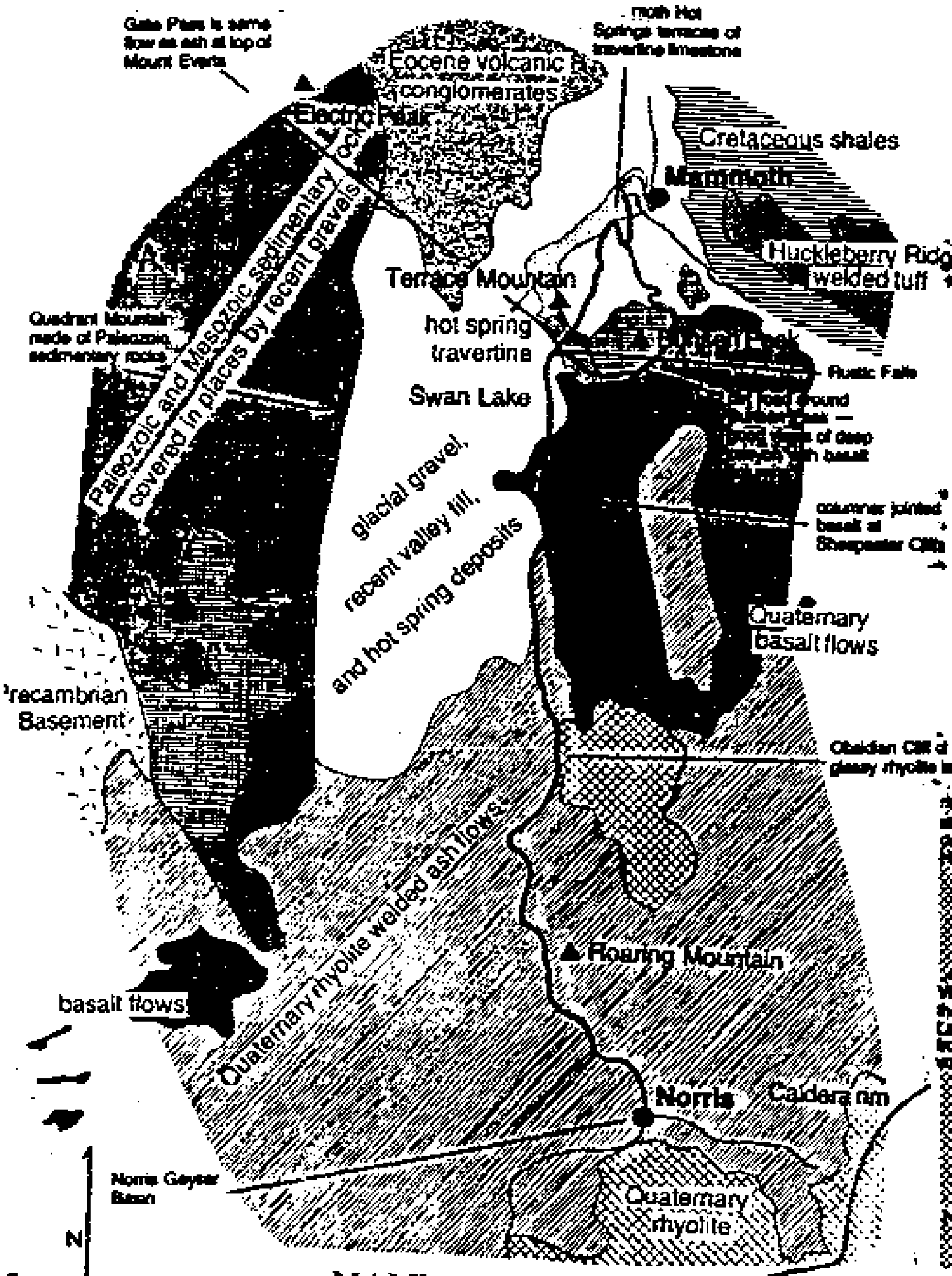

MAMMOTH - NORRIS

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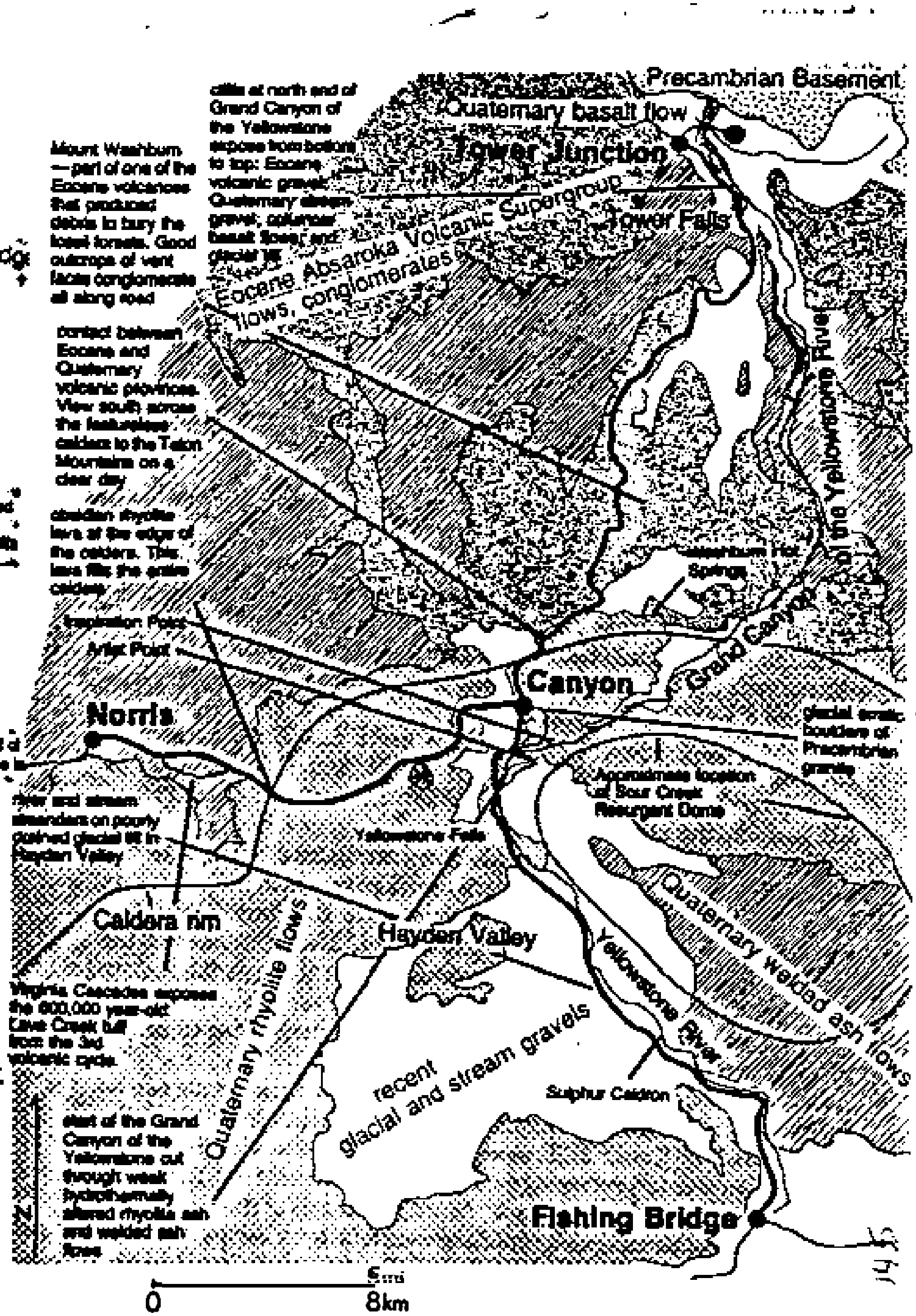

NORRIS - SOLFATERA PLATEAU

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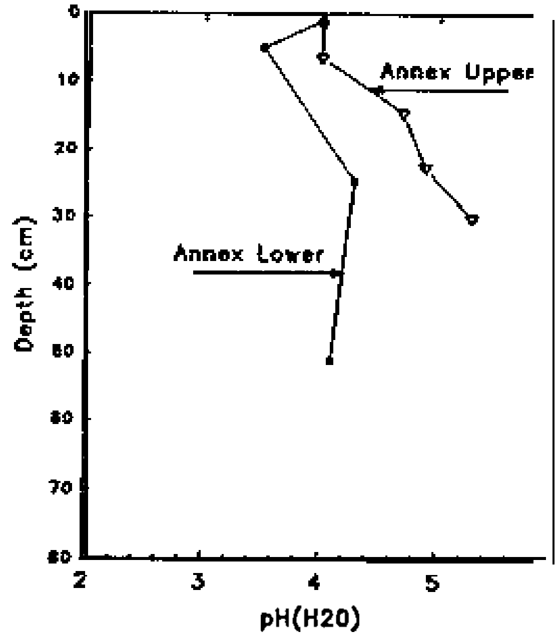
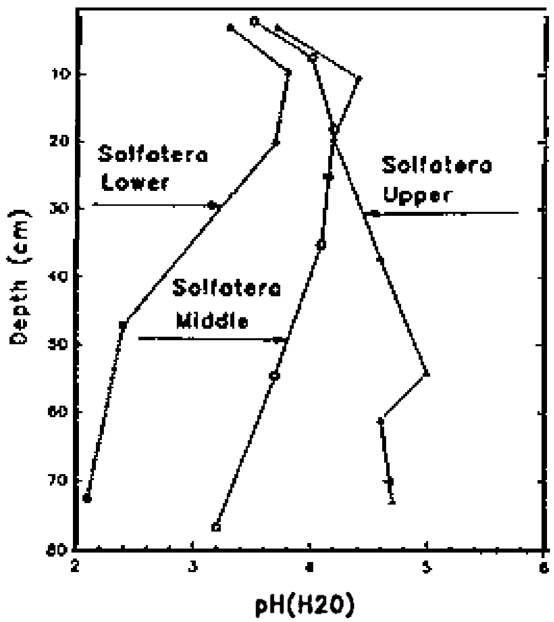
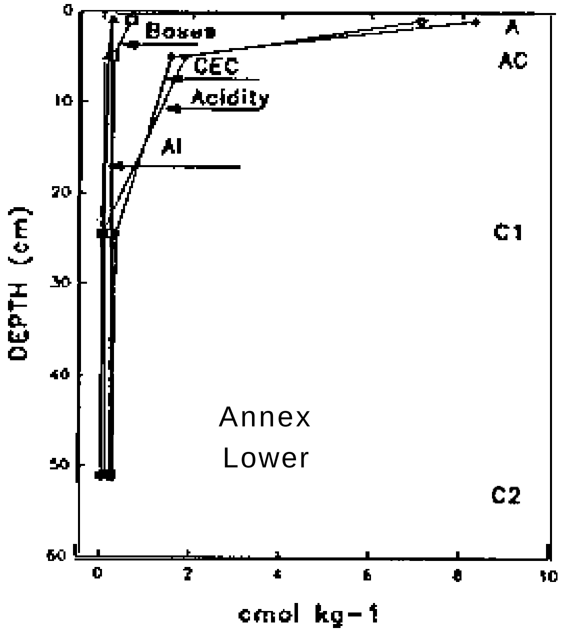
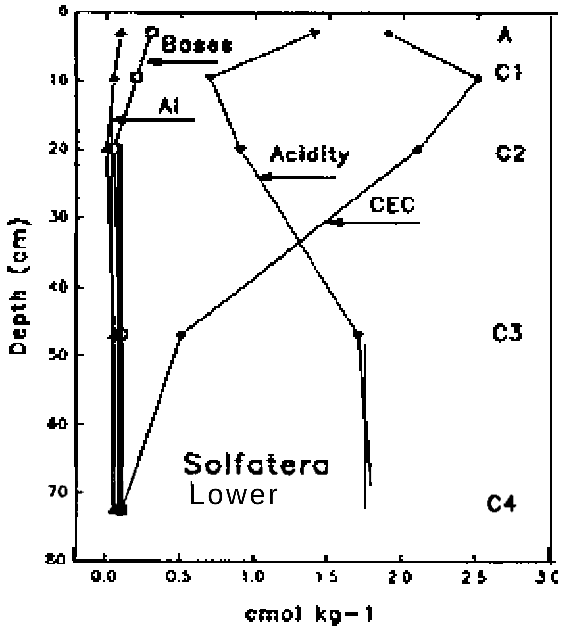
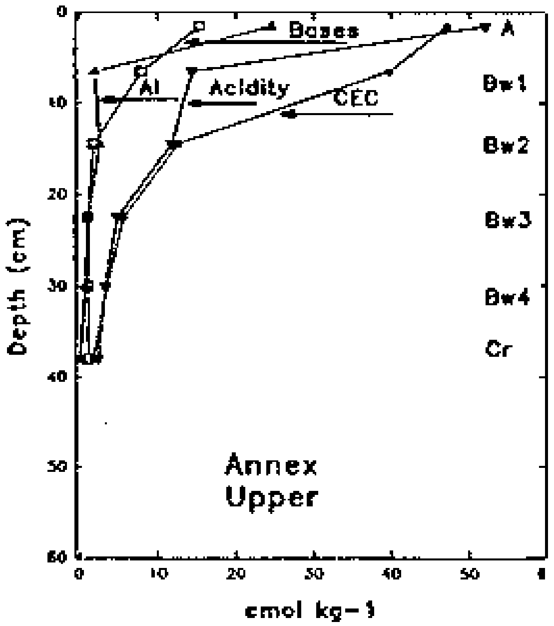
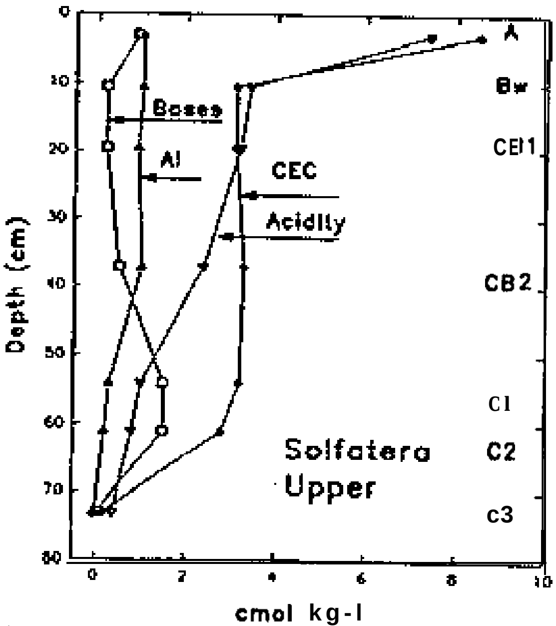

Annex Upper
Annex Lower
Depth (cm)
pH(H20)


Solfatera Lower
Solfatera Upper
Solfatera Middle
Depth (cm)
pH(H20)


Bases
CEC
Acidity
Al
A
AC
C1
C2
DEPTH (cm)
Annex Lower
cmol kg-1


Bases
Al
Acidity
CEC
A
C1
C2
C3
C4
Depth (cm)
Solfatera Lower
cmol kg-1


Bases
Al
Acidity
CEC
A
Bw1
Bw2
Bw3
Bw4
Cr
Depth (cm)
Annex Upper
cmol kg-1


Bases
Al
CEC
Acidity
A
Bw
CB1
CB2
C1
C2
C3
Depth (cm)
Solfatera Upper
cmol kg-l

REF (6)

146

Table 3. Selected characteristics from saturated paste extracts.

Horiz	EC	pH	Ca	Mg	Na	K	Al	Si	CO3	HCO3	f	Cl	SO4	NO2	NO3
	dS/m		-----	-----	-----	-----	-----	mmol / kg	-----	-----	-----	-----	-----	-----	-----
Upper Annex															
Oa	0.30	3.9	2.06	0.52	0.41	2.88	0.59	1.24	0.00	0.00	2.22	11.12	0.52	0.00	0.41
A	0.21	4.2	0.14	0.04	0.12	0.12	0.04	0.23	0.00	0.01	0.05	0.24	0.05	0.00	0.04
AC	0.14	5.1	0.03	0.02	0.13	0.06	0.01	0.10	0.00	0.03	0.03	0.15	0.03	0.00	0.03
Cl	0.11	5.1	0.01	0.01	0.05	0.05	0.03	0.17	0.00	0.00	0.03	0.11	0.03	0.00	0.03
Lower Solfatara															
A	1.15	2.2	0.16	0.04	0.12	0.10	0.11	0.13	0.00	0.90	0.05	0.19	0.85	0.00	0.05
Cl	0.43	2.5	0.10	0.02	0.10	0.05	0.02	0.12	0.90	0.00	0.05	0.15	0.25	0.00	0.02
C2	0.52	2.6	0.11	0.04	0.20	0.07	0.04	0.11	0.00	0.00	0.10	0.32	0.39	0.00	0.02
C3	20.50	1.2	0.29	0.05	0.02	0.10	0.23	0.24	0.00	0.00	0.00	0.90	11.16	0.00	0.00
C4	21.60	1.2	0.25	0.05	0.09	0.07	0.03	0.14	0.00	0.00	0.00	0.44	9.59	0.00	0.00

EC = electrical conductivity

REF (6)

Table 4. Clay mineralogy for selected horizons.

Soil	Horizon	KK†	MI	CR	AL	QZ
Lower Norris	A	XX‡	-	X	X	XX
	AC	X	-	XXXX	XX	XX
	C1	X	-	XXXXX	XXX	XX
	C2	- §	-	XXXXX	XXX	XX
Upper Norris	A	XXXX	XX	X	-	XX
	Bw2	XXXXX	X	XX	X	XX
	Cr	XXXXX	X	XX	X	XX
Lower Solfatera	A	X	X	XXX	X	XX
	C2		-	XXX	X	XX
	c4		-	XXXX	XX	XX
Middle Solfatera	A	XX	X	XX	X	X
	BC	XX	X	XXX	X	X
	C2	-	-	XXXXX	XX	XX
Upper Solfatera	A	X	X	XX		X
	C1	XX	-	XXX	X	X
	c3	XX	X	XX		X
	c5	-	-	XXXXX	XX	XXX

† KK, kaolinite; HI, mica; CR, cristobalite; AL, alunite; QZ, quartz.

‡ Relative quantities approximately ● queta to: XXXXX = >500 9 kg-1; XXXX = 300-500 g kg-lf XXX = 100-300 g kg-1; XX = 30-100 9 kg-l; X = 0-30 9 kg-l.

§ - = not detected.

REF (6)

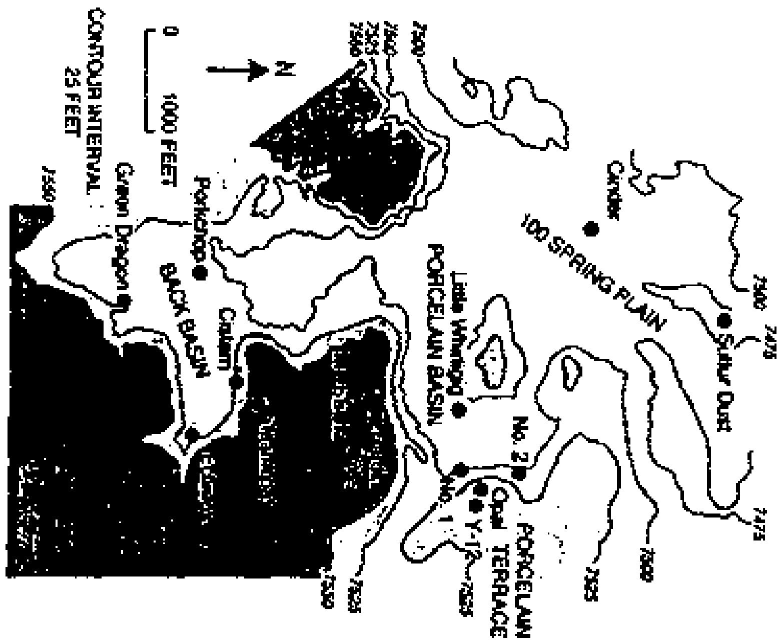


Figure 25. Sketch map of Norris Geyser Basin showing topographic features, U.S. Geological Survey drill holes Y-9 and Y-12, and locations of selected hot springs and geysers. Contours show equal altitude. No. 1 and No. 2 show locations of springs represented by analyses 1 and 2, table 4. Stippling has been added to accentuate the topographic relief in Norris Geyser Basin region. Darker shading indicates higher elevations.

REF (2)

Table 4. Chemical compositions (mg/kg) of selected thermal waters, Norris Geyser Basin.

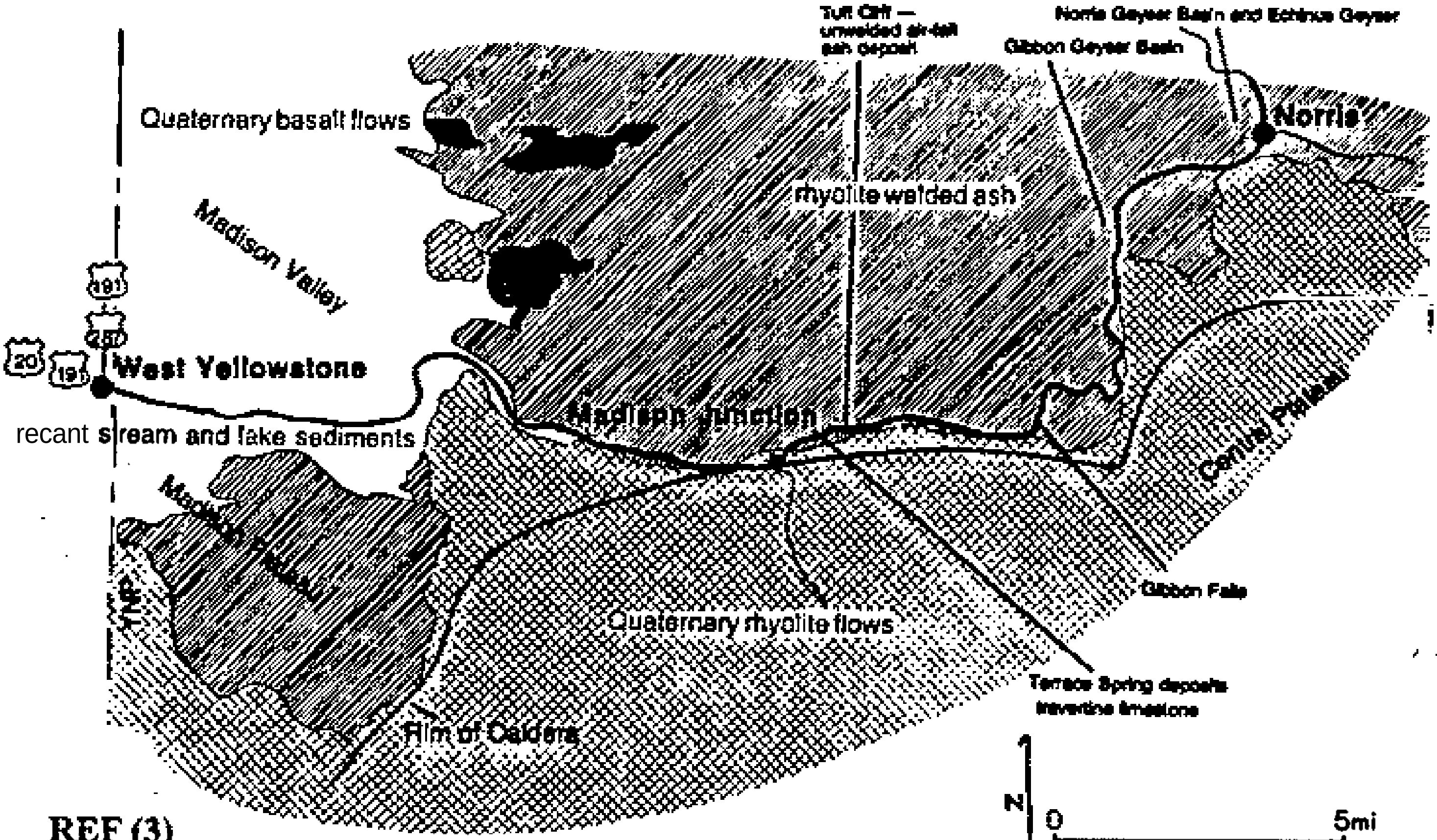
Analysis No.	Name	Date	Ref	°C	pH	SiO_2	Na	K	Ca	Mg	Li	Cl	SO4	HCO_3
1	South base Porcelain Terrace	07/03/75	1	92	7.00	589	400	93					24	
2	South base Porcelain Terrace	09/02/90	2	88	2.82	520	334		2.60	0.01	7.18	675	133	60 0
3	South base Porcelain Terrace	09/06/90	2	89	5.36	665	400	100	2.82	0.08	8.00	624	99	32
4	Little Whirligig	09/27/71	3	91	3.20	420	349	83	2.50	0.50	5.M	607	113	0
5	Sulfur Dust	09/12/61	4	so	2.75	280	250	57	4.50	0.15	3.50	427	197	0
6	Porkchop	09/18/60	4	12	7.45	435	526	66	6.40	0.50	7.40	860	33	18
7	Porkchop	06/??/89	5	92	8.50	741	388	91	3.60	0.06	6.60	687	23	62
g	Echinus Geyser	09/15/86	2	90	3.14	257	148	45	3.70	0.52	1.00	125	170	0
9	Echinus Geyser		2		3.06	296		52	4.M	0.52	0.75	117	360	0
10	Opal Spring	09/19/60	4	90	1.90	168	5	2	0.70		0.05	5	760	0
11	Harding	06/07/71	3	93	3.53	325	26	,a	0.90	0.25	0.09	2	123	0
12	Y-12 drill hole	09/13/69	2	238	7.86	352	377	21	1.90	0.20	1.43	528	34	79
13	Y-9 drill hole	09/16/69	2	195	8.58	412	268	16	0.80	0.04	0.98	go	43	488

References:
(1) Thompson and Yadav (1979).
(2) Unpublished U.S. Geological Survey data.
(3) Thompson and others (1975).
(4) Rowe and others (1973).
(5) Kharaka and others (1990).

REF (2)

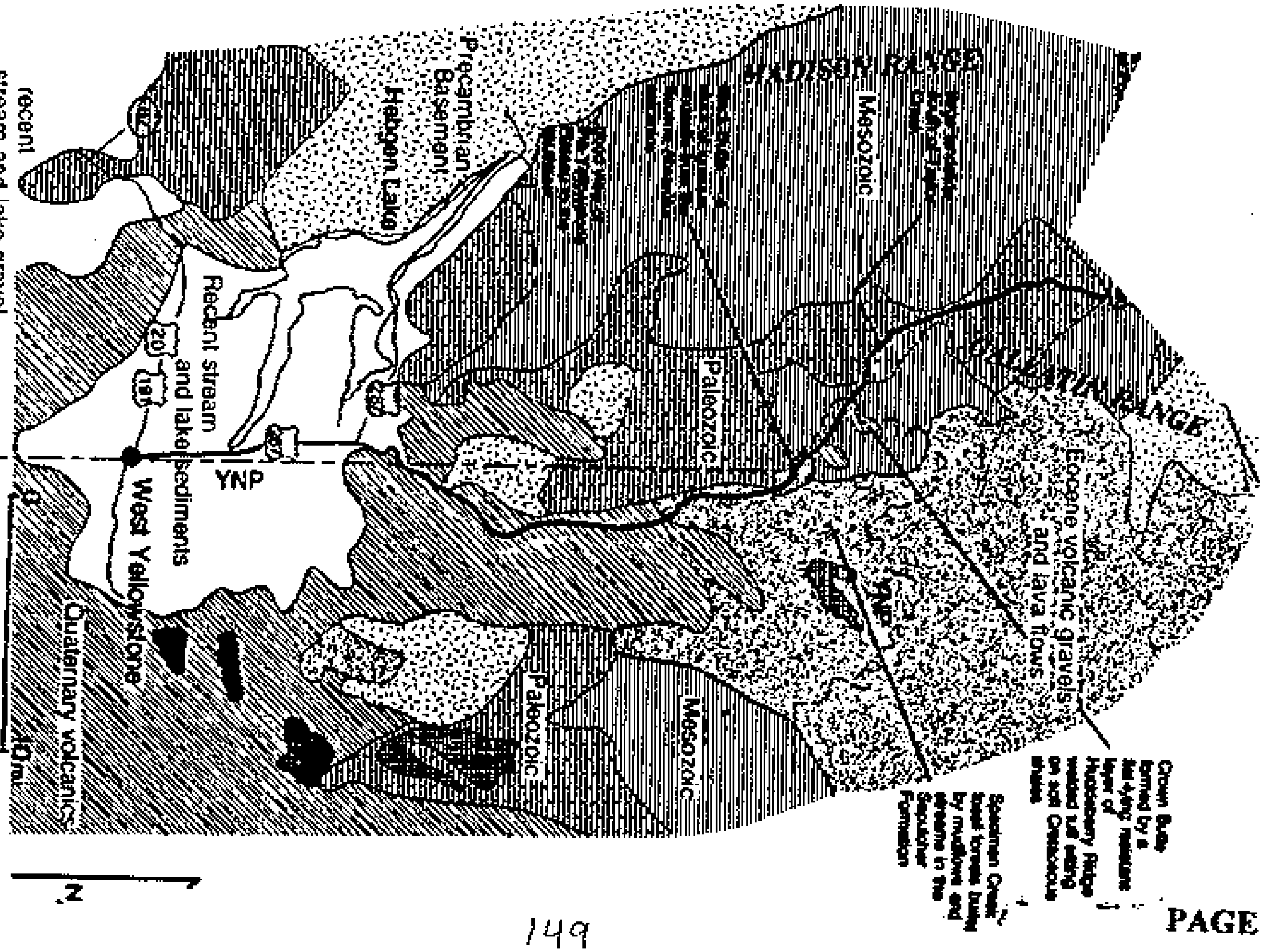
ACTIVITY OF SELECTED GEYSERS

Geyser	Interval	Duration	Height (m)
	Norris Geyser Basin		
Steamboat	4 days–50 years; latest 10/2/91	3–40 minutes	70–120
Echinus	50–60 minutes	7–13+ minutes	10–30
	[redacted]	Supers: 30–60+ minutes	10–30
[redacted]	[redacted]	[redacted]	[redacted]



REF (3)

NORRIS - WEST YELLOWSTONE

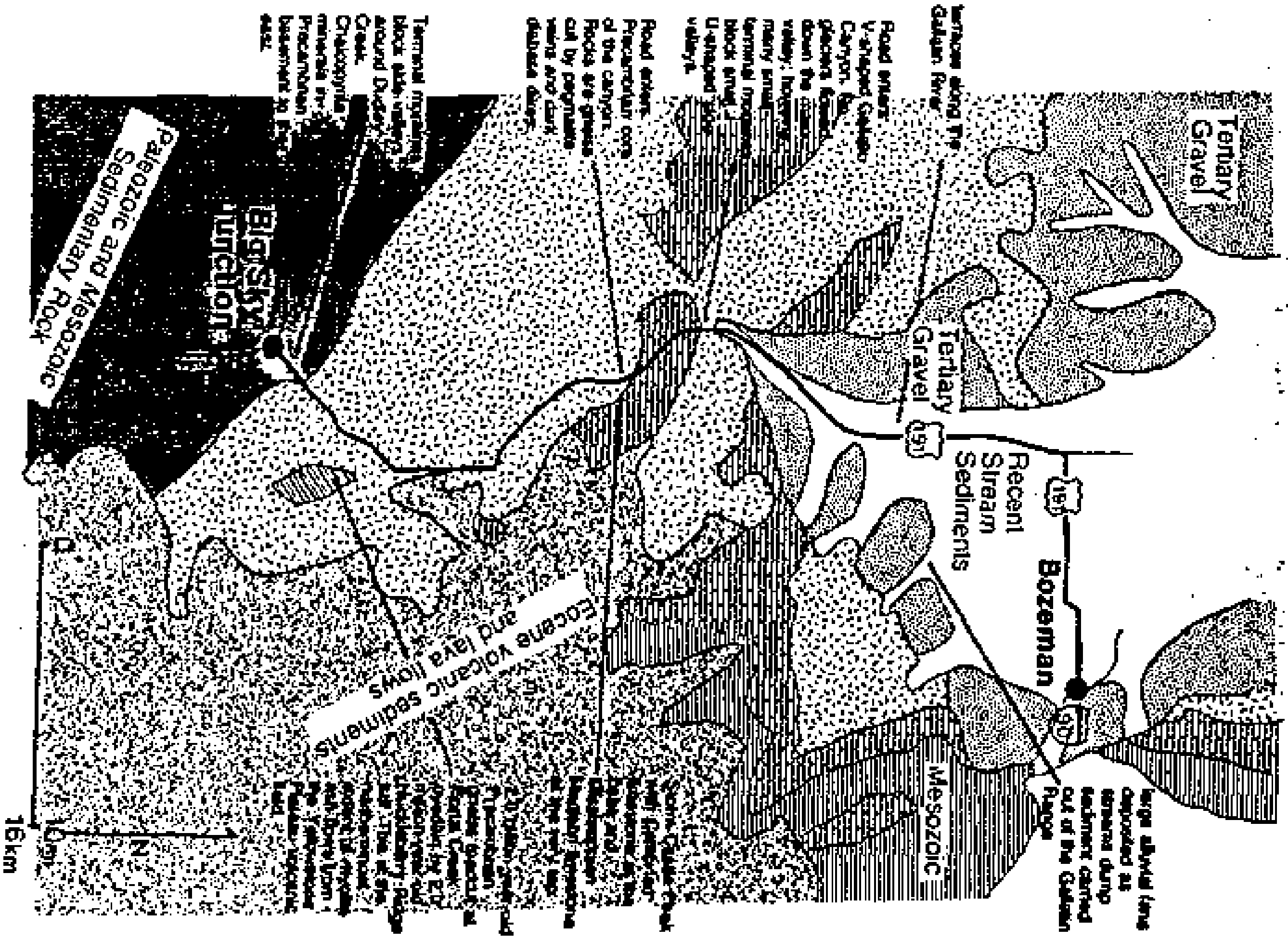


WEST YELLOWSTONE - BIG SKY JUNCTION

REF (3)

PAGE

BIG SKY JUNCTION - REF (3)



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(1) Alt, D., and D.W. Hynman. 1986. Roadside geology of Montana. Mountain Press Publ. Co., Missoula, MT.

(2) Fournier, R.O., R.L. Christiansen, R.A. Hutchinson, and K.L. Pierce. 1994. A field trip guide to Yellowstone National Park, Wyoming, Montana, Idaho • volcanic, hydrothermal, and glacial activity in the region. U.S. Geo. Surv. Bull. 2099. U.S. Gov. Print. Off., Washington, D.C.

(3) Fritz, W.J. 1985. Roadside geology of the Yellowstone Country. Mountain Press Publ. Co., Missoula, MT.

(4) Parsons, W.H. 1978. Middle Rockies and Yellowstone. K/H Geo. Field Guide Series. Kendall\Hunt Publ. Co., Dubuque, IA.

(5) Rodman, A.W., H.F. Shovic, and D.P. Thoma. (In press). Soils of Yellowstone National Park. Center for Resources. Yellowstone National Park, WY.

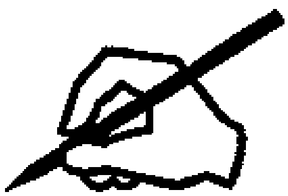
(6) Wilson, M.A., A.W. Rodman, D.P. Thoma, and H.F. Shovic. (In preparation). Acid-sulfate hydrothermal soil properties in Central Plateau Region, Yellowstone National Park, WY.

COMMITTEE REPORTS

for the

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

June 2 - 7, 1996



Best Western Grantree Inn
Bozeman, Montana

Soil Quality/Soil Health Committee Report
6/7/96

Committee Members:

Chad McGrath, USDA, NRCS, Portland, OR
Cliff Fanning, BLM, Portland, OR
Gerald Nielsen, Montana State University
Bill Ypsilantis, BLM, Coeur d'Alene, ID
Robert Meurisse, USDA Forest Service, Portland, OR
Lewis Daniels, USDA, NRCS, Lakewood, CO
Robert Klink, Bureau of Indian Affairs, Portland, OR
Hays Dye, USDA, NRCS, Phoenix, AZ
D.M. Hendricks, University of Arizona
Goro Uehara, University of Hawaii
Wally Miller, University of Nevada
Jerry Freeouf, USDA Forest Service, Lakewood, CO
Alan Kosse, Bureau of Indian Affairs, Gallup, NM
Dwight Hovland, BLM, Anchorage, AK
Terry Woosley, BLM, Reno, NV
Neil Peterson, USDA, NRCS, Boise, ID
Gary Ford, USDA Forest Service, Coeur d'Alene, ID
Chris Smith, USDA, NRCS
Greg Snell, USDA, NRCS
Gary Muckel, USDA, NRCS
Alan Amen, BLM
Dan Shurtlif, USDA, NRCS
Committee co-chair
Karl Hipple, USDA, NRCS, Spokane, WA
Committee chair
Cathy Seybold, USDA, NRCS, Corvallis, OR

The committee was given four charges that were addressed as follows:

a. **Develop interagency soil quality delinition:**

The committee recommends the following definition for soil quality:

The **capacity** of a **soil to function, within ecosystem boundaries and land use, to sustain and improve biological productivity, environmental quality, and plant and animal health, relative to its inherent characteristics.**

In other words, a healthy soil resource base ensures a sustainable food and fiber production in an economically and environmentally sound matter. Soil quality was also suggested as having a value judgement that has economic implications, The capacity of the soil to "function" is referring to what the soil does. Five vital soil functions of soil have been identified: (1) sustain biological activity, diversity, and productivity; (2) partition water, energy and solute flow, (3) filter, buffer, immobilize, detoxify materials; (4) supply, store and cycle nutrients and other materials; (5) support structures and protect archeological treasures.

Soil quality and soil health have been proposed as having different meanings. Three definitions for soil health were suggested: (1) the evaluation of soil quality over time; (2) the gage used to ascertain whether or not the soil is functioning according to the natural processes under which it formed; and (3) the condition of the soil with reference to its inherent quality and ability to perform its vital ecosystem functions. After much discussion, the committee came to the conclusion that soil health was included in the concept of soil quality and definition as stated above; therefore a separate soil health definition was not necessary.

b. Propose criteria for assessment of soil quality:

The committee recommends using indicators of soil quality as a means for assessing the quality of a soil. Soil indicators consist of visual, physical, chemical and biological attributes of the soil, and collectively can be used to assess its quality. Indicators depend on soil function; therefore soil function or functions must be identified before indicators are selected. Five vital soil functions were identified and are listed in the soil quality definition section above. Usually, a core set of indicators are chosen (referred to as a minimum data set) that collectively give an indication of the soils quality or capacity to function effectively.

Soil quality indicators should be sensitive to soil changes due to land management. Examples of specific indicators are soil respiration, infiltration, and soil color to indicate organic matter levels. Indicators should also be chosen based on the category of people making the assessment; three categories were suggested: land owners; technical advisors, and research scientists. Indicators should also be chosen based on the hind of land (e.g., rangeland, forest land, agricultural land) or land use. The function of the soil will vary depending on the kind of land and land use, so indicators must be chosen to reflect those functions. Also, the scale of assessment (e.g., site, field, state, national) needs to be considered in the selection of indicators.

It was proposed that long-term monitoring of soil quality indicators be established for assessing changes in soil quality over time. Monitoring would help to establish sustainable organic matter levels needed for sustained productivity, and would also establish erosion rates and water table depths for hydric soil indicators, Long-term monitoring will determine changes in productivity, and allow for adjustments in land management that are needed to improve quality. It will also determine if soil management systems are achieving their goal.

One proposal was that the "healthy rangeland" initiatives of BLM be used as a starting point for development of field assessment criteria for rangelands.

c. **Propose standard methods for measuring:**

There is a need for several "standard" approaches for measuring soil quality that will depend on the specific land use, degree of accuracy or precision desired, specific type of indicator variable and for whom the sampling is intended. We need to maintain flexibility **in measuring** soil quality because of geographic and local differences in soils. Local standards should be developed in order to encompass the unique biophysical conditions at a site.

For indicators that have standard methods listed in the "Soil Laboratory methods Manual" or "Soil Survey Manual", those methods could be used. Choose standard methods for indicators as appropriate for the area and soils. Sampling methods for indicators should capture the spatial and temporal variability of soils. Units of measurement should be presented in both Metric and English units.

It was proposed that a "standard" minimum data set could be established for measuring soil quality. Such a data set might include such measurements like bulk density, pH, organic matter, K_{sat}, aggregate stability/distribution, and electrical conductivity.

Establishing long-term monitoring sites for soil quality indicators was suggested as a possible standard method for measuring or monitoring soil quality over time. Examples of long-term monitoring sites might include Primary Sampling Units (PSU), LTERs, and CFI.

d. Define inherent potentials of soils:

After much discussion, the committee could not come to a consensus on what inherent potential was intended to define. The committee recommends deferring this charge back to the Steering Committee, and to Maury Mausbach, for further clarification. The committee is requesting a second chance to address this charge after clarification.

Our discussion included several proposed definitions for inherent potential of a soil, these were: (1) a soil's natural ability to act on or react **to** a given set of factors affecting that soil; (2) a soil's inherent ability to sustain production of whatever crop it supports. This includes all land uses; (3) the ability of soils to carry out their vital functions in their normal environment over the long-term, using standard cultural practices; (4) the natural ability of a soil to sustain productivity, maintain environmental quality, and promote animal and human health.

Other topics proposed for inherent potentials included the following: (1) productivity of wildlands could be assessed by using the ecological site concept: seral stage are the reference points and PNC is the inherent potential; (2) the SRPG (Soil Rating for Plant Growth) that Ray Sinclair is developing may be a way to establish and/or a starting point for determining the inherent potential of soils; (3) soil potential ratings, as defined in the National Soil Survey Handbook, indicate the relative quality of a soil (through a soil potential index) for a particular use compared with other soils in a given area. It was suggested that this method could be used to aid in decision making.

Future Marketing Strategies Committee Report
West Regional NCSS Conference, Bozeman, MT
June 2 - 7, 1996

List of Participants:

Janis Boettinger
Bill Broderson
Tom Paine
Eric Vincent
Scott Davis
Joe Moore
Bob Lund
Dick Folsche
Dave Smith
Wayne Robbie
Dick Arnold
Henry Shovic

Charges:

a. Develop educational strategies to promote public interest in soils and soil health.

b. Develop a catalog of available soil educators.

c. Compile sources of available soil education tools.

Accomplishments:

Present resolution to Western Cooperative Soil Survey Conference for adoption; present justification and action items.

Goals:

1. Resolution adopted by WCSS Conference participants and presented to National Steering Committee for consideration by other regions and NCSS.

2. Do it.

Resolution:

The partners of NCSS accept shared responsibility for developing, updating, cataloging, and disseminating soil education strategies, tools, educators, and materials for enhancing public interest, understanding, and knowledge of the importance of soils and soil health through use of the World Wide Web, coordinated by NRCS- NSSC.

Justification and Background

Soil is an important resource that is essential for the sustainability, protection, and enhancement of environmental quality and socio-economic development in the U.S.

Public awareness of soils and soil health is important for stewardship of natural resources.

Education about soils at all levels (primary through adult) is necessary for promoting stewardship/conservation of natural resources.

NCSS partners are most knowledgeable about soils and soil educational resources and, therefore, should pool their knowledge base and facilitate public awareness of soils.

Action Items:

Pilot Project

. Solicit contributions of existing soil educational resources and obtain permission to catalog.

. Submit catalog to NSSC for linkage to the NRCS World Wide Web page.

. Monitor numbers of hits and evaluate success.

Specific Resouces for Cataloging and Linkage/Reference

. Soil and Water Conservaion Society educational materials.

. National Geographic "Kid Net" (Dave Smith).

. NRCS California Teacher Aids (Eric Vincent).

. "From the Surface Down" -NRCS, Bill Broderson.

. New Mexico Association of Conservation Districts "Project Soil" and other NM resources (Wayne Robbie).

. NRCS NSSC materials, e.g., soil quality, history of soil survey materials, etc. (Gary Muckel☺).

. Soil Survey status maps for each state.

. Yellowstone Soil Survey (Henry Shovic).

. Alaskan Soil Survey (Joe Moore).

. List of soil educators and contacts (all).

. Soils of the U.S. (Lloyd Quant).

Research and Development Committee Report

West Regional NCSS Conference, Bozeman, MT
June 2 - 7, 1996

Charges:

a. Identify and prioritize research and development needs related to NCSS roles.

b. Identify opportunities for meeting research and development needs (eg. source of funding, collaborative agreement) within new organizational structures.

Research and Development Needs

-- Communication and tecnology transfer utilizing new tools-- ie. INTERNET.

-- Mapping techniques to match NASIS capabilities.

-- Use of new imagery types as ancillary tools.

-- Validation of Guidance sheets used in Western U.S

-- Clearer guidance on GIS development (standardize?).

-- Western U.S hydric indicators.

-- Soil health indicators in desertic regions.

-- Risk assessment in use of soil survey interpretations.
 -- Spatial reliability, quantification, measured vs. estimated, temporal.

-- Landscape modeling vs. site modeling.

-- Marketing of NCSS data and products.

Research and Development Opportunities

-- Data mining on Internet.

-- LTER's (NSF).

-- Partnering/Teaming (multi-agency).

-- NASA-Mission to Planet Earth.

-- Institutes and centers of excellence.

_ Sharing staff, equipment, data.

_ Increased communication with partners via a National Research Agenda Committee (with regional committees).

Research and Development Committee Recommendation

Establish a Western Regional NCSS standing committee to address research and development issues and needs.
Move for acceptance of report.

WESTERN REGIONAL COOPERATIVE
SOIL SURVEY CONFERENCE

BOZEMAN, MONTANA
JUNE 2-7, 1996

COMMITTEE for RIPARIAN SOILS

WILLIAM VOLK -CHAIR
JOHN NESSER - CO-CHAIR

COMMITTEE CHARGES:

A) Develop definition of riparian soils. -
B) Propose interagency criteria to field map riparian areas.
C) Propose methods to identify riparian areas using existing soils data.

This work group has been assigned the task of promoting discussions relative to interagency efforts to identify and map landscape areas having riparian values.

Strong reference is made to the information contained in the proceedings of the Western Regional Cooperative Soil Conference held at Flagstaff, AZ. on the campus of Northern Arizona State University during June 22-26, 1992. Many worthwhile comments and suggestions are contained in the proceedings. An interagency meeting on Riparian Area Mapping Conventions was held in Phoenix Az., on April 16-18,96. The need for interagency coordination and agreement on this issue was the driving force. Additional information and references are available in the meeting report.

The focus of this committee is to build upon the existing base and propose changes or additions to be incorporated into the National Soil Survey Handbook.

Conference participants are encouraged to discuss these issues, present their viewpoint, provide references, actual experiences or any case studies to committee chairs or members, preferably in written or electronic form.

DEFINITIONS:

See attached definitions from sources such as the Forest Service, Bureau of Land Management, Society of Range Management and others. (material from the Interagency meeting in Phoenix).

Conference participants must be cognizant of the need to address riparian needs and challenges. To become ensnared in deep debate over a definition that by necessity must cover the U.S. may not be productive. We must agree on the basics and go forth to address the issues. We should try to avoid the difficulties that now troubles the Hydric soils definition.

PROPOSAL:

A small interagency group meet to develop or select a common definition from those contained in the Phoenix report. Definition will then be forwarded to committee for consideration of incorporation into the National Soil Survey Handbook section 629- Glossary of Landform and Geologic terms.

FIELD MAPPING CRITERIA:

Cartographic methods currently used in traditional soil surveys are inadequate to meet the assessment and management needs of most riparian/wetland areas. Most if not all current soil surveys do not discuss riparian areas or values. Both FS end BLM are required to inventory riparian areas and are interested in interagency cooperation to address inventory and assessment procedures of these high value areas. Riparian areas occur regardless of ownership or administrative boundaries. Congress will ask for the extent and/or condition of riparian areas and consistency in reporting is important.

Three basic criteria are involved in riparian areas, material from the Phoenix meeting are presented below. Additionally, influences such as mapping scale, varied terminology requiring some definition, legal scrutiny, various purposes of inventory provide for local, regional or national differences.

1. BOIL8 CRITERIA:

Soils in natural riparian areas exhibit distinct features that are caused by deposition, flooding and/or water table. Riparian soils will typically have free water (water table) available for plant use at some (most) time during the growing season.

2. HYDROLOGIC CRITERIA:

Hydrologic features of riparian areas are flooding and or free water in the rooting zoned. Flooding and or free water are present for a frequent duration sufficient to influence plant community composition. Riparian areas are associated with watercourses or water bodies.

3. VEGETATION CRITERIA:

Current or potential riparian plant communities consist of species that require free water or tolerate flooding in the rooting zone of the soil.

PROPOSAL:

1. Inventory what is there, use an ecological survey approach to describe riparian areas. Arizona NRCS approach with the National Park Service is a good example. Interdisciplinary approach is strongly recommended; ownership of the effort and product across disciplines and agencies is a strong step towards success.

2. Identify and discuss riparian values in all mapping units that have riparian/wetland areas as a minor unnamed component, perhaps even if in the case of inclusions. These small riparian or wetland areas often equal or surpass the resource values of much larger upland areas.

3. Treat delineated riparian areas as a regular polygon unit.
   -label with a map unit symbol, correlate within legend.
   -populate the NASIS data base accordingly.
   -attributes selected to meet the needs of the customers.

4. Areas to small to delineate as a polygon will use a line segment or special symbol method. Map unit symbols are assigned to the riparian area, correlated and have unique descriptions. (BLM reference, TR 1737-7 and methods outlined by George Staid1 (SCS Retired) in his technical note dated 3-8-91).

5. Use the software template Siteform with additions from pages 18-22 of the USFS aquatic framework. Expanded use with review and updates to the software will increase use and application.

6. Develop a list of criteria to be considered in the inventory of riparian areas. Additional items can be added to the criteria in the references and material from the Flagstaff and Phoenix meetings. List should be cross referenced to issues or potential uses, and divided into minimum, optional or specialized, categories. In this manner, steps towards consistency can be initiated.

IDENTIFICATION of RIPARIAN AREAS with existing SOILS DATA:

* Use of soil geographic databases, such as STATSGO or SSURGO or the proposed next generation NASIS. Other unamed data bases that have attributes to address Riparian or wetland issues included in this concept.

* Regional planning specialists could request GIS data (map) from data bases such as STATSGO. Specialists would select attributes (elements and codes) such as frequent flooding, hydric soils, very poor or poor drainage classes, hydrophytic vegetation, ponding, wetland wildlife habitat, selected Gt. groups etc. to locate areas having potential riparian areas influencing regional planning efforts.

Local watershed(s), small groups or perhaps single owner planning efforts could request similar maps from an available data bases such as SSURGO. This request could key on selected elements and codes as was done in the STATSGO example. Care must be exercised as "one size may not fit all". Electronic data bases give specialists the unique ability to select attributes that are related to the issue, producing a tailor made-map. Several data bases such as soils, hydrology, ownership, topography etc., to provide a better product.

* For more specific local applications the existing hard copy soil surveys could be enhanced by on site investigations to provide the needed information at a larger scale.

* Attributes could be used in combinations to cross check applicability. Attributes (elements and codes) may be MLRA or LRU specific. We must remember that we are serving the "customer" who wants a service and a product from our data bases and experience. It should be our goal to work with and for those customers. If we don't our customers will go to other less scientific or reliable sources.

* Other federal and state agencies have soils information that was produced for other purposes but may suit the needs of today. As an example the Bureau of Reclamation has soil surveys and studies relating to irrigated agriculture that may have value. Let's use what is available, the taxpayer (you and I) doesn't need pay twice.

* Material was presented at the Phoenix meeting describing the use of a Helicopter utilizing an IRZ InfraScan technique using film sensitive to near infrared wavelengths to discern riparian vegetation. This method also incorporated GPS for georeferencing of data.

SUMMARY OF RIPARIAN AREA DEFINITIONS

!RCS --General Manual -190-411.01

:iparian areas are ecosystems that occur along watercourses or water bodies. They are distinctly different ·om the surrounding lands because of unique soil and vegetation characteristics that are strongly ıfluenced by free or unbound water in the soil. Riparian ecosystems occupy the transitional area between ıe terrestrial and aquatic ecosystems. Typical examples would include floodplains, streambanks and ıkeshores.

iparian areas are not a separate land use, but may exist withii all land covers and uses, such as cropland, ayland, pastureland, rangeland, and forest land.

[RCS -- National Range and Pasture handbook (draft)

!lossary:

Riparian - Areas or habitats adjacent to streams, laker, or other natural free water, which has a predominant influence on associated vegetation or biotic communities,

Riparian Ecosystems - (1) Those assemblages of plants, animals, and aquatic communities whose presence can be either directly or indirectly attributed to factors that are water-influenced or related. (2) Interacting system between aquatic and terrestrial situations, identified by soil characteristics, and distinctive vegetation that requires or tolerates free or unbound water.

BLM -- TR 1737-7 (1992) Riparian Area Management

Riparian areas are a form ofwetland transition between permanently saturated wetlands and upland areas. These areas exhibit vegetation or physical chatacterirtics reflective of permanent surface or subsurface water influence. Lands along, adjacent to, or contiguous with perennially and intermittently flowing rivers and streams, glacial potholes, and the shores of lakes and reservoirs with stable water levels are typical riparian areas.

BLM - TR 1737-9 (1993) -- Riparian Area Management

... Excluded are such sites as ephemeral streams or washes that do not exhibit the presence of vegetation dependent upon free water in the soil.

JSFS - Integrated Riparian Evaluation Guide, Intermountain Region March **1992**

Riparian areas consist of riparian ecosystems, aquatic ecosystems, and wetlands. They may be associated with lakes, reservoirs, estuaries, potholes, marshes, springs, bogs, wet meadows, and intermittent or perennial streams where free and unbound water is available.

Riparian areas are ecologically more diverse than surrounding uplands.

Glossary:

Riparian Areas - geographically dilineable area with distinctive resource values and characteristics that are comprised of the aquatic and riparian ecosystems. Riparian areas may be associated with lakes, reservoirs, estuaries, potholes, springs bogs, wet meadows, and ephemeral, intermittent, or perennial streams.

Riparian Complex-a unit of land consisting of biotic and abiotic factors, which is identified by changes in geomorphology, landform, soil, stream gradient and vegetation.

Riparian Ecosystems - a transition between the aquatic ecosystem and the adjacent terrestrial ecosystem identified by soil characteristics or distinctive vegetation communities that require free or unbound water.

Riparian Vegetation - plant communities dependent upon or tolerant to the presence of free or unbound water near the ground surface (high water table)

SOCIETY OF RANGE MANAGEMENT

Glossary:

Riparian - Referring to or relating to area adjacent to water or influenced by free water associated with streams or rivers on geologic surfaces occupying the lowest position on a watershed.

Riparian Ecosystems - (1) Those assemblages of plants, animals, and aquatic communities whose presence can be either directly or indirectly attributed to factors that are water-influenced or related. (2) Interacting system between aquatic and terrestrial situations, identified by soil characteristics, and distinctive vegetation that requires or tolerates free or unbound water.

Riparian Zone - The banks and adjacent areas of water bodies, water courses seeps and springs whose waters provide soil moisture sufficiently in excess of that otherwise available locally so as to provide a more moist habitat than that of contiguous flood plains and uplands.

Riparian Vegetation - Plant communities dependent upon the presence of free water near the ground surface (high water table).

Tabla 1-1. Riparian area definitions from literature sources

Source	Definition
Lowe (1964a:62)	"a riparian association of any kind [excluding marshes] is one which is in or adjacent to drainageways and/or their floodplains and which is further characterized by species and/or life-forma different than that of the immediately surrounding non-riparian climax.'
Dick-Peddie and Hubbard (1977:86)	"associated with water courses. Riparian may refer to vegetation associated with large rivers or with small, evan intermittent drainages such as arroyos."
McCormick (1979:363)	'Riparian wetlands are lowland terrestrial ecotones which derive their high water tables and alluvial soils from drainage and erosion fmm adjacent uplands on the one side, or from periodic flooding from aquatic ecosystems on the other."
Johnson and McCormick (1979:program to the meeting)	'ecosystems with a high water table because of proximity to an aquatic ecosystem or subsurface water...[and]... usually occur as an ecotone between aquatic and upland ecosystems but have distinct vegetation and soil characteristics. Aridity, topographic relief, and presence of depositions1 soils most strongly influence tha extent of high water tables and associated riparian ecosystems....Riparian ecosystems are uniquely characterized by the hlgh species diversity, high species densities-and high productivity. Continuous Interactions occur between riparian, aquatic, and upland terrestrial ecosystems through exchanges of energy, nutrients, and spades.
Warner and Hendrix (1984:xxv)	"environs of freshwater bodies, watercourses, and surface-emergent aquifers (springs, seeps, and oases) whose transported waters provide soil moisture sufficiently in excess of that otherwise available through local precipitation to potentially support the growth of mesic vegetation."
Johnson et al. (1984:380)	"On or pertaining to land adjacent to riverine and estuarine channels, lacustrine beds, or oases and other sites where surface water and/or groundwater occurs in excess of on-site precipitation; occupied by biotic communities differing in species composition and/or population densities from those of the surrounding uplands due to the substrate: a) being periodically covered with water; b) having higher soil moisture; or c) in the case of rocky banks or cliffs, existing plant and animal species are dependent on a proximity to water."

Sheet 1 of 2

[Concluded]

Society for Range Management (contained in a statement of Findings regarding the Public Rangelands Policy Amendments Act of 1985)	"Riparian zones or areas are the banks and adjacent areas of water bodies, water courses, seeps and springs whose waters provide soil moisture sufficiently in excess of that otherwise available locally so as to provide a more moist habitat than that of contiguous flood plains and uplands.'
Bureau of Land Management definition contained in Draft Riparian Area Management Policy Statement	"Riparian areas are zones of transition from aquatic to terrestrial ecosystems, whose presence is dependent upon surface and/or subsurface water, and which reveal through their existing or potential soil-vegetation complex the influence of that water. Riparian areas may be associated with features such as lakes; reservoirs; estuaries; potholes; springs: bogs; WCC meadows; muskegs; and ephemeral, intermittent, or perennial streams."
Anderson (1987:70)	"a distinct ecological site, or combination of sites, in which soil moisture is sufficiently in excess of that otherwise available locally, due to run-on and/or subsurface seepage. so as to result in an existing or potential soil-vegetation complex that depicts the influence of that extra soil moisture. Riparian areas may be associated with lakes; reservoirs; estuaries; potholes; springs; bogs; wet meadows; muskegs; and intermittent or perennial streams. The distinctive soil-vegetation complex is the differentiating criteria."
Minshall et al. (1989:6)	"Land inclusive of hydrophytes and/or with soil that is saturated by ground water for at least part of the growing season within the rooting depth of potential native vegetation."
Huffman (in Larson et al. 1981); definition for bottomland hardwoods	"...a floodplain ecosystem dominated by woody vegetation that has demonstrated ability, because of morphological adaptations(s), physiological adaptations(s), and/or reproductive strategies to perform certain requisite life functions which enable the species to achieve maturity in an environment where the soils within the root zone may be inundated or saturated for various periods during the growing season."

Sheet 2 of 2

Table 1-2. Unique characteristics and features that separate riparian ecosystems from other ecosystems'

Riparian ecosystems:

-Are linear in shape as a consequence and function of their proximity to rivers and streams, and often have very high edge-to-area ratios.

-Receive and process more energy and material from adjacent Landscapes than other types of ecosystems.

-Are connected to other ecosystems, both upstream and downstream. and upslope (upland ecosystems) and downslope (aquatic ecosystems]. Functionally, there are continuous interactions among riparian, aquatic. and upland ecosystems through the exchange of energy, nutrients, and species. This exchange is active in mobile organisms but also occurs passively with flooding events.

-Occur along streams. rivers, arroyos, ponds, lakes. or other water bodies.

-Have vegetation growth dependent upon relatively high soil moisture content.

-Have complex hydrologic and geomorphic satdngs and experience periodic flooding.

-Possess alluvial or other characteristic soils (some, but not all lands).

-Have special water-related functions such es erosion control.

-Are producdva sites with special management needs.

-Involve an array of plant types and plant communities

-Have multiple resource uses and values

-Have promoted increasing public interest, legislation, end government programs to protect, mitigate, recover, altar, and enhance riparian areas.

-Are characterized by a combination of high species diversity, high spacias densities, and high productivity.

-Are acotonal in nature. occurring between aquatic and upland ecosystems: however, they tend to have distinct vegetation and soil characteristics.

' Sources: Brinson et al. (1981), Kusler 119951, Martin (1986), Beschta (1977)

B U S I N E S S   M E E T I N G   M I N U T E S

for the

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

June 2 - 7, 1996

Best Western Grantree Inn
Bozeman, Montana

168

Western Regional Cooperative Soil Survey Conference
Bozeman, Montana
June 7, 1996

Business Meeting Minutes

The meeting was called to order by Chuck Gordon at approximately 10 a.m.

Old Business

No old business.

New Business

Location of next Reeional Conference

The location of the next Regional Conference was discussed. There was discussion about whether a fixed rotation of sponsoring organization was required. No consensus was reached on that. Two potential locations were tentatively nominated:

Las Cruces, New Mexico
Needles, Nevada - Canyonlands area of Utab

It was moved, seconded, and accepted by voting members by voice vote to close the nominations for location of next conference. The regular rotation of sponsoring organization would be the Western Regional Agricultural Experiment Stations. The representatives from New Mexico and Utah were not present at the business meeting. They were to be contacted by Ken Scheffe and Bill Brodenson respectively to determine their interest in sponsoring the next meeting.

Permanent Steering Committee Chair

Bill Dollarhide submitted a proposal to amend the by-laws to eliminate the position of the permanent chair and to add a NSSC representative as associate member to maintain files, assist with conference coordination, etc. (see attached amendments to by-laws). The second part of his proposal was adding a soil scientist on the West and Northern Plains Regional Conservationist staffs as an advisor (see attached amendments to by-laws). The proposal was accepted by voting members by voice vote.

Soil Taxonomv Committee

Bill Dollarhide submitted a proposal to abolish the soil taxonomy committee as a permanent standing committee. He noted it could be reappointed at a later date if needed as a temporary committee. This proposal was not accepted by voting members. Further discussion ensued about the duties and functions of the committee and how those would be handled. Ken Scheffe suggested that each state soil scientist be responsible for distribution of proposed taxonomy amendments to cooperators. Bill Dollarhide resubmitted his proposal to abolish the soil taxonomy committee as a permanent standiig committee (see attached amendments to by-laws). The proposal was accepted by voting members by voice vote.

Research Committee

Jerry Nielsen proposed establishing a Western Regional Soil Research Committee (see attached proposal). Chris Smith suggested adding language for peer review. Jerry's proposal was accepted by voting members by voice vote. Further discussion centered around creating a depository for research results.

Regional Representatives to Attend National Meeting

Bill Dollarhide proposed that the West and Northern Plains Regional Conservationists will coordinate how many and which representatives will attend the National NCSS meeting. The proposal was accepted by voting members by voice vote.

Research Committee

Hayes Dye proposed that the present conference steering committee appoint members to the Research Committee. The motion was accepted by voting members by voice vote.

The meeting adjourned at 10:32 a.m.

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

5301 Longley Lane
Building F, Suite 201
Reno, NV 89511

"Commitment to Quality"

AMENDMENTS TO BY-LAWS - WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

III.

B. steering Committee

delete - Head, Soils staff, Western States (Permanent Chairman).

add - NSSC Representative - as associate member to maintain files, by-laws, committee rosters/charges, proceedings and assist with conference coordination.

C. Advisors

add - Soil Scientist on West Regional Conservationist staff and Soil Scientist on Northern Plains Regional Conservationist staff.

V.

F. Permanent Standing Committee-------

delete - 1. Western Regional Soil Taxonomy Committee

Note to accompany amendments -

The NSSC will distribute proposed amendments, the soil taxonomy, to all states and National Offices of cooperating agencies. The NRCS state soils representative will distribute to cooperators in each state for review and comments.

Soil Taxonomy Committees

Presently there are 5 Soil Taxonomy Committees, 4 regional committees plus 1 from the Soil Science Society of America. The regional committees are aligned along the same boundaries as the Regional NCSS Work Planning Conferences. Despite recent changes brought about by reorganization, it was suggested to maintain the old boundaries of the regions with each region having a Soil Taxonomy Committee.

Committee membership has always been comprised of a mixture of cooperators from various agencies and universities. This membership has rotated with the exception of a permanent committee member from the NTC and the chair for all the committees, Bob Ahrens.

With the advent of MO's it was suggested that regional committees open committee membership to include all MO leaders as permanent members. Members from universities and agencies other than NRCS can serve on a permanent basis or on a rotational basis, whichever is decided. It would be desirable to have one member from each regional committee to act as a coordinator to ensure membership is agreed upon and rotated, if necessary. Bob Ahrens will remain chair of the committees and continue sending proposals to each member.

The Western Region has already decided to maintain their current membership for another 2 years.

Below is a breakdown of MO's within regions:

East
Amherst

West
Anchorage
Bozeman
Davis
Lakewood
Phoenix
Portland

South
Auburn
Little Rock
Morgantown
Raleigh
Temple

North Central
Bismarck
Indianapolis
Salina
St. Paul

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE
Business Meeting

I Proposal to establish a
Western Regional Soil Research Committee

1. Purpose

The committee's purpose is to identify, document, prioritize and address. the critical research and development issues; to identify opportunities for partnering; to increase credibility; to increase visibility; and to insure the technical excellence of the National Cooperative Soil Survey.

2. Membership of the Standing Research Committee

Western Regional Conference Steering Committee will appoint membership on a rotating basis from state university representatives, Natural Resources Conservation Service, Forest Service, Bureau of Land Management, and other representation as deemed appropriate by the Conference Steering Committee.

COMMENTS--NCSS WORK PLANNING--BRAINSTORMING SESSION

There was a strong emphasis on forest soils in this conference. The info was of great interest to me as an NRCS cooperator. However, though NF Regional soil scientists were well represented, very few forest level soil scientists attended. Even though there was some advertising. I would like to see more participation from scientists involved in progressive soil surveys on Federal forested land. Possible better targeting? Otherwise excellent conferencel!

Regional joining of all soil surveys.
Change name - or get into work planning.
-- Disposition of regional planning session.
-- Who in region planning conference has responsibility to forward committee recomendations to NSSC or elsewhere.
-- Imediately submit committee reports.

Steering Team meet at end of this conference and set disposition of committee actions.

Purpose
- -New issues.
- -Bring people up to date on ideas and thinking.
- -Mislabeling many issues as soils issues only and need to look at broader perspective more than just soil issues.
- -More at other ecosystems.
- -Suggest in some future conferneces - address soil users including sociologists.
- -The human ecology side.
- -Distribution to management.
- -Public info release email.
- -Marketing strategy to implement results.
- -Watershed approach.
- -Can planning conference play a role in stimulating a discussion on watershed approach by including other people from other disciplines at conference.
- -Relation MLRA, CRAs, watersheds.
- -Future acquisition of satelite imagery as well as others through NAP committee.

Would like to see more interdisciplinary papers/reports/presentations. Interdisciplinary team approach mentioned several times as necessary, but emphasis with presentations still primarily all soils. Suggest presentations by foresters, range specialists, biologists, growers. My first experience at NCSS conference--very good meeting.

---

1. A week is too long. Suggest starting at noon on Monday and end at noon on Thursday (3 days).
2. Any topics considered by committees need to have substantial pre-works (It is impossible to accomplish much at these conferences-too many people, etc.). Committees should present a proposal for consideration,

Need to do better outreach or communicate with NRCS line management to obtain better understanding and support for future desired activities.

Need'to formalize the implementation of committee recommendations. Many or most of the recommendations, after publishing in the National and Regional Conferences are just plain forgotten.

I believe the presentations from NCSS related activities by old and new partners should continue about like present.
The committee and issues arrangement should be restructured I think. It would seem a committee could first address an issue and brainstorm the issue develop an action plan--then meet or communicate as a committee as needed to develop a proposal that would be finalized at the next work planning conference.

Continue structured communication with cooperators.
Keep informed on new technologies and needs.
On committee work things (items) need to be seen through to completion.

Provide facilitators to help with conducting breakout sessions.
Devote more of agenda to presentations on projects currently being completed by NCSS cooperators--that have relevance to soil survey. Presentations on research must particularly be evaluated to determine if participants will benefit from the information presented.

Making the task easier. faster. more accurate.

1. Field level Internet access --not NHQ, R.O., SO, MO, but FIELD.
2. Training on Internet and browsers.
3. Index and atlas of available spatial/temporal natural resource info products available.
4. Hardware/software availability and access.
   a. Employee reimbursment.
   b. Shared equipment with other agencies, municipal, universities
5. Liasons to other data users/developers (formal /informal).
6. Sharing state/local pilot project information much broader via Internet home pages.
7. Put implementation and use of Internet into PAW or other job tasks and descriptions.

Needs a central theme.
Integrate more NRCS programs like NRI, wetlands, climate data access facility, GIS, etc. into conference.
Tie state programs into conference not just MO--taxonomy and correlation issues.
Keep field crews from host state involved --have them participate via presentation, field tours, etc.

Act on recommendations.
Begin conference after noon on Monday (to reduce travel costs).
Hold business meeting earlier in the week.
Get on the World Wide Web. How do we do it?
Eliminate most of the welcoming speakers.
With new NRCS organization who are voting members?

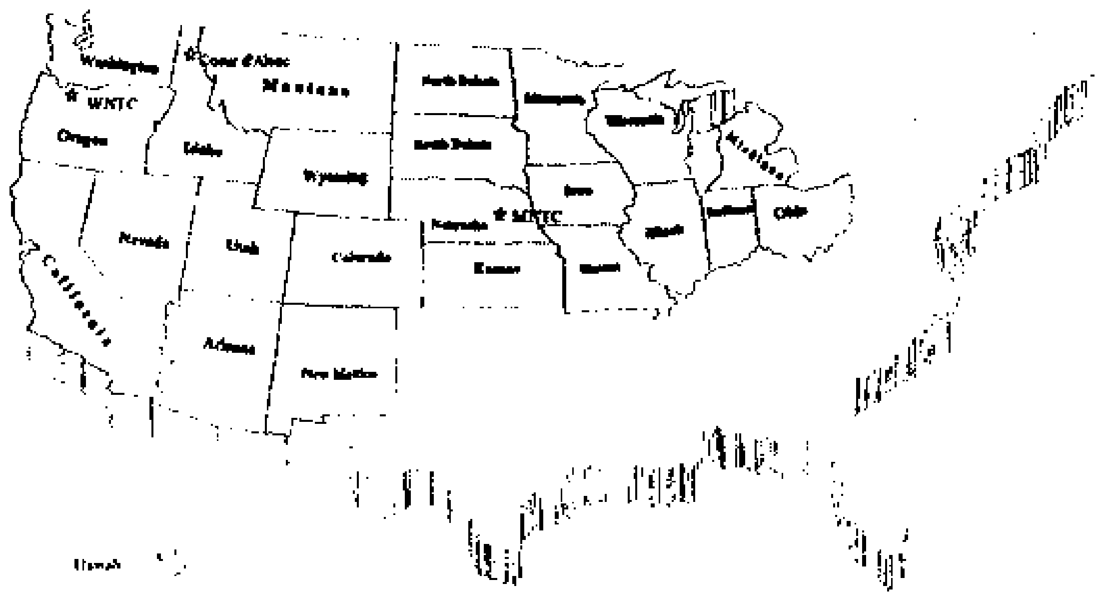
NATIONAL COOPERATIVE SOIL SURVEY

Western/Midwestern Soil Survey Conference Proceedings

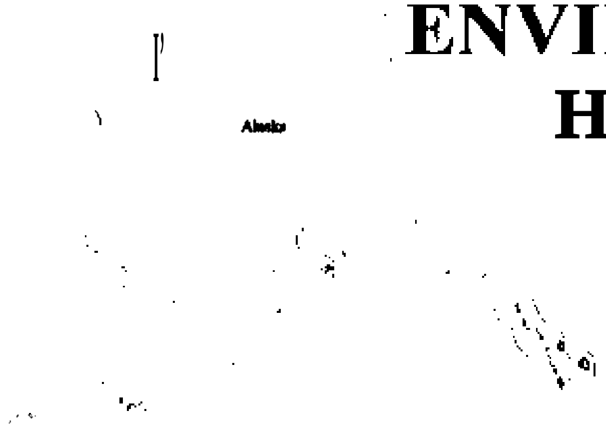
Coeur d'Alene, Idaho
June 12-17, 1994

PROCEEDINGS

Western/Midwestern Regional Cooperative Soil Survey Conference



BUILDING ALLIANCES FOR ENVIRONMENTAL HARMONY



WESTERN/MIDWESTERN REGIONAL **COOPERATIVE**
SOIL SURVEY CONFERENCE

Soil Survey in Ecosystem Management

Sponsored by

Bureau of Land Management
Idaho Soil Scientist Association
Soil Conservation Service

Special Assistance from

Bureau of Reclamation
Midwestern Region Agricultural Experimental stations
Pintlar Corporation
University of Idaho
U.S. Forest Service
Washington society Professional Soil Scientists
Washington state University
Western Region Agricultural Experimental stations

Other Contributing Organizations

American Excelsior Co.
Coeur d'Alene Tribe
Decagon Devices
Earth Info Inc.
Electronic Data Solutions
Idaho Conservation League
Idaho Department of Health and Welfare
Idaho Department of Parks and Recreation
Intermountain Resources
National Society of Consulting Soil Scientists
North American Green
Oregon state University
Panhandle Health District
Plum Creek Timber

Holiday Inn Convention Center
Coeur d'Alene, Idaho
June 12 to June 27, 1994

1994 NCSS REGISTRATION LIST

Aho, Terry - Soil Conservation Service, Spokane, WA
Allen, Robert - Bureau of Land Management, Reno, NV
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Tugel, Arlene - Soil Conservation Service, Portland, OR
Vogt, Kenneth - Soil Conservation Service, Columbia, MO
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Walters, Alan - Soil Conservation Service, Naches, WA
Weisel, Charles - Soil Conservation Service, Coeur d'Alene, ID
Wettstein, Carol - Soil Conservation Service, Lakewood, CO

White, Dean - Soil Conservation Service, Waterville, WA
Winward, Rulon - Soil Conservation Service, Rexburg, ID
Ypsilantis, Bill - Bureau of Land Management, Coeur d'Alene, ID

Sunday, June 12

Tour of Bunker Bill Superfund Area

8:30	Depart from Holiday Inn parking lot
9:20 - 9:35	BLM Haeardous Dust Abatement Project - Bill Ypsilantia, BLM, Coeur d'Alene, ID
9:35 - 9:50	SCS Plant Materials Trial - Ron Payton, SCS, Moscow, ID
lo:oo - 10:10	Silver Valley Soil Survey - Chuck Weisel, SCS, Coeur d'Alene, ID
10:10 - 10:25	Grouse Creek SCS Erosion Control Project - Dave Brown, SCS, Coeur d'Alene, ID
10:35 - 11:05	Pintlar Corp. Cleanup Efforts - Trey Harbert, Pintlar Corporation, Kellogg, ID
11:20 - 11:35	Discussion of BLM's Role in Gondola Project - Scott Forsell, BLM, Coeur d'Alene, ID
11:35 - 12:05	Gondola Ride to Silver Mt. Ski Resort
12:05 - 1:15	Lunch at Silver Mt.
12:15- 1:15	History of Superfund Site (Luncheon Presentation) - Scott Peterson, Idaho Dept. Health & Welfare, Kellogg, ID - Jerry Cobb, Panhandle Health District, Silverton, ID
1:30 - 2:oo	Gondola Ride to Base of Ski Resort
2:10	Depart for Coeur d'Alene
3:00	Arrive Coeur d'Alene
3:oo - 5:oo	Registration - Holiday Inn Lobby

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Monday, June 13

8:00 - 9:00	Registration - Bay 1, Convention Center, Holiday Inn
8:00-3:30	Exhibitor's Session - Foyer of Convention Center/Lobby, Holiday Inn
9:oo - 9:15	Opening Remarks - Bill Ypsilantis, Conference Chairperson, Bureau of Land Management, Coeur d'Alene, ID
9:15 - 9:30	Welcome by Bureau of Land Management - Del Vail, State Director, Boise, ID
9:30 - 9:45	Welcome by Soil Conservation Service - Ed Burton, Deputy State Conservationist, Spokane, WA
9:45 - 10:00	Welcome by Forest Service - John Nesser, Region 1 Soil Scientist, Hissoula, MT - David Jolly, Regional Forester, Missoula, MT
1o:oo - 10:30	Break
10:30 - 10:45	Welcome by University of Idaho - Dr. David Lineback, Dean, College of Agriculture, Moscow, ID
	Agency reports:
10:45 - 11:oo	Soil Conservation Service - Dr. Richard Arnold, Director, Soil Survey Division, Washington, D.C.
11:00 - 11:15	Bureau of Land Management - Glenn Bessinger, Soil Program Lead, Washington, D.C.
11:15 - 11:30	Forest Service - Wayne Robbie, Region 3 Soil Scientist, Albuquerque, NM
11:30 - l:oo	Lunch
l:oo - 1:15	Western Region Agricultural Experimental Stations - Dr. Gene Kelly, Colorado State University, Fort Collins, CO
1:15 - 1:30	Midwestern Region Agricultural Experimental Stations - Dr. Pierre Robert, University of Minnesota, St. Paul, MN
1:30 - 2:oo	The Great Flood - Brian Rowder, Farragutt State Park, ID
2:00 - 2:30	Geological and Pedologio History of the Palouse

- Dr. Alan Busacca, Washington State University

2:30 - 3:00 **Volcanic Ash Influenced Soils of Idaho**
- Dr. Paul McDaniel, University of Idaho

3:00 - 3:30 **Break**

3:30 - 4:15 **Agency Meetings**

Soil Conservation Service, Western/Midwestern Regions
- Bay 2, Convention Center, Holiday Inn

Agricultural Experimental Stations, Western/Midwestern Regions
- Boardroom, Holiday Inn

US Forest Service
- Conference Room, Comfort Inn

Bureau of Land Hanagament
- Coeur d'Alene Room, Shilo Inns

4:15 - 5:00 Soil Conservation Service, Western Region
- Bay 2, Convention Center, Holiday Inn

Soil Conservation Service, Midwestern Region
- Bay 1, Convention Center, Holiday Inn

Agricultural Experimental Stations, NCR4
- Small Conference Room, Shilo Inns

Agricultural Experimental Stations, WRCC-30
- Boardroom, Holiday Inn

US Forest Service (continuation)
- conference Room, Comfort Inn

Bureau of Land Management (continuation)
- Coeur d'Alene Room, Shilo Inns

6:30 - 7:00 Boarding time for cruise boat.

7:00 - 9:00 **Conference reception on the Coeur d'Alene cruise boat.** Eric Thomson, BLM, Coeur d'Alene, ID will provide commentary at points of interest about BLX management on the lakeshore. spouses welcome! (cruise departure at 7 p.m. sharp)

Tuesday, June 14

9:00 - 3:30 Exhibitor's Session
- Foyer of Convention Center/Lobby, Holiday Inn

8:00 - 8:20 Ecosystem Management Overview / Forest Health Assessment
- John Nesser, USFS, Missoula, MT

8:20 - 8:40 Soil Relationships to Ecosystem Uanagement
- Robert Meurisse, USFS, Portland, OR

8:40 - 9:00 Ecosystem Basis for Soil Survey
- Jim Culver, SCS, Lincoln, NE

9:00 - 9:10 Field trip orientation

9:10 - 10:10 Poster sessions
- Foxies Lounge area, Holiday Inn

Special Use Soil Survey for Desert Tortoise
- Eddie Garner, BLN, Las Vegas, NV

Soil Survey Enhancement and Ecological Site Correlation
- Al Amen, BLH, Denver, CO

Slashburn Effects on a Spodosol in the Rain Forest of the Humid Tropics
- Arlene Tugel and John Kimble, SCS, Portland, OR

Analysis Based on Ecosystem Happing Hierarchies
- Cathy Maynard, USFS, Helena, MT

Special Soil Surveys and Pigmy Rabbit
- Jay Kehne, SCS, Spokane, WA

Riparian Area Management to Range Reform 94
- Ronnie Clark, BLH, Lakewood, CO

Seasonal Occurrence of Perched Water Tables in the Eastern Palouse Region
- Rod Gabhart, University of Idaho, Moscow, ID

Procedures for Proposing Changes to Soil Taxonomy
- Robert Engel, Robert Ahrens and John Witty, SCS, Lincoln, NE

Biological Control of Noxious Weeds
- Robert Mitchell, BLH, Miles City, MT

10:10 - 10:40	**Break**
10:40 - 12:00	**Committee Meetings**

The Role of NCSS in Sits Specific Soil Surveys
- Bay 1, Convention Center, Holiday Inn

Drastically Disturbed Soils
- Coeur d'Alene Room, Shile Inns

Ecosystem Based Soil Surveys for Resource Planning
- Bay 2, Convention Center, Holiday Inn

Distribution and Access to Soil Survey Data
- Small Conference Room, Shilo Inns

Redefining the Cooperative Role in NCSS
- Boardroom, Holiday Inn

New Ways of Making Soil Survey Interpretations
- Conference Room, Comfort Inn

12:00 - 1:15	**Lunch**
1:15 - 3:00	**committee Meetings**

The Role of NCSS in Site Specific Soil Surveys
- Bay 1, Convention Center, Holiday Inn

Drastically Disturbed Soils
- Coeur d'Alene Room, Shilo Inns

Ecosystem Based Soil Surveys for Resource Planning
- Bay 2, Convention Center, Holiday Inn

Distribution and Access to Soil Survey Data
- Small Conference Room, Shilo Inns

Redefining the Cooperative Role in NCSS
- Boardroom, Holiday Inn

New Ways of Making Soil Survey Interpretations
- Conference Room, Comfort Inn

3:00 - 3:30	**Break**
3:30 - 4:45	**committee Meetings**

The Role of NCSS in Site Specific Soil Surveys
- Bay 1, Convention Center, Holiday Inn

Drastically Disturbed Soils
- Coeur d'Alene Room, Shilo Inns

Ecosystem Based Soil Surveys for Resource Planning
- Bay 2, Convention Center, Holiday Inn

Distribution and Access to Soil Survey Data
- Small Conference Room, Shilo Inns

Redefining the Cooperative Role in NCSS
- Boardroom, Holiday Inn

New Ways of Making Soil Survey Interpretations
- Conference Room, Comfort Inn

7:00 - 8:30	NCR3 Nesting - Coeur d'Alene Room, Shilo Inns
7:30-8:30	Idaho Soil Scientist Association Meeting - Bay 1, convention center, Holiday Inn

Wednesday, June 15

Conference Field Tour

Busses Depart from Holiday Inn parking lot at 7:00 a.m.

stop 1 - Patterned Ground/Channeled Scabland Soil - Miller Ranch, Washington (arrive 8:05, depart 9:05)

stop 2 - Palouse Paleosols - Ewan, Washington (arrive 9:25, depart 10:20)

stop 3 - Lunch stop - Steptoe Butte, Washington (arrive 11:20, depart 12:20)

stop 4 - Loess Soil on Forest Site Converted to Cropland - Setters, Idaho [arrive 1:45, depart 2:45)

stop 5 - Volcanic Ash Soil - Fourth of July Pass, Idaho (arrive 3:30 depart 4:30)

Busses Arrive at Holiday Inn parking lot at 5:00 p.m.

Thursday, June 16

8:00 - 8:20	An Integrated Landscape Resource Analysis Approach to Comprehensive Watershed Management - Al Amen, BLH, Denver, CO
8:20 - 8:40	Variation of Surface Soil Salinity on Steep Wancos Shale Ecosystems - Dennis Murphy, BLH, Montrose, CO
8:40 - 9:00	Long Term Soil Productivity and Volcanic Ash Soils - Debbie Page-Dumroese, USFS, Moscow, ID
9:oo -9:20	Ecosystem Mapping Hierarchies; Aquatic and Terrestrial - Cathy Maynard, USFS, Helena, MT
9:20 - 9:40	overview of Forest Ecosystems - Dr. David Perry, Oregon State University, Corvallis, OR
9:40- 1o:oo	Soil Invertebrates in a Forest Ecosystem - Dr. Andy Moldenke, Oregon State University, Corvallis, OR
1o:oo -10:30	Break
10:30 - 10:50	SWAPA - Nathan McCaleb, SCS, Lincoln, NE
10:50 - 11:10	Restoring Riparian Ecosystems - Wayne Elmore, BLW, Prineville, OR
11:10 - 11:30	Water Quality - Terry Sobecki, SCS, Portland, OR
11:30 - l:oo	Lunch
l:oo - 1:20	Conservation Efforts along the Coeur d'Alene River - Frank Frutchey, Kootenai County, Coeur d'Alene, ID
1:20 - 1:40	Wetland Delineations - Arlene Tugel, SCS, Portland, OR
1:40 - 2:oo	Water Quality Issues and Related Soil Information Needs in the Clark Fork-Pend Oreille Watershed - Ruth Watkins, Tri-State Implementation Council, Sandpoint, ID
2:oo - 2:20	Incorporation of Soil Information into Cumulative Effects Analysis in Idaho - Brian Sugden, Plum Creek Timber, Columbia Falls, MT
2:20 - 2:40	NASIS - Harold Maxwell, SCS, Boise, ID
2:40 - 3:20	Break

3:20 - 3:40	PM-10 - Jim Carley, SCS (retired), Spokane, WA
3140 - 4:00	The Role of the Soil Scientist in Land Use Planning - A Consultant's Perspective - Pierre Bordenave, InterMountain Resources, Sandpoint, ID
4:00 - 4:30	A century Minus Five ---- and Counting - Dr. Richard Arnold, SCS, Washington, D.C.

Friday, June 17

8:00 - 8:20	**National Ecological Hierarchy** - Tom Collins, USFS, Ogden, UT
8:20 - 8:40	**Use of Soil Information for Assessing Ecosystem Health** - Phil Cernera, Coeur d'Alene Tribe, Plummer, ID
8:40 - 9:00	**A Political Perspective on Ecosystem Management and Its Consequences to Idaho** - Senator Mary Lou Reed, Idaho state Senate, Boise, ID
	Committee report5
9:00 - 9:20	**Role of NCSS in Site Specific Soil Surveys** - Del Mokma, Michigan State University, East Lansing, MI
9:20 - 9:40	**Drastically Disturbed Soils** - Sam Indorante, SCS, Illinois
9:40 - 10:00	**Ecosystem Based Soil Surveys for Resource Planning** - Robert Meurisse, USFS, Portland, OR
10:00 - 10:30	**Break**
10:30 - 10:50	**Distribution and Access to Soil Survey Data** - Scott Davis, BLM, Lakewood, CO
10:50 - 11:10	**Redefining the Cooperative Role in NCSS** - Paul McDaniel, University of Idaho
11:10 - 11:30	**New Ways of Making Soil Survey Interpretations** - Arlene Tugel, SCS, Portland, OR
11:00 - 12:00	**West Region business meeting** - Bay 2, Convention Center, Holiday Inn - Dennis Heil, SCS, Portland, OR
	Midwest Region business meeting - Bay 1, Convention Center, Holiday Inn - Nathan McCaleb, SCS, Lincoln, NE
12:00	**Adjourn**
1:00 - 3:00	Steering committee meeting - Coeur d'Alene Room. Shilo Inns

FACILITATORS

Monday, June 13

morning	Bill Ypsilantis, BLM, Coeur d'Alene, ID
afternoon	Russ Xrapf, BLM, Phoenix, AZ

Tuesday, June 14

morning	Tommie Parham, SCS, Albuquerque, NM

Thursday. June 16

morning	Annie Greene, USFS, Dillon, MT
afternoon	Mary Davarsa, BLM, Prineville, OR

Fridav, June 17

morning	Dennis Heil, SCS, Portland, OR

Exhibitor's Session

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Western/Midwestern Regional
Cooperative Soil Survey Conference

Soil Survey in *Ecosystem Management*

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Welcoming Remarks

1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

Del Vail

State Director

Bureau of Land Management

Boise, Idaho

I'm very happy to have this opportunity to welcome you to The Gem State - Idaho. Idaho is truly the "Gem of the West" with the deepest canyon on the North American continent, many of the west's great untamed rivers, majestic mountain ranges, and immense wilderness areas. Dramatic elevation ranges in the state are illustrated by Mt. Borah at over 12,000 feet and the inland seaport of Lewiston at a mere 750 feet above sea level.

The uncompromising beauty of this state is reflected in the clear waters of its over 2,000 lakes. In fact, Idaho has the greatest concentration of lakes of any western state. These lakes are a fisherman's paradise. A few months ago, a local fisherman caught a record setting 43 pound Mackinaw out of Lake Pend Oreille, the largest lake in the state located just 18 miles north of Coeur d'Alene. And later today, you will have an opportunity to enjoy a cruise on Lake Coeur d'Alene which was rated as one of the five most beautiful lakes in North America by National Geographic.

Idaho is a large, uncrowded state. With almost 53 million acres of land, it is the nation's 11th largest state yet only ranks 40th in population. Even though it is one of the fastest growing states in the U.S., its population just recently surpassed one million people. In fact, there are more sheep and cattle in Idaho than people.

Idaho has a rich historical heritage. The Lewis and Clark expedition crossed the Bitterroot Range at Lola Pass and followed the Selway and Clear-water Rivers to the Snake River in 1805.

Between 1842 and 1860, three hundred thousand emigrants traveled west along the Oregon Trail. One hundred fifty years later, wagon ruts are still visible along the 580 miles of the trail crossing southern Idaho. The 150th anniversary of the trail was celebrated in 1993 through the successful cooperation of BLM and numerous other organizations.

In 1846, Idaho was acquired by the United States as part of the American territory agreed to in the Webster-Ashburton Treaty with Great Britain. Idaho Territory was created in 1863. It included Montana until 1864, and most of Wyoming until 1868. On July 3, 1890, Idaho became the 43rd state.

Almost two-thirds of Idaho is federally owned. The Bureau of Land Management administers nearly 12 million acres or about 22 percent of the land in the state. This land encompasses a wealth of natural and historic resources.

Public land administration has come a long way since the passage of the Taylor Grazing Act of 1934 and the inception of the BLM in 1946. Demands on the resources are continually increasing and becoming more diverse. Laws and regulations that guide our management are infinitely more complex than they were just a few years ago. The challenges that face us are considerable, but the Bureau of Land Management in Idaho is ready to meet those challenges in a professional manner and forge ahead into new frontiers of land stewardship thru Ecosystem Based Management.

To provide you with an idea of the scope of the task facing BLM, let me acquaint you briefly with some of the unique resources in our care and some of the critical issues we are tackling. BLM administers almost 1,800 miles of spawning and rearing habitat in the Pacific Northwest: 70 percent of which occurs in Idaho. Sockeye salmon were listed as an endangered species in November 1991 and three races of Chinook salmon were listed as threatened in May 1992. Listing requires federal agencies to avoid any further losses and undertake actions to recover the species. Section 7 of the Endangered Species Act requires federal agencies to consult with the National Marine Fisheries Service to determine if proposed actions comply with the act. BLM has reviewed all ongoing actions, including livestock grazing, recreation, mining, timber harvest, and road construction and maintenance to determine which activities "may affect" the listed salmon species. Hundreds of biological evaluations and assessments have been prepared and consultation is proceeding. This is a tremendous workload which greatly influences how these traditional public land activities are conducted. I can assure you the BLM is committed to protecting the habitat of these listed species.

The Snake River Birds of Prey Area, located just outside Boise, has the highest known nesting density of raptors in North America. Over 700 nesting pairs of 15 different species of eagles and hawks occur within this area, most of which is managed by BLM.

Major populations of deer, elk, moose, and Rocky Mountain bighorn sheep winter on BLM land. Approximately 95 percent of the California bighorns, 80 percent of the antelope and 80 percent of the sage grouse populations in the state are dependent upon BLM land for habitat.

Threatened and endangered plants also are important components of the ecosystem on public lands. The Coeur d'Alene District has developed a recovery plan for MacFarlane's Four O'clock, Idaho's only endangered plant species.

A 119-miles stretch of the South Fork of the Snake River in eastern Idaho has been identified by the U.S. Fish and Wildlife Service as Idaho's most important cottonwood riparian ecosystem. It is also one of the most significant bald eagle nesting areas in the United States, producing about one-half of the bald eagles born in Idaho.

BLM is cooperating with the Idaho Department of Fish and Game, Ducks Unlimited, and the Idaho Nature Conservancy to conserve and improve fish and wildlife habitat in the Thousand Springs/Chilly Slough areas. These areas contain a wide diversity of wildlife as well as a highly productive trout fishery, and public recreational opportunities.

Recreational use of public lands has mushroomed in recent years. The river management program involving the Lower Salmon, Bruneau/Jarbridge, and Owyhee Rivers has received national recognition. New programs, such as watchable wildlife, cave management and management of BLM's Back Country Byways, are rapidly expanding. Tourism is the fastest growing industry in Idaho and BLM provides recreation sites and unspoiled lands that draw travellers from around the world.

Range Reform and changes in the mining claim fee structure have had a profound impact on the workload of the BLM in Idaho and elsewhere. Thousands of public inquiries have had to be answered regarding these complex, ongoing issues. Just last Wednesday, over 50 formal hearings were jointly held with the USFS throughout the west to obtain public comments on the administration's Range Reform 94 proposals, The Clean Water Act amendment of 1987 placed additional emphasis on nonpoint source pollution control by requiring BLM to meet the requirements of the State of Idaho Nonpoint Source Management Program and the Idaho Antidegredation Regulations.

Third-order soil surveys have been completed on approximately 97 percent of the public lands in Idaho, with Butte County the last major mapping effort in the state. The soil surveys are being correlated with the range sites and habitat types. New soil initiatives will center on the assessment of ecosystem health.

Management of various programs, such as soil, water, range, wildlife, forestry, minerals, lands, recreation, and others, has been the traditional means of administering the wide array of resources and uses of the lands the BLM administers. However, the emphasis is shifting towards Ecosystem Based management of the entire state.

Idaho BLM is at the leading edge of this conversion to ecosystem-based management. The State of Idaho has been divided into four ecoregions: the Upper Columbia River, Salmon/Clearwater Rivers, Lower Snake River and the Upper Snake River. These ecoregions have been further subdivided into ecosystem management areas. At the present time, 10 ecosystem management areas have been designated. Additional ecosystem management areas will be designated as the process continues.

The ecosystem management process within BLM will rely strongly on interdisciplinary teams to develop and implement on-the-ground management. Cooperation between federal and state agencies, user interest groups and conservation groups will be essential to the success of ecosystem based management. Ecosystems do not conform to political and agency boundaries and they must be managed, to the greatest extent possible, without regard to traditional administrative lines on maps. However, that doesn't infer that management of private land will be dictated by federal agencies.

Hopefully, we can work together with private landowners to build partnerships and develop a consensus about making good land stewardship decisions that will benefit all interested parties.

Soil has been described as the "Placenta of the Ecosystem" since it nourishes all the other components of that system. Protection of that placenta is critical to the preservation of health, function, and inherent productive capability of the ecosystem. Mush of the species richness and diversity of ecosystems is encompassed in the soil mantle. Thousands of microbial and macro-invertebrate species and associations of these species are present in surprisingly small volumes of soil. We need to discover more about how our management of the land impacts these and other components of the soil. Our prosperity, and ultimately our very survival, may depend upon the answers to these questions.

I know you have a full and informative agenda for your sessions this week. I hope you can tackle some of the critical issues facing all of us as we move into ecosystem based management.

Again, I want to sincerely welcome you to Idaho.

Welcoming Remarks

1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

Ed Burton

Deputy State Conservationist

Soil Conservation Service

Spokane, Washington

Welcome to the West/Midwest Regional Work Planning Conference. We extend a special welcome to our friends/colleagues from the Midwest region and to the field and area soil scientists who are able to be here this week. We extend special thanks to the Coeur d'Alene division of the Bureau of Land Management for their effort to host this conference. We are anxious to show our geographic area to you and to team up with our cooperators during this conference to discuss ideas and strategies to take us into the future. There are many new challenges for each of us with downsizing, reinvention/reorganization efforts and new and increased requests to meet our customer's needs.

We have a beautiful, unique area which provides the classroom/laboratory for this workshop. Continental and alpine glaciation created the U-shaped valleys and the lakes of Worth Idaho and Northeastern Washington. The numerous failures of Glacial Lake Missoula created the Channeled Scablands of Eastern Washington and the volcanoes of the Cascade Mountain Range have provided the unique parent materials for the Andisols of this area. Your Wednesday field trip will provide you the opportunity to see much of this first hand.

There are about 360 million acres of Federal land and about 400 million acres of nonfederal land in the West. It is often intermingled in complex patterns which provides unique opportunities to partnership in our soil survey efforts. There are numerous opportunities for resource inventory and management, for developing and improving interpretations and transferring technical data to our customers. With the computer hardware/software technology that now exists and our needs as partners, it is important that our data bases are accessible by ALL cooperators in the National

Cooperative Soil Survey (NCSS) program. In Washington, the Forest Ecosystem Management Assessment Team (FEMAT) and the East Side Forest Assessment Project are examples of new opportunities for cooperation among agencies in the NCSS.

Not only is land use varied in the West, traditional uses such as timber production, recreation, irrigated and dryland crop production, and livestock grazing are now impacted by new pressures and expectations, especially at the urban/agriculture interface. This provides soil scientists with new customers, new challenges and the need for innovative resource management systems to protect these resources. Water quality programs of some form are being required or considered by all levels of government. Land owners and users need current, accurate soils information to make natural resource planning and implementation decisions.

There are about 127 active soil surveys in the west. Ninety-five are on nonfederal lands and 32 are on Federal lands. There are about 220 million acres yet to be mapped in the West. For example, Washington State has about 700,000 acres of nonfederal lands not yet mapped for a "once over". However, we have another 4 million acres that need to be updated/remapped to meet customer needs. Several million acres of other lands have the need to be updated or make soil surveys to meet the NCSS standard level.

The lands of the West are varied and access is often limited because of the ruggedness of the resource we are attempting to inventory/manage. Landscape, climate, geology, and plant community diversity also dictates the number of soil series that are mapped and the number of soil interpretation records needed to provide interpretations for our customers. Of the approximately 16,000 soil series recognized in the U.S., roughly 10,500, or 60 percent, have been proposed and are used in the West. About 70 percent of the 30,000 soil interpretation records (SCS-SOI-5s) are used in the west. Again, this generates a lot of data to store, manipulate and access. There is also a demand for new data from our customers which needs to be supported by ADEQUATE field and laboratory observations so that the data provided are reliable and can be certified. There is no substitute for quality data in any program.

The West, particularly AK, CA, ID, OR, and WA, have most of the soils now recognized as Andisols. The need to properly inventory these soils has created a tremendous workload for the reclassification effort and a large workload exists to quantify and quality the soil properties that need to be entered into soil databases so that the data can be certified. This is an area where partnering with our cooperators will be useful in generating this data.

Workloads generated by soil correlation, reclassification, phase 1 National Soil Information System (NASIS), emerging issues (wetlands), along with downsizing, has created a situation where many of our internal and external client requests for information and services are no longer being provided. The demand for soils information and, therefore, soil scientists, if anything, is going to increase.

The challenges to meet our responsibility of the wetland program will further tax our ability to provide timely, quality, traditional services to our clients. This and other new responsibilities will require some new levels of cooperation among NCSS cooperators as this workload will create shifts in priorities and staffing needs. This is a time to build on what we have and look for new opportunities for cooperation. This increasing demand for accuracy, current data and more of it is a challenge to the members of the National Cooperative Soil Survey to be creative in addressing user/client needs and to expand and enhance partnerships.

The National Cooperative Soil Survey and the partnerships we have are a fine example of working together, making the best use of available staff and resources to provide a product that benefits society and our ability to manage for ecosystem health. I commend you for your contribution.

Enjoy your stay here. If we can be of any help to you, let us know. I wish you a successful conference and an enjoyable week.

Welcoming Remarks

1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

David F. Jolly

Regional Forester

Forest Service

Northern Region

On behalf of the Forest Service, let me welcome all of you to Coeur d'Alene in beautiful northern Idaho. I appreciate this opportunity to share some thoughts with you concerning Ecosystem Management and the role of the National Cooperative Soil Survey.

The Forest Service has managed ecosystems since its inception; so have many other Federal and State agencies. That management has often focused on selected parts of ecosystems rather than on whole ecosystems or on the processes that keep ecological systems healthy, diverse, and productive. Our knowledge and thinking have evolved. We are now embarked on a course of managing ecosystems to sustain both their diversity and productivity while at the same time laying the foundation for sound multiple-use, sustained-yield management. I want to offer some thoughts on what is different about management today as compared to the past, define Ecosystem Management, and suggest some principles for Ecosystem Management.

First, what is different today than in the past? Today we find that:

1. people need and want a wider variety of uses, values, products, and services from the land:

2. new information and a better understanding of ecological processes emphasizes the role of biological diversity as a factor in sustaining the health and productivity of ecosystems and the need for integrated ecological inventories at various scales to support ecosystem management;

3. people outside the Forest Service and other Agencies want more direct involvement in the decision-making process: and

4. the complexity and uncertainty of natural resources management calls for stronger teamwork between scientists and resource managers in all Agencies.

An ecosystem is a community of organisms and its environment that functions as an integrated unit Ecosystems occur at many different scales and change over time. They do not have natural boundaries: they grade into others and are nested within a matrix of larger ecosystems.

Ecosystem Management means the use of skill and care in handling organisms and their environments. It implies that the system is the context for management rather than its individual parts. It is the means to an end, not an end in itself. We do not manage ecosystems just for the sake of managing them. We manage them for specific purposes such as producing, restoring, or sustaining certain ecological conditions: desired resources uses and products: and aesthetic, cultural, or spiritual values. Put another way, ecosystem management means to product desired resource values, uses, products, or services in ways that also sustain the diversity and productivity of ecosystems.

What them, are some key principles for Ecosystem Management? I would suggest these:

1. Manage for diversity and sustainability: Multiple-use, sustained-yield management depends on sustaining the diversity and productivity of ecosystems at multiple geographic scales.

2. Recognize that ecosystems are dynamic and complex: Future conditions are not perfectly predictable and any ecosystem offers many options for uses, values, products, and services which can change over time.

3. Define desired future conditions: Descriptions of desired future conditions for ecosystems should integrate ecological, economic, and social considerations into practical statements that can guide management activities.

4. Management must be coordinated: Ecosystem connections at various scales and across ownerships make coordination of goals and plans essential. Landscape and regional scales are increasingly important in analyses and management guidelines. However, this does not translate into a right to regulate private property rights or dictate the actions

of other landowners. We are partners and cooperators in ecosystem management, not regulators.

5. Data needs to be integrated: *In* order to support integrated management of lands and resources, inventories and data should be integrated. This is one area in which the National Cooperative Soil Survey can play a key role.

6. Management and Research should be integrated: Monitoring and research should be integrated with management to continually improve the scientific basis of ecosystem management.

In conclusion, let me state that the knowledge and understanding of soils has always been and will continue to be integral to our understanding of ecosystems and how they function. Scientific, integrated inventories are key to the further development of our knowledge base.

Once again, welcome to Idaho. I wish you an enjoyable and productive conference.

1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

Agency Report

Richard Arnold

Director, Soil Survey Division

Soil Conservation Service

Washington, D.C.

Country-wide Forums. There are 2 kinds. One deals with ideas for the 95 Farm Bill. What changes may be desirable or needed? Conservation Reserve Program receives a lot of attention as contracts are completed and land may go back into production. Interest in soil and water quality, as discussed in the recent National Research Council report, addressed the importance of maintaining and improving the quality of soil and water resources.

Another set of forums, we call then the Chief's Forums, are concerned with how best to serve the needs of the country. Should the mission be modified? Is a natural resource conservation service, NRCS, an appropriate mechanism?

It is an opportunity for everyone to have a say. We are interested in your comments, your suggestions, your concerns. There will be meetings all across the country. Tell us what you think. It is for employees of SCS, FS, BLM, BIA, NPS and all other agencies. It is for university folks, special interest groups. It is for individuals - farmers, ranchers, foresters, wildlife specialists, energy, conservation, production, protection, stewardship, urban folks, rural folks, everyone who cares. Please take part; in person, in writing, on the hotline, and encourage others.

Restructuring of USDA. Secretary Espy is waiting for Congress to give its approval to re-organize the USDA, to go from about 40 offices and agencies to something in the 20's, to downsize even further, to close some offices and combine others, to make USDA more responsive and efficient. Things are somewhat on hold. After the buyout (about 1,000 of 13,000 employees), it is necessary to re-think how to cope with our responsibilities. State realignments are occurring. Will SCS have another buyout? I don't know - if so it likely will be a directed effort to protect certain job series and encourage others to leave. No definite word as yet. Most everyone is on an interim staffing plan; a consolidation process, a time of re-evaluation, and thinking about what we likely can do and cannot do. NHQ will probably be re-aligned but not right away. Chief Johnson wants to hear more of the "heartbeat" of America - then make a move.

Budgets. Well, I've already told you the good *news.* The bad news is the frustration of adapting to unwanted changes. A subcommittee of the House did a mark-up of 95 budget - OUCH! Do Wetland6 but we'll cut out other activities. For example, greatly reduce river basin and watershed activities. Soil survey is looking at a 1993-like budget - no pay increase, no inflation, no $2.5 M for digitizing, no $6 M for orthophotoqraphy. If that is to be our budget, we will have to juggle priorities more than anticipated. We fare better than some other SCS programs, but that makes us a higher percent of the budget and that means covering more off-set for the agency.

Soil Survey. We report to the Deputy Chief for Technology, Richard Duesterhaus. Rich was previously the Assistant Chief for the Northeast. He's a fine person and will very capably lead us through the transition. The Soil Survey Steering Team is functioning fairly well. A lot of tough decisions now because of budgets, re-thinking of SCS priorities, little stumbling blocks and the like. But they are getting better all the time and we have a strong commitment to a total Soil Survey program.

Based on your comments, suggestions, and criticisms, we have started to flush out the Soil Survey Program Plan into a real strategic plan that tells us our objectives, where we are *now*, where we want to be, what we are doing to get us there, and how we measure our progress. We currently have 5 strategic issues and 24 specific objectives. It is a flexible document. It begins to meet the national performance policies of the U.S. Government.

The Future. Our strategic issue number 3 is to provide a basic inventory of soil information for the entire country that is produced according to NCSS standards and procedures. We really believe this. The people of the U.S. deserve the best information possible that is consistent and relevant. How should we achieve this? Are there things we could be doing that we aren't doing now? The Federal Geographic Data

Committee (FGDC) is charged with making geographic data meet standards and be readily available. This sounds OK but the implications are staggering - how to get U.S. soil surveys in a coordinated, integrated database that everybody can tap into - a big job - tough to comply with these new regulations.

Please consider ways to do the right things for the right reasons. Should USDA efforts in soil inventory be combined? Only the mapping and GIS? Whole reports? What about data application - technical soil services - keep separate or handle jointly? Lots of unanswered questions - but some truly interesting opportunities to serve the needs of society.

What about coordinating surveys for the whole U.S.? All private and all public lands. Would Congress entertain such a request - do the people of the U.S. desire efficiency and effectiveness for their tax dollars?

Think about it - talk about it - let us know. Go to the Forums, write letters, get active, get involved. It's your Soil Survey - where do you want it to go? Where should we be in the 21st Century? How can we best serve the best interests of the folks of the U.S.?

We have proposed a number of alternatives for the SCS top staff and our Assistant Secretary to consider - they are doing that and will offer us their opinions soon. The next century will surely be exciting - no matter which path we follow.

Thanks.

1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

Agency Report

Glenn Bessinqer

Soil Program Lead

Bureau of Land Management

Washington, D.C.

Ecosystem Management and Soil Surveys in the BLM

In the Bureau of Land Management, we're working towards implementation of ecosystem management. And, like many other agencies, our concept of ecosystem management is not yet solid. There seems to be many ideas and perceptions on how to approach the concept and, just possibly, we may never adopt a single approach.

To better accommodate ecosystem management, we are going through some significant changes in the BLM. Our organizational structure, at all levels, is being revised. And, probably of greater significant, our budget process is changing from program specific to a project basis - a very positive change in regard to our ability to manage the soil resources on the public lands.

The common ecosystem management buzz terms I consistently hear are capability, sustainability, diversity, and health. And, the definitions for these terms are found, to a very large degree, in the soil ecosystem.

As a result, I believe that ecosystem management provides the soil profession an excellent opportunity to assume a leadership role in public land management. Our knowledge, and the analysis and application of soil information, is a prerequisite to virtually all land use decisions; a fact that becomes more and more apparent to managers and other resource specialists as we begin to manage ecosystems and not uses such as mining, grazing, and the like.

As all of you know, the traditional soil survey is the premier process for identifying ecological baselines. The survey provides more than just soil information. It provides the ecological setting for the landscapes we manage.

But, it seems to me, that the use of the information is relatively limited. And, I'm not sure exactly why. Maybe it's because we haven't adequately demonstrated and nor sold it's utility to management and others. Is it because we've been too focused on the collection of the data itself and not the interpretation and on-the-ground applications?

Whatever the reasons, it is becoming more and more difficult for us to get the priority and budget we need for soil surveys. To help mitigate this situation, the soil survey strategy being developed is that:

1. New soil surveys will be conducted only as part of an interdisciplinary efforts to gather and apply ecological information - ecological inventories vs. soil surveys:

2. Priority for ecological inventories within the BLM will be based on more immediate management needs, consistent with planning schedules, budgets, and other measures. We cannot afford what I call a "blanket" goal like, "100% coverage by a specific date." It just will *not ever* happen: and,

3. Established project management tools and techniques will be used to plan and control inventories. We must:
   - Have direct management involvement;
   - Meet our schedules and budgets; and,
   - Get the type and quality of information we need.

Other objectives that we are working towards that will help us meet our goal for soil resource management in the BLM includes:

- Modernization of our business systems, especially through automation. Our information must be automated and the professionals highly computer literate.

- Human Resource Development through training and recruitment of a work force that is culturally diverse and have new ideas. Knowledge and background in system ecology must be stressed in training and recruitment.

- Outreach activities to increase internal and external cooperation and coordination through education and direct participation.

- New Science centered around soil ecological systems. We need to go way beyond the relatively well known physical and chemical aspects of the soil and increase our capability in understanding the biological systems of soils.

The bottom line, as I see it, is that soil resource management will be even more critical with ecosystem management. Soil surveys will become true ecological inventories. The soil scientists will work in interdisciplinary teams oriented towards total ecosystems. We will conduct our work in a much more structured and business-like manner to help assure our success. And, the work environment will be more collaborative, modern and automated.

1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

Agency Report

Wayne A. Robbie

Soil Scientist

Forest Service

Albuquerque, New Mexico

The Forest Service is pleased to participate in this conference. Our agency has a long history of involvement to the National Cooperative Soil Survey and looks forward to maintain this involvement. The Forest Service is very active in promoting the concept and principles of Ecosystem Management. Therefore, the theme is most appropriate and timely. Some of the activities that we, as an agency, are currently involved in that relate to ecosystem management include the development of the National Hierarchical Framework for Ecological Units, continued advancement in the design of a database structure for pedon and site information and supporting environmental research with emphasis on forest and rangeland ecosystems as related to soil quality.

The National Hierarchical Framework of Ecological Units is a product that assigned by the ECOMAP steering committee at the Washington Office. It's development had the involvement of many soil scientists within the National Forest Systems, Forest Service Research and other Federal Agencies. The purpose of the framework is to organize a multiscale approach to the classification and mapping of terrestrial ecosystems. This framework will be presented later in the conference. The Forest Service will utilize this framework for analysis, planning and research when considering multiple factors in assessing ecosystem composition, structure and function along with the frequency, magnitude and extent of ecosystem processes.

The Forest Service has developed a database to store and retrieve pedon and site information. SORIS (Soil Resource Information System) is an Oracle application in a relational format. It is currently being reviewed by our Regional Soil Scientists. The design of its structure, and data elements and definitions are believed to be compatible with other agencies efforts in database development. It is designed to have portable features to ensure data transfer and exchange.

Concurrently, with the development of SORIS, there is an ongoing effort to develop system-generated applications to provide analysis and interpretations. This effort involves the design and testing of models that process site or pedon data. As this effort continues to evolve, additional applications will be recognized and added.

The soils program of the National Forest Systems in cooperation with Forest Service Research are continuing the National Long-Term Soil Productivity Study. While primarily focused on forest ecosystems and the types of management activities associated with this environment, it is now being proposed to expand this study to rangelands which would include desert, grassland and Pinyon-Juniper woodland ecosystems. Specific attention would focus upon the types and effects of cultural activities and management practices that include recreation, grazing and fuel wood harvesting. These ecosystems occupy large areas of the landscape and are significant with respect to production of products and contain inherent values to local communities.

In closing, the Forest Service is advancing rapidly in gaining knowledge, organizing our knowledge and distributing our understanding about ecosystems and their management. Our role within the National Cooperative Soil Survey will continue to share information and contribute to the advancement of soil science.

WESTERN REGION EXPERIMENT STATION REPORT AT NATIONAL COOPERATIVE SOIL SURVEY CONFERENCE, BURLINGTON, VT.
(This Report Compiled by E.F. Kelly)

A brief summary of the Soil Survey activities in the western region was presented. This summary was compiled from responses to a questionnaire submitted to each of the Agriculture experiment station cooperators. Reports by individual states follow the questionnaire summary.

1. Principle research activities at present:

Much of the focus of the applied research in the western region relates to the environmental aspects and application of soils information to water resources. Major areas of research within the region include: 1) Wet soils research, 2) Water quality of runoff from agricultural land, 3) Soil vulnerability to ground water contamination, 4) Erosion control, and 5) Grazing impacts on soils and the environment.

Basic Pedology research in the region related to the use of soils in Climate Change and Global Change Research. Specific projects include: 1) Changes in Soil Chemistry induced by different plant communities, 2) Loess stratigraphy and landscape evolution, 3) Geochemical mass balance, 4) Host of mineralogical investigations, 5) Global Change, 6) Soils & Paleoclimate, 7) Soil Response to changing C02, 8) Soil Climate studies, 9) Land use Changes on soil biogeochemistry.

2. Principle sources of funding for your research:

Experiment station cooperators are under a considerable amount of pressure to generate research dollars due to reductions in Hatch Formula funds. Many cooperators receive minimal support from the university to be directly involved in NCSS activities other than travel to and from regional workshops. The majority of money received comes from contracts and grants with subject areas and funding sources aligned as follows:

Water Quality	Global Change	Other
SCS	DOE EGG	TNC
EPA	NASA	Dept of Defense
DEQ	NSF	
Dept of AG		
Water resources		
USDA		

3. Number of graduate students:

Based on responses graduate students in the region were listed as follows: MS = 19, PhD = 12. It would be interesting to see how other regions compared. Funding constraints again seem to limit the number of graduate students in individual programs.

4. Principle teaching Activities:

A re-orientation of the pedology positions outside of traditional agricultural applications requires the experiment station cooperators to develope and teach courses outside of the traditional soil genesis, classification and survey and related courses.

Traditional Courses

Introductory soils
Soil Morphology and Survey
Soil Genesis and Classification
Mineralogy
Soil Judging

New courses (Non-Traditional)

Biology of the Soil Environment
Agroecology
Environmental Applications of Soil Science

Environmental soil science
Wetland Science
Soil Ecology

5. What changes have you made in your curriculum or courses in recent years that you feel meet the changing needs of the soil science community ?

Many of the Universities are now designing curriculum which addresses issues outside of the agricultural applications of soils. Many cooperators indicated that emphasis is now being placed on issues such as Global change, environmental application of soils information and ecological applications of soil science.

6. Involvement in Soil Survey activities:

Many of the cooperators indicated limited involvement in field soil survey activities (Field Reviews) due to time constraints and budget limitations that influence travel. Cooperation in soil survey activities is now directed toward areas that require little travel away from the university and where university facilities and expertise can be utilized. These activities include: 1) Education sessions, 2) Training Sessions, 3) Workshops, 4) Consultation on issues and Policy, 5) work planning conferences, 6) conduct lab analyses for survey, 7) Respond to information requests

7. What limits the extent of your involvement in NCSS:

Major limitations in NCSS activities as noted by respondents were 1) Drastic cuts in Ag Experiment station budgets, 2) No time for field reviews or manuscript review, 3) Little credit given for service activities (This is how the NCSS activities are perceived by higher administration), 4) heavy emphasis on external funding (now salaries are being included), 5) Publish or perish, 6) lack of active surveys nearby

8. Other general comments:

Many University cooperators indicated that budget cuts have left little time to participate in NCSS activities. Most Universities are now at a critical mass in terms of personnel involved in NCSS and related activities. Under ideal circumstances some cooperators noted that each university could use another pedologist for service activities. At many universities extension and research positions are being cut as retirements occur. Clearly our involvement will be based on creative ways to conduct basic pedology research, this will be the direction of NCSS experiment station cooperators in years to come. Many cooperators believe that increased cooperation with NCSS could help strengthen develop new directions in soils research.

Most cooperators agreed that the time is right for a re-thinking of how the NCSS can become a highly publicized and successful government program.

ARIZONA

Dr. David Hendricks

Research projects are as follows: 1) concerned with comparing the nature of soils on forested northern slopes with grass covered southern slopes of Green's Peak, a high elevation cinder cone, 2) A study is of the Andisols and related soils of the San Francisco Volcanic Field near Flagstaff, 3) A study of soils along a climosequence on the island of Hawaii in cooperation with the Jet Propulsion Laboratory, CSU, the SCS and others, 4) Research concerning the geomorphology, and genesis of soils formed on a sequence of marine terraces near the Mendocino triple junction.

Served as co-chair for the Western Regional Soil Survey Conference and led the field trip for the conference held in Flagstaff in 1992. Occasionally participate in field reviews.

Teaching responsibilities included: Soil Chemistry, Soil and Environmental Chemical Analysis, and Soil Genesis.

CALIFORNIA (U.C. Berkeley)

Dr. Ronald Amundson

Research activities center on the following: 1) use of Stable C and 0 isotope research on soil and plant carbonates and their relationship to climate, 2) Processes controlling ^{14}C in soils, 3) Use of paleosols in environmental reconstruction. In terms of direct soil survey activities I have served as an Informal collaborator on genesis of soils as related to Fresno County soil survey.

Teaching Responsibilities included: Soil Genesis (lectures and field trips), Summer field course, Graduate Seminar. Actively involved in training of graduate students in Isotope geochemical analyses of soil organic matter, minerals and plants.

CALIFORNIA (U.C. Riverside)

Dr. Robert Graham

Research activities are as follows: 1) Weathered granitic rock: hydraulic properties, plant utilization, genesis, geomorphic distribution, and pedologic processes, 2) Decade-scale genesis in a biosequence of native plants at the San Dimas Experimental Forest lysimeter installation, 3) Climatic gradient (457-2795 mm MAP) of mesic serpentinitic soils in the Klamath Mountains, California, 4) Use of near- and mid-IR for mineral identification across a plutonic contact in Baja California, 5) Pedologic and geomorphic processes on a marine terrace sequence in central

coast California. NCSS activity limited by the lack of **active** soil surveys in area.
Teaching responsibilities included: Soils of Southern California (each year), Soil Mineralogy (odd-numbered years), Soil Mineralogy Lab (odd-numbered years), Pedology (even-numbered years).

Department also created a viable soil science option in our environmental science undergraduate program and established an introductory soil science course with a choice of two labs, one of which emphasizes soil survey reports and land-use planning; the other emphasizes the fundamental subdisciplines of soil science. A new course titled, "Biology of the Soil Environment" has been added. It emphasizes biogeochemical cycling, bioremediation, and other soil-plant-microbe relations not targeted by traditional soils courses.

COLORADO

Dr. Eugene Kelly

Research Activities Centered on the following: 1) the use of stable C and 0 isotopes in soils research, 2) Holocene Paleosols of the central Great Plains and their use as proxies for paleoclimate, 3) Paleoclimate of the Pacific NW (with WSU-Busacca), 4) Organic matter dynamics in Great Plains and tropical environments, 5) Climosequence on the Island of Hawaii (develop isotopic characterization of silicate clays w/JPL, UA, CASE WESTERN RESERVE, SCS), 6) Isotopic composition of soil water (JPL-Chadwick) an its utility in modeling the hydrologic regime of arid and semi-arid ecosystems.

Soils survey activities are now limited to the publication of "Soil Survey of CPER", workshops, work planning conferences, and conducting analyses for NCSS of Colorado. There may be an opportunity to provide some basic pedological research and technical support for the Soil Survey of Rocky Mountain national Park. Past Chairman of WRCC-93, Currently serving on Technical Advisory Committee to NSSC.

Teaching Activities included: Soil Genesis and Survey (fall), Forest and Rangeland Soils (fall), Advanced Soil Genesis (w/Univ of WY class is taught spring), Wetland Science (team taught by hydrologist, ecologist, pedologist), Environmental Soil Science (team taught), Soil Judging. Most courses now focus on the environmental applications of soil science.

Department has decided to change name from Agronomy to Dept of Soil and Crop Science. Department now offers an under graduate concentration "Environmental Soil Science".

HAWAII

Dr. H. Ikawa

Research Activities included: 1) Determine tree performance (native koa, loblolly and Caribbean pines) in a three-elevational transect on island of Maui, 2) evaluate tree performance (native koa) as related to chemical and biological properties of Andisols, Oxisols, and Ultisols on the islands of Hawaii and Oahu. Participate in the soil survey of the island of Hawaii being conducted by the SCS--field review, sample collection for selected laboratory characterization (15 & 1/3 bar water, mineralogy). Update the classification of Andisols, Oxisols, and Ultisols of Hawaii.
Hawaii State Governor's Agricultural Coordinating Committee, McIntire-Stennis funds, Hatch funds, State funds, U.S. Forest Service, U.S. Fish and Wildlife Service

Teaching Responsibilities: Introductory soil science (4 cr.); soil formation and classification (4 cr.) Teaching now has more emphasis on environmental awareness

IDAHO

Dr. Paul McDaniel

Research Activities include the following: 1) Influence of eolian parent materials on genesis, classification, and properties of Idaho soils, 2) Epiaquic conditions in fragipan-dominated landscapes, 3) Genesis of E horizons in ash-influenced forest soils, 4) Changes in soil chemistry induced by successional plant communities in the Grand Fir Mosaic Ecosystem (We are studying the effects of bracken fern/coneflower communities on soil pH and potential Al^{+3} toxicity in clearcut areas of central and northern Idaho), 5) Aggradational and erosional history of the Radioactive Waste Management Complex, Idaho National Engineering Laboratory.
Attend a limited number of field reviews and work-planning conferences and have helped with organization of recent NCSS-related field trips. University laboratory has also provided a few analyses and chemicals to assist some of the active surveys. I do not actively participate in review of materials such as soil survey manuscript, proposals for new series, and other technical documents, although these materials are circulated to me for comment. New Chairman WRCC-93.

Teaching Responsibilities include: Soil Judging, Soil Development and classification, Advanced Soil Genesis, Soil Mineralogy (team-taught).

Recently changed our curriculum to offer 3 options under the Soil Science B.S. degree: 1) Agroecosystem Management, 2) Environmental Science, 3) Land Resources. We currently offer a soils course entitled 'Pesticides in the Environment' and will soon offer one entitled 'Solute Transport in Porous Media'.

NEW MEXICO

Dr. Curtis Monger

Research Activities focus on Soil-geomorphic response to climate change in the now arid regions of the Southwest. Act as the Liaison to New Mexico National Cooperative Soil Survey.

Teaching responsibilities include: Soil Morphology and Classification, Soils-Land Use, and the Environment, Soil Genesis,
Introductory Soils

We have modified the Soils and Land Use course to emphasize the environmental aspects of soil science

OREGON

Dr. Herb Huddleston

Research activities: 1) Wet Soils Research (we're one of the national sites for monitoring of water tables), 2) Ponded Hydric Soils Research (determine the distribution of ponded areas in farm fields and their correlation with geomorphic surfaces and hydric soils), 3) Evaluation of Soil Vulnerability to Groundwater Contamination by Pesticides, 4) Environmental Applications of STATSGO Maps and Databases - we're using STATSGO, in conjunction with a comprehensive database on pesticide uses on crops in Oregon, to prepare generalized maps of the distribution of uses of specific chemicals. We're also using STATSGO to prepare maps of hydric soils in Oregon, maps of soil-pesticide vulnerability ratings, and perhaps to show the distribution of ponded soils, 5) Water Quality of Runoff from agricultural land.

Soil Survey Activities include an occasional field review, providing Leadership for education session for introducing new soil survey reports, Participation in SCS soil scientist training sessions and workshops, Communication and consultation with State office staff on issues and policies, Participation in annual work planning conferences.

Teaching Responsibilities Include: Soil Morphology and survey, Soil genesis and classification, Environmental Applications of Soil Science, Soil Judging workshops, Each year we prepare students for competition in the regional contest in the fall, then use the winter term to prepare for national competition, which then occurs in the spring term. This year Oregon State hosted the national soil judging contest.

We have made an attempt to integrate our teaching of soil physics, soil chemistry, and soil biology, into a 3-term sequence: Properties of Soil Ecosystems (Fall term), Soil Ecosystem Processes (Winter term), and Soil Ecosystem Modeling (Spring term).

UTAH

Dr. Janis Boettinger

Research Activities include: 1) Soil genesis and soil chronofunctions related to Pleistocene glacial chronology of the north slope of the Uinta Mountains, 2) Mechanisms controlling concentrated flow erosion in gypsiferous soils: A pedologic approach (collaboration with L.D. Norton, USDA-ARS), 3) Soil characteristics and relation to on-site and remotely sensed soil moisture, vegetation type and cover, and evapotranspiration in a typical Great Basin valley, 4) Zeolite occurrence and stability in soils (collaboration with R.C. Graham, Univ. Calif., Riverside), 5) Ammonium absorption characteristics of a clinoptilolite (zeolite) from northern Utah (collaboration with L. M. Dudley, P.T. Kolesar, USU).

Hosted the 1992 FY Utah Cooperative Soil Survey Planning Conference and Field Trip, St. George, UT,. Involved National Cooperative Soil Survey personnel and objectives in my research program. Also respond to information requests, try to find students for temporary jobs and student coops, etc. WRCC-93 representative to the NCSS Standards Committee.

Teaching responsibilities include: Soil identification and interpretation (name change soon to be in effect: Soil Genesis, Morphology and Classification), General Soils, Pedology.

Developing a new undergraduate curriculum in soil and water sciences. The new major, called "Environmental Soil-Water Science" is designed to replace part of the old "Plant and Soil Sciences" major. This major is designed to give students a strong background in basic sciences and math; an understanding of the physical, chemical and biological processes and interactions in the soil-water zone at the earth's surface; and a choice of specializing in soil, water, or an integration of soil and water.

WASHINGTON

Dr. Alan Busacca

Research Activities Include: 1) Stratigraphy and interpretation of paleosols in loess, 2) dust entrainment and human health 3) soil-landscape survey

Minimal involvement in NCSS activities. Provided some soil geomorphology assistance and NSSL lab sampling; state generalized soil map

Teaching Responsibilities Include: Soil genesis and morphology (undergrad and grad), World agricultural systems. Our Department added an option in "Environmental Soil Science" to the B.S. in soils.

WYOMING

Dr. Larry Munn

Research Activities include: 1) Influence of soil properties on forest productivity, 2) Vulnerability of groundwater to pollution from nitrate and pesticides, 3) Use of RUSLE to estimate erosion.

Soil Survey activities involved coordination the distribution of STATTSGO to GIS users at UW.

Teaching Responsibilities Include: Introductory Soils (Spring semester), Soil Morphology, Genesis and Classification (Fall semester), Advanced Soil Genesis and Classification (Spring, alternate years), Agroecology (Introductory) (Spring, team taught)

Dropped our undergraduate soil science major. We dropped undergraduate degrees in Soils, Crops and Entomology and replaced them with a degree in Agroecology. We have recently added courses in Soils in Environmental Quality and Chemistry of Reclamation Materials and Soils. We have hired a Soil Physicist starting in August 1993 to emphasize soil water. We still offer a program whereby a student can qualify as a Soil Scientist on the federal register.

MIDWESTERN REGION AGRICULTURAL EXPERIMENT STATIONS

REPORT

Dr. Pierre C. Robert, University of Minnesota

I. SOIL SURVEY PROGRAM STATUS. JUNE 1994.

Current status of state soil surveys compiled from NCR-3 reports:

	IL	IN	IA	KS	MI	MN	MO	NE	ND	OH	SD	WI
No. Counties	102	92	99	105	83	87		93	53	88	66	
Published	72	87	85	105	57	56		85	36	75	54	
In Press (Update)	25	2	13	· (2)	10	18		7	14	3 (1)	12	
In Progress (Update)	5 (3)	(4)	4 (3)	(4)	9	10 (3)		1 (5)	3 (2)	(7)	(4)	
Waiting (Update)	·		(1)	(0)	7	3				10 (4)		

II. SOIL SURVEY DIGITIZATION STATUS

IL.
- Three out of 102 counties are digitized
- One Survey was digitized by the IL Geo. Survey and another one by Lake County. Both used hand digitizing, rubber sheeting, and DLG-3 file format.
- The third survey was digitized by the county by re-compiling 1:12,000 maps on ortho 1/4 quads, scanning, and storing in DLG3 format.
- SCS use the same procedure for 8 watersheds (about 100,000 ac.)

IN.
- No coordinated system
- Counties or parts of counties are digitized by various agencies and various systems.

IA.
- Most counties by July 1994.
- Georeferenced soil maps by sections (USGS coordinates)
- ISOIL software or export to GIS
- Internet project

KS.
- Statewide project W/ Agronomy, Geography, and SCS
- Completion by 1995
- Recompilation on USGS 7.5 quads, scan digitization
- SCS soil scientist for quality control
- Archival by Kansas Geological Survey

MI.
- Nine soil surveys digitized
- Recompilation of 6 additional soil surveys
- Contracts W/ MI Dep. Natural Resources
- Nineteen digitized but need some editing to meet mapping standards

MN
- Forty two surveys (Ag counties) are digitized in SSIS raster format
- Capability to georeference and use standard GIS formats

NE.
- Recompilation on 7.5 quads of 2 nd generation surveys
- Digitization by NE Natural Resources Commission
- Updated survey (3 rd generation) at 1:12,0000 scale on ortho base digitize by Conservation & Survey Division.

ND.
- SCS digitizing center in Fargo has completed digitizing two county soil surveys

OH.
- Forty eight surveys are digitized in OCAP raster format
- Digitization by the OH Capability Analysis Program (OCAP) of OH Dep. Natural Resources

SD.
- Currently, there are 7 digitized county **surveys** available.
- Six additional county surveys are in process of editing
- Two surveys are in process of digitization and 3 are being recompiled
- Files are exported from GRASS to DLG3 format. Survey fomat is 7.5 min quads in UTM

III. RESEARCH ACTIVITIES RELATED TO SOIL SURVEY

Illinois. Ken Olson

- Soil productivity-erosion relationship.
- Evaluation of conservation tillage systems for the restoration of productivity of previously eroded soils.
- Crop yield prediction by soil.
- Quantification of erosion and sedimentation rates.
- New (about 230) and revised soil productivity indexes.

Indiana. Donald Franzmeier

- Monitoring water table depth, reduction, and water movement in several toposequences. This is part of the SCS global change initiative.
- Compaction and cementation in C horizons of soils formed in glacial till.
- Soil formation in barrens (prairie remnants) within hardwood forest areas.
- Detection and quantification of the amount of residue cover on fields using remote sensing (AVIRIS) data.
- Geomorphology of the Flatwoods area of southern Indiana.

Iowa. Tom Fenton

- Erosion-productivity project including soil quality.
- Use of electrical conductivity in soil survey.
- Cooperative project with SC'S on stratigraphic relationships under loess-covered benches in Lucas County.
- Cooperative project with SCS on soils of the Savan Terraces.
- Landscape evolution of the Des Moines Lobe.
- Hydric soil characteristics in Iowa.
- Cooperative project with SCS on water table of selected soils.

Kansas. Michael Ransom

- Clay translocation and carbonate accumulation in the 16-26 inch rainfall zone of western Kansas.
- Distribution and properties of clay minerals in Kansas soils with emphasis on application to soil fertility.
- Soil genesis and geomorphology on the Konza Prairie (LTER). Soil mapping at a scale of 1:2,000, study of genesis for a 125 ha watershed, and accumulation of carbonates, gypsum, and Na in polygenetic soils,
- Parent material stratigraphy and genesis of soils developed in eolian materials in the Southern High Plains.
- Cooperative project with SCS on the hydrology and genesis of soils in playas in southwestern Kansas.

Michigan. Del Mokma

- Impact of accelerated erosion on soil properties and productivity.
- Soil absorption of septic tank effluent and sand filter effluent.
- Impact of cultivation on spodic horizon properties.

Minnesota. Pierre Robert

- Landscape evolution in southeastern Minnesota (E. Nater)
- Wet soil monitoring (J. Bell)

- Soil-terrain modeling (J. Bell)
- Relationship of turf quality to management practices (T. Cooper)
- Describing soil and crop variability on a sand-plain landscape with surface-collected data (J. Anderson)
- Method for the prediction and quantification of soil property variability using GIS technologies (P. Robert)
- Forest productivity index (D. Grigal)
- Soil productivity modeling of agricultural land (P. Robert)
- Soil7 GIS (I'. Robert)
- Precision farming (P. Robert).

Nebraska. Mark Kuzila

- Comparison of sampling methods to determine map unit composition.
- Relationship of spectral reflectance to turbidity generated by the erosion of common soil types.
- Carbon tetrachloride retention by modern and buried A horizons.
- Determination of the impact of landuse on soil organic matter in the Sand Hills of Nebraska.
- Morphological and chemical changes in Moody and Hastings soils after 30-35 years of cultivation.
- Utilization of the soil survey database to predict pesticide mobility.
- Use of video camera to determine in situ soil color.

Ohio Neil Smeck

- Permeability and water movement in sediments, dominantly colluvium, on a forested slope in southeastern Ohio In situ permeabilities were measured using an amozemeter.
- Examination of the properties of colluvial deposits in eastern and southeastern Ohio.
- Study of fractures in glacial till deposits with particular interest in the hydrology of till around land fill sites in northern Ohio.
- Comparison between properties of silt deposits on the upland and lower landscape positions along an abandoned valley in central Ohio.

North Dakota. Dave Hopkins

- Water movement in landscapes, wetland hydrology, and geochemistry
- Wet soil indicators and their reliability in terms of identifying hydric soils
- Organic matter/aggregate stability study of western ND agricultural soils.

South Dakota. Doug Ma10

- Technology transfer of applied/basic soils information for the agriculture and environment of South Dakota:
  - C sequestration in SD soils using lab data of the past 50 years;
  - Data base of all soil series (lab and morphology data);
  - Resampling of sites (1920 & 1937) for impact of cultivation and the environment on C, N, P, Ph, etc.;
  - Evaluation of various computer models used to define and manage sensitive aquifer areas;
  - Revise bulletins on soil classification, soil productivity, etc.
- In cooperation with SCS, testing of hydric soil indicators, gathering of basic soil data, and soil productivity ratings for several MLRAs.
- Spatial distribution of soil selenium in south-central SD. (J. Doohttle)
- Erosion impacts on soil productivity and soil properties (T. Schumacher)
- Hydric soil identification and characterization in prairie potholes (D. Rickerl)
- Site-specific farming (G. Carlson)
- Differences in herbicide adsorption/desorption rates on different soil series (S. Clay)
- Influence of soil parent materials on fertilizer and other chemical movement (D. Clay).

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Interaction between aggrading geomorphic surfaces. formation of a Late Pleistocene paleosol in the Palouse lc eastern Washington state

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ABSTRACT

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Variable rates of loess deposition contributed to dramatic regional variation in a soil-stratigraphic unit. the Washtucna Soil. in the Palouse loess deposits in the Channeled Scabland of eastern Washington stale. Throughout most of the Channeled Scabland, the morphology of the Washtucna Soil is that of a single buried soil, but it bifurcates into two well-developed and pedologically distinct buried soils in areas immediately downwind of the major source of loessial sediment. Regional loess stntigraphy confirms that the two well-developed soils formed during the same interval of time during which only one soil formed in areas that are distal to loess source areas. The variable and perhaps rapid rates of soil formation suggested by the stntigraphy resulted from an interaction between variable rates of loess deposition and the formation of superimposed calcic soils. Petrocalcic horizons with weak Stage IV morphology formed as the zone of carbonate accumulation moved up into former A and cambic horizons that had been profusely burrowed by cicadas. The development of cicada burrows in one phase of soil development that were subsequently engulfed by pedogenic carbonate under a rising land surface seems to have yearly accelerated the development of the petrocalcic horizons. Accelerated rates of formation of the petrocalcic horizons occurred when extrinsic (pulses of loess deposition) and iatnnsic (engulfment of burrowed horizons) thresholds were exceeded. Stratigraphic evidence suggests that the soil formation that accompanied the rise in the land surface due 10 additional loess deposition may have occurred during the late Wisconsin glaciation when giant glacial outburst floods in the channeled Scabland triggered a new cycle of loess deposition.

Introduction

Soil formation on an aggrading surface is a competition between pedologic and sedimentologic processes, a competition that can lead to very complex soils and soil-stratigraphic relationships. Complexity results from the compression or dilution of soil profile features with variations in aggradation rate and from the sometimes extreme overlap of features from different episodes of soil development. Although the complexity can be great, we have found in the loess of the Palouse and Channeled Scablands of eastern Washington that the opportunities for insights into soil and geomorphic processes can be equally great. This paper discusses the regional relationships of a key late Quaternary soil-stratigraphic unit. now a buried soil, through the relationship between the physical, chemical, and morphological properties of this buried soil to its paleolandscape position and to its location within the regional distribution system of loessial sediment. A key buried soil in our late Quaternary

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loess sections. the Washtucna Soil. actually divides into two well-developed buried soils very near the loess source. The regional stratigraphic relationships of this soil suggest some surprising insights into rates and processes of soil development and implications for soil stratigraphy and landscape evolution.

Depending on (1) whether an aggrading loessial landsurface rises at a constant or variable rate, (2) what the rate of rise is relative to competing rates of soil formation, (3) whether aggradation comes as a series of pulses separated by stillstands of deposition, and (4) whether erosional events also occur, the whole suite of surface and subsurface soil-forming processes move up through the sediment like a rising elevator in a building. As a result, the marks of pedogenesis can be weakly to strongly impressed on the sediment, and the potential exists for slight to severe overlap of different periods of pedogenesis in the same sediment.

Bowman et al. (1986) have stated that in this situation there is no fixed parent material: A horizons upon first burial become B horizons; these new B horizons begin to accumulate illuvial material eluviated from the new layer, and as more layers are deposited on the surface, these B horizons are eventually removed from the active zone of soil-forming processes and are preserved in the stratigraphic record. As a result, it is the now-buried soil that forms the "parent material" for subsequent soil development. Many terms have been proposed for soils that overlap vertically in such a way that at least part of the profile has been affected by two or more episodes of soil development: compound soils (Morrison, 1967), polymorphic soils (Simonson, 1978), complex soils (Bos and Sevink, 1975), welded soils (Ruhe and Olson, 1980), and superimposed soils (Busaccaet al., 1985; Busacca, 1989).

Superimposed soil profiles have important consequences in studies of soil genesis because the morphological properties of the former soil, such as texture, pedologic and biologic structures, and chemical properties, can greatly influence subsequent episodes of soil development. Differences in the degree of geologic and pedologic overlap can cause large spatial variation in morphologic propenies of soils across landscapes. Knowledge of the spatial variation resulting from differential sediment influx is crucial in estimating the duration of soil formation on landscapes and in avoiding miscorrelation of soil units among exposures or geomorphic surfaces. Regional stratigraphic correlations can be especially difftcult to make when a superimposed soil separates laterally into two or more soil profiles (e.g., compound or multi-story soils of Morrison, 1967). The multitude of stratigraphic relationships and different soil-profile morphologies created by differing degrees of pedogenic overlap, nevertheless, can provide useful knowledge about the interaction between soil formation and geomorphology.

In this paper we examine the impact of variable rates of influx of eolian sediment (loess) on the formation and the landscape and regional variation in properties of a buried soil. The buried soil is the Washtucna Soil (McDonald and Busacca, 1990), an important regional soil-stratigraphic unit in the Palouse loess of the Channeled Scabland and Palouse regions of Washington state. The Washtucna Soil and the loess in which it has formed are bracketed stratigraphically by two distinct layers of volcanic ash that provide age control and an independent means of stratigraphic correlation across the study area.

The morphology of the Washtucna Soil in most places in the Channeled Scabland is that of a single buried soil; however, in some places it bifurcates, that is, it divides into two pedologically distinct buried soils. Other occurrences of superimposed soils that change laterally into subdivided soils have been described where each soil represents a stratigraphically different or discrete time of soil formation that is superimposed upon a generally older, preexisting soil. Stratigraphic relationships between the Washtucna Soil and the bracketing tephras. however, indicate that at least two distinct buried soils formed at some sites within the same interval of time in which only one soil profile was formed throughout most of the Scabland and Palouse. In addition, the degree of soil development of each of the two buried Washtucna Soils is about the same as that of the single Washtucna Soil profile, suggesting that rates of soil formation were accelerated at the dual-soil site relative to the single Washtucna Soil site. In this paper, we propose a simple model for the interaction between loess deposition and the formation of superimposed calcic soils and discuss the effect of this interaction on soil stratigraphy and rates of soil formation.

The Palouse loess

Loess in the Channeled Scabland and on the eastern Columbia Plateau beyond the margin of the Channeled Scabland is known informally as the Palouse loess (Fig. 1). The Palouse loess, which covers more than 10,000 km^2 and in places is up to 75 m thick (Ringe, 1970), forms the deepest and most continuous loess deposit in the northwestern U.S.A. In the western and drier parts of its occurrence where present-day mean annual precipitation is less than about 450 mm, the deposit contains dozens of buried soils, sheets of unaltered loess, and numerous volcanic ash layers in vertical sequence (Busacca, 1990). Buried soils consist of cambic horizons and horizons of pedogenic accumulations of calcium and magnesium carbonates (hereafter referred to as carbonates) and silica. Paleomagnetic measurements indicate that the geologic record in the loess spans at least the last 1 million years (Packer, 1979; Kukla and Opdyke, 1980; Foley, 1982). Recent research has demonstrated that the loess adjacent to Scabland Coulees contains a record of multiple episodes of giant glacial-outburst floods that coursed through the Channeled Scabland during Pleistocene glacial maxima (McDonald and Busacca, 1988). Repeating stratigraphic sequences within the loess consist of flood-cut unconformities, loess layers, and buried soils: these sequences suggest that episodes of Scabland flooding triggered some periods of loess deposition, which were followed by periods of soil formation (McDonald, 1987; McDonald and Busacca, 1988; Busacca, 1990). A thick Cordilleran Ice Sheet extending into southern Canada or the northern U.S. is required to generate these large-scale floods, so the stratigraphic record in the loess may be one of the best terrestrial proxy records of glacial-climatic cycles in North America.

The primary minerals in the loess are quartz, feldspars, and micas (Rieger, 1952; McCreery, 1954). The initial source of carbonate in the buried soils is considered to be principally detrital, derived from eolian redistribution of weakly calcareous slackwater sediments that accumulated in basins and valleys to the southwest of the Palouse and Scabland during episodes of glacial-outburst flooding (Fig. 1). Detrital carbonate in unaltered loess ranges from 2 to 5 percent (0.03-0.10 g/cm’). Lack of measurable carbonate in the upper part of most surface soils indicates that the detrital carbonate has been leached and reprecipitated in the subsoil horizons.

The study area

The four road-cut exposures described here are located in loess deposits in the southcentral part of the Channeled Scabland (Fig. 1). The road-cuts are oriented normal to the long axes of hills of loess.

The present-day climate is semi-arid due to the rain shadow of the Cascade Mountains that lie to the west of the Channeled Scabland. Because of the semi-arid climate and sagebrush-steppe vegetation, most of the surface soils that have formed *in loess* in the area that we discuss are Mollisols (Soil Survey Staff, 1975). Aridisols occur in areas of the Scabland that receive less than 225 mm of mean annual precipitation.

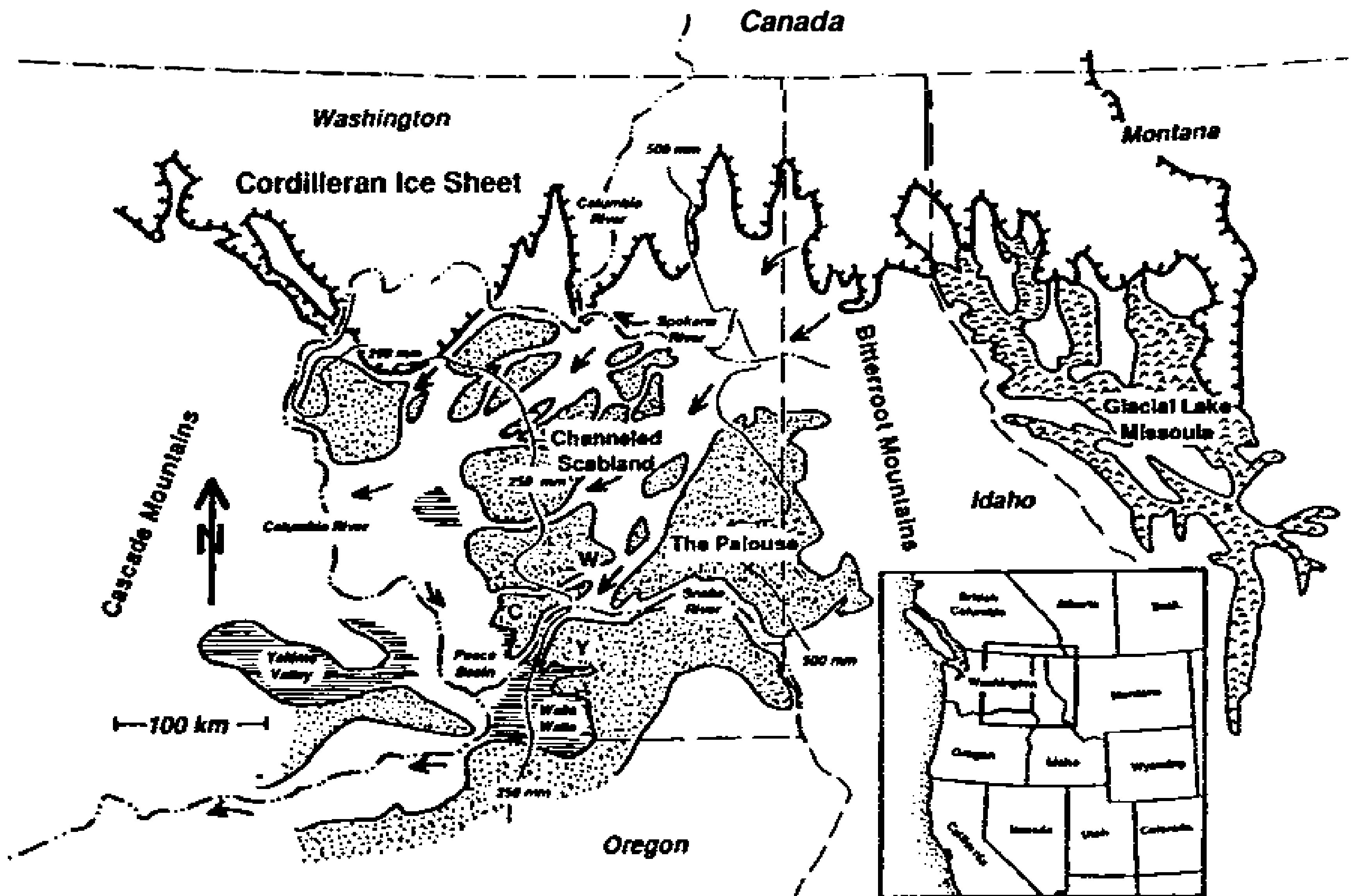

Fig. 1. Map of the western United States (inset) and generalized map of the Lake Missoula–Channeled Scabland system that also shows locations of the study sites. Cordilleran Ice Sheet shown at its late Wisconsin maximum by the heavy hachured line. Arrows show major pathways of water through the Channeled Scabland. Stipple pattern shows areas of deep loess cover in the Channeled Scabland and the Palouse. Horizontal lines show major areas of slackwater sediments in the Pasco Basin and Walla Walla Valley. Small pockets of slackwater sediments deposited in adjoining valleys not shown. Study sites are Washtucna (*W*), Connel (*C*), and Clyde (*Y*). Site locations are WA-5: 46°46′24″N, 118°21′22″W; CON-1: 46°37′16″N 118°42′42″W; CLY-1: 46°16′15″N, 118°29′42″W; CLY-2: 46°16′20″N, 118°29′42″W. Isobyets of [redacted]

Stratigraphic descriptions were made from hand-dug trenches in road-cuts. Buried soils and loess layers were described and sampled using standard methods for soils (Soil Survey Staff, 1981).

The Washtucna soil-stratigraphic unit

The Washtucna Soil is a well-developed soil that contains a weakly to strongly cemented perrocalcic horizon (Fig. 2, Table 1). The petrocalcic horizon, which is continuously cemented and has a thin laminar cap, has the general character of weak Stage IV morphology (Gile et al., 1966); however. the petrocalcic horizon lacks strong K fabric. The Washtucna Soil throughout the Channeled Scabland is stratigraphically bracketed by two distinct volcanic ash layers erupted from Mount St. Helens (Fig. 2, *MSH*). Correlations between the tephras and the reference samples from the volcano are based on analysis of major elements in volcanic glass and in ilmenite and magnetite phenocrysts. and on phenocryst mineralogy (Foley, 1982; Nelstead. 1988). The soil is underlain by the MSH set C tephra (Fig. 2), which has been radiocarbon dated at the volcano at approximately 36.000 yr B.P.

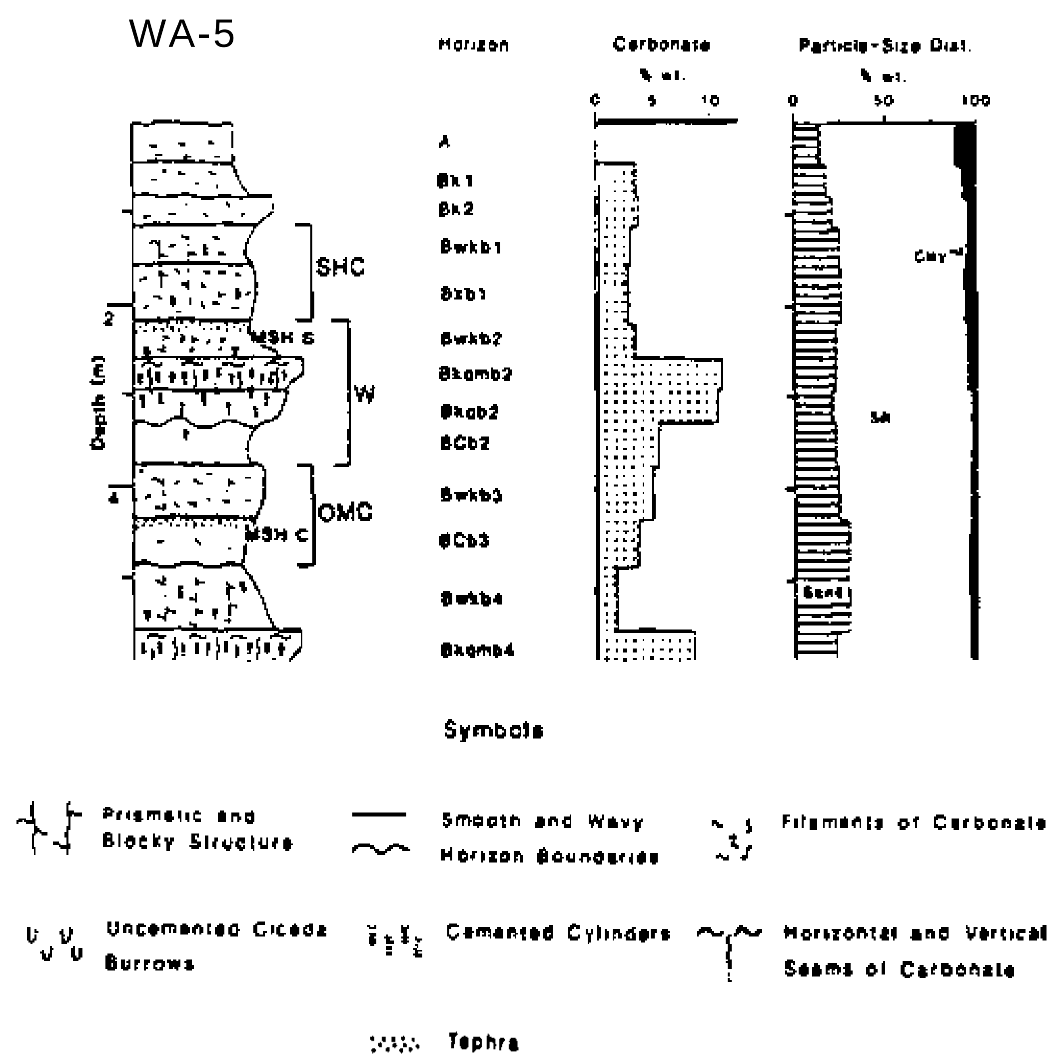

Fig. 2. Schematic stratigraphic column for the WA-S site showing representative soil morphology, carbonate. and particle-size distribution (carbonate free). Tehpras shown are Mount St. Helens set S (*MSH S*) and set C (*MSH* C). Numbers following the "b" in the horizon symbols designate the vertical position within the sequence of buried soils. Brackets show stratigraphic interval of buried soil-stratigraphic units: Sand Hills Coulee Soil (*SHC*), Warhtucna Soil (*W*), and the Old Maid Coulee Soil (*OMC*). (From McDonald and Busacca, 1990.)

TABLE I

Selected morphology of the Washtucna Soil(s)

Site	Depth (cm)	Horizon[a]	Dry color	Structure[a]	DC[b]	Cyl[c] (vol%)	Carbonate morphology[d]	Total mass[g] carbonate (g/cm^2)
WA-5	218-259	Bwkb2	10YR 6/3	Icpr: Icsbk	sh	15	d. 1sf	16.14
	259-295	Bkqmb2	10YR 7/2 10YR 6/3[f]	m	vh	90	d. 5co. 2ss	
	295-328	Bkqb2	10YR 7/2	2csbk	sh	30	d. 5co. 1ss	
	328-377	BCb2	10YR 7/2	m	so	2	d	
CON-I	2 18-284	Bwkb2	10YR 6/3	Icpr: Icsbk	sh	I5	d	22.34
	284-322	Bkqmb2	10YR 7/3	m	eh	90	d. 5co. 2ss	
	322-409	Bkqb2	10YR 7/3	Icsbk	h	50	d. 5co. Iss	
	409-494	BCkb2	2.5Y 7/2	m	so	5	d. Isf	
CLY-2	444-495	Bwk1b2	10YR 6/3	m	sh	5	d	4.31
	495-557	Bwk2b2	10YR 6/3	m	sh	I5	d. 2sf	
	557-584	Cb2	2.5Y 7/2	*m*	so	0	d	
	584-646	Bwkb3	10YR 6/3	1 csbk	sh	I5	d. 2co	5.78
	646-670	Bkq1b3	10YR 7/2 10YR 7/3[f]	2csbk	h	85	d. 5co. 1ss	
	670-737	Bkq2b3	10YR 6/4	2csbk	sh	60	d. 5co	
	737-787	Bkqmb4	2.5Y 7/2	m	eh	90	d. 5co. 2ss	18.47
	787-822	Bkqb4	2.5Y 7/2	m	so	50	d. 4co. 1ss	
	822-882	BCkb4	2.5Y 7/2	m	so	10	d. 1sf	
	882-949	Ckb4	2.5Y 7/2	m	so	0	d. 1sf	
CLY-1	400-451[e]	Bwkb2	10YR 6/3	2cpr: Icsbk	so	5	d. 3sf	11.5
	451-492	Bwkb3	10YR 6.3	Icpr: *Icsbk*	so	10	d. 3sf	
	492-533	Bwkqb3	10YR 7/3	Icpr: Icsbk	sh	10	d. 5co	
	533-581	Bwkqmb3	10 YR 7/3 10YR 6/3[f]	m	vh	90	d. 5co. 2ss	
	581-622	Bwkqb3	2.5Y 7/2 10YR 6/4	2csbk	so	55	d. 5co	
	622-I 12	Bkqmb4	2.5Y 7/2 10YR 6/3[f]	m	eh	90 5	d. 5co. 2ss	16.56
	712-772	BCkb4	10YR 7/2	m	so		d. 2sf	

[a]Notations modified from Soil Survey Staff (198 1). Primary structure:secondary structure.
[b]Dry consistence.
'Volume percentage of cemented cylindrical nodules.
'Notations for carbonate morphology: (distribution) d -disseminated: sf – filamentous; co – coatings on nodules: ss – seams. (abundance) 1 = very few (<2%); 2 = few (2–25%); 3 = common (25–50%); J-many (> 50%); 5 = nearly continuous.
'Approximation depth of MSH S tephn.
'Color of interior of cylindrical nodules.
[g]Total mass of soil carbonate (g/cm^2) = (bulk density) (% carbonate) (horizon thickness in cm). Bulk density value determined from multiple horizons (n-27) ranging from petrocalcic to unweathered. Bulk density= 1.40 ± 0.06 g/cm'.

(Mullineaux. 1986). The soil is overlain by the MSH set S tephra. which has been radiocarbon dated at Mount St. Helens at approximately 13,000 yr B.P. (Mullineaux, 1986).

The Washtucna Soil and the loess layer in which it formed represent an interval of time before the end of the Late Wisconsin episode of giant floods in the Channeled Scabland, which occurred between about 17,000 and 12,000 yr B.P. (Waitt, 1985; Atwater, 1986), but after the next older episode of Scabland flooding. Radiocarbon ages of the MSH set C tephra at Mount St. Helens and charcoal from Scabland flood deposits that yields a radiocarbon age of about 40,000 yr B.P., and the age of Late Pleistocene stratigraphy in the Canadian Prairies (Fenton, 1984) suggest that this older episode of flooding is early or middle Wisconsin in age and occurred between 75 and 40 ka (McDonald and Busacca, 1988, 1990). Stratigraphic and sedimentologic evidence suggest that the sand- and silt-rich slackwater sediments left by this episode of older floods formed the primary eolian source for the loess layer in which the Washtucna Soil formed (McDonald and Busacca, 1990).

Spatial variability of the Washtucna Soil

Washtucna

The Washtucna Soil as it is exposed in roadcuts across much of the Channeled Scabland has the morphology of a single buried soil. We use the Washtucna Soil at the WA-5 site near the town of Washtucna, Washington (Fig. 1) to represent the properties of the single buried soil (Fig. 2, Table 1).

The top of the Washtucna Soil at the WA-5 site is defined by the position of the MSH set S tephra. The horizon that contains the tephra in its upper part seems to have formed the original A and Bw (cambic) horizon of the buried soil (Bwkb2, Fig. 2). The typical dark coloration of the A horizon caused by the humified organic matter is conspicuously absent from the Washtucna Soil and other buried soils in the Channeled Scabland. We attribute this to oxidation of organic matter after burial of the soil by younger loess. Because of the absence of organic matter and because of overprinting by later pedogenesis, former A horizons throughout the loess now have a similar appearance to that of cambic or calcic horizons; therefore, we label former A horizons as B horizons because that is their appearance today.

The cambic horizon (and former A horizon) of the Washtucna Soil has a slightly higher chroma and less pedogenic carbonate than do buried soil horizons above and below it, and has a weak to moderate blocky structure. Pedogenic carbonates are common in the cambic horizon of the Washtucna Soil (and nearly all buried soil cambic horizons in the Scabland) but are not generally present in cambic horizons of the presently forming surface soils; therefore, we attribute pedogenic carbonate in buried cambic horizons to be due largely to the overlapping of subsequent pedogenesis. Buried cambic horizons containing pedogenic carbonates are designated with "k".

The dominant feature of the Washtucna Soil is its light-gray petrocalcic horizon (Bkqmb2. Fig. 2, Table 1) that has weak Stage IV morphology (Gile et al., 1966). The petrocalcic horizon at the WA-5 site is weakly to strongly cemented, is about 35 cm thick, contains 12% carbonate (0.17 g/cm’), and has vertical and horizontal seams of carbonate and abundant cemented cylindrical nodules (insect burrows). The nodules make up about 90% of the horizon volume. Thin (<2 mm) vertical seams of carbonate define polygons that are 50 to 100 cm wide. Horizontal seams of carbonate form a weakly developed laminar cap at the top of the petrocalcic horizon.

Cylindrical nodules are a conspicuous feature of most buried soils formed in the loess. Nodules can range from 1 to 3 cm in diameter and are weakly to strongly cemented by pedogenic carbonate. Cementation of the nodules is also enhanced by small amounts of silica such that the nodules do not completely break down when soaked in hydrochloric acid. The nodules originated as the burrows of soil fauna such as cicadas. Burrowing apparently occurred within the A and cambic zone of the loessial soils early in a cycle of soil development. The burrows have become cemented at a later time after continued loess deposition caused the zone of precipitation of carbonates to move upward into the position of A and cambic horizons.

It is important to emphasize here the almost universal presence of cemented cicada burrows within carbonate-cemented zones in paleosols formed in loess in the arid parts of eastem Washington. Because the burrowing of the sediment by cicadas is a near-surface process in uncemented loess (Hugie and Passey, 1963), the precipitation of carbonates within the burrowed zone must occur at a later time in a deeper relative profile position after the land surface has moved up. Most petrocalcic horizons in soils such as the Wasbtucna Soil must have formed during two phases of soil development: The first phase forms the burrowed zone and the second phase cements it. These two phases may occur somewhat simultaneously during times of low rates of loess deposition as the rising landscape causes carbonate to precipitate in the deepest part of the early formed burrowed zone; the remainder of the burrowed zone is then progressively engulfed by the rising zone of accumulation of carbonate.

There are two transitional horizons below the petrocalcic horizon of the Washtucna Soil. The Bkqb2 (Fig. 2) has discontinuous vertical seams of carbonate and 40% cemented cylindrical nodules that have nearly continuous coatings of carbonate. The nodules are in a matrix of soft calcareous loess. The BCb2 horizon (Fig. 2) is structureless and has only a few percent cemented nodules and filamentous carbonate in former root channels.

Connell

The morphology of the Washtucna Soil at the CON-I site (Fig. 1) near the town of Connell. Washington represents soil formation in thicker loess. The loess between the MSH S and C tephras thickens from about 2 m at the WA-5 site to over 7 m at sites much nearer principal source areas for the loess. which were in the Walla Walla Valley and Pasco Basin (Figs. 1, 3). Because of its intermediate location between these extremes (Fig. 1), loess is almost 3 m thick between these ash markers at the Connell site (Figs. 3b, 4).

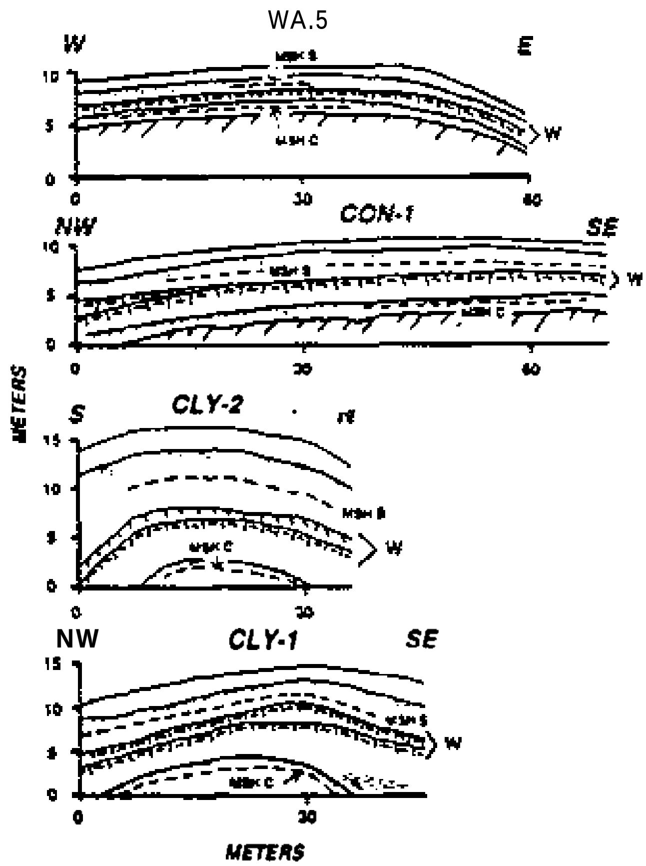

Fig. 3. Scbemrtic cross-sectional diagrams of road-cut exposures for the four study sites: WA-S. CON-I. CLY-2. CLY-I. Position of the Wasbtucna Soil (*W*) shorn by symbols for horizontal and vertical seams of carbonate (Fig. 2). The position of the Sand Hills Coulee and Old Maid Coulee soil-stratigraphic units shorn by line and stipple pattern. Position of tephras MSH set S (*MSH S*) and MSH set C (*MSH C*) shown by heavy dashed lines. diagonal hachure oven parts of the WA-5 and CON- exposures not considered here.

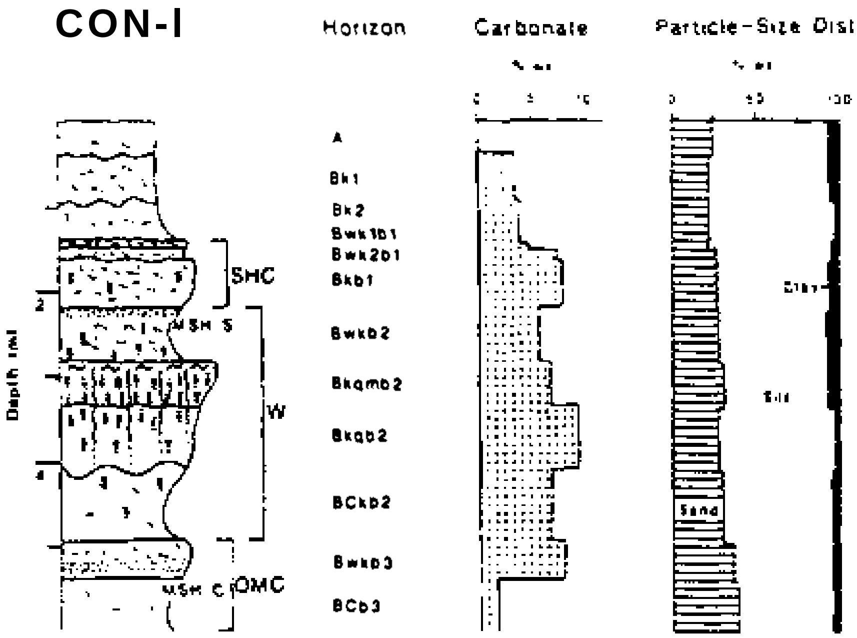

Fig. 4. Schematic stratigraphic column for the CON-I sire. Symbols used are defined in Fig. 2.

The Washtucna Soil at the CON-I site (Fig. 4) is generally similar to that at the WA-5 site, except that corresponding horizons at the CON-1 site are thicker than at WA-5 site because of the slightly greater loess thickness.

The combined effect of greater loess thickness and landscape position on soil formation is shown by soil-stratigraphic relationships on the outer flanks of the CON-I exposure where layer thickness increases from about 3 m to more than 4 m (Fig. 3b). There, the single petrocalcic horizon bifurcates into two separate petrocalcic horizons. Each petrocalcic horizon is 30 to 40 cm thick, separated by a Bkq horizon that is 40 to 60 cm thick and has 30 to 50% cylindrical nodules in a soft loess matrix. It was at sites like this that we first began to suspect that the genesis of tbe Wasbtucna Soil could be complex and consist of more than one period of soil formation.

Clyde

Two road-cut exposures, CLY-I and CLY-2, are located about 30 km south-southeast of the Connell sites (Fig. 1), near Clyde, Washington. These two sites are very close to the sediment source and as a result, the loess at these two sites is 5 to 7 m thick between the MSH S and C ash markers. Both sites have a dramatically different sequence of buried soils between the markers than we saw at the Washtucna or Connell sites. Because of the very great loess thickness at sites like Clyde. we refer to them as proximal to the loess source, and sites like Connell and Washtucna as distal.

At the two Clyde sites and at many other proximal sites that we have examined. the Wasbtucna Soil divides into at least two well-developed buried soils (Figs. 3c,d, 5, 6). Although the two sites are only about 0.5 km apart, they show subtle differences in features due to their different landscape positions.

The Wasbtucna Soil at the CLY-2 site subdivides into three soil profiles (Fig. 5). The morphology of the lowest of the three soils (horizons ending in b4: Fig. 5, Table 1) is generally similar to that of the single Wasbtucna Soil at the CON- 1 site. The dominant feature of this buried soil is a light-gray petrocalcic horizon that has weak Stage IV morphology. The petrocalcic horizon (Bkqmb4, Fig. 5) is

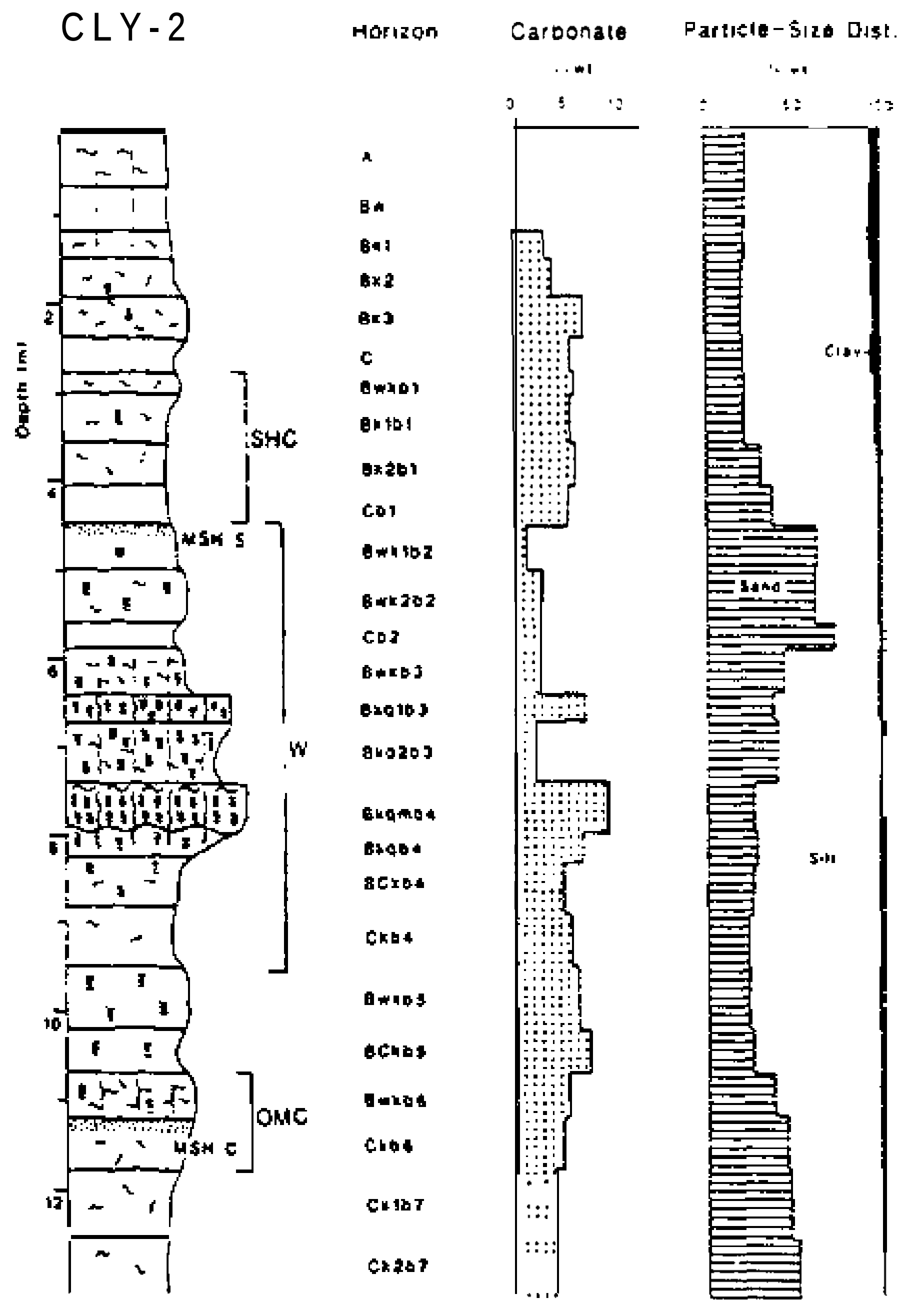

Fig 5. Schematic stratigraphic column for the CLY-2 site. Symbols used are defined in Fig. 2.

strongly cemented, 50 cm thick, and has 9% carbonate (0.13 g/cm^3). Vertical seams of carbonate 1 to 4 mm thick define large polygons that are 50 to 150 cm in diameter. Horizontal seams of carbonate 1 to 2 mm thick form a weak laminar cap. Cemented cylindrical nodules that have a nearly continuous coating of pedogenic carbonate make up about 90% of the horizon. Pedogenic accumulation of carbonate decreases downward through the two transitional horizons that underlie the petrocalcic horizon (Bkqb4, BCkb4, Fig. 5). The original A and Bw horizons of this buried soil have been engulfed by carbonate from a subsequent cycle of soil development (Bkqlb3, Bkq2b3, Fig 5).

The second soil of the Washtucna Soil sequence (—b3: Fig. 5, Table 1) has been formed partially in a loess layer that was deposited on top of the underlying tint Washtucna Soil and partially by overprinting features onto the underlying soil. This layer is recognized by a sharp increase in the sand content. The second soil has Stage III morphology and is less developed than the underlying soil. The Bkq1b3 horizon (Fig. 5) is an incipient petrocalcic horizon that has about 6% carbonate (0.08 g/cm^3) and vertical seams of carbonate (2-3 mm thick) that form large polygons similar to those in the underlying petrocalcic horizon. Cemented cylindrical nodules that have a nearly continuous coating of carbonate form 80 to 90% of the horizon volume. Although much of the horizon consists of cemented nodules, the nodules have not been continuously cemented together to form a petrocalcic horizon. The overlying horizon (Bwkb3, Fig. 5) has weak blocky structure and scattered cylindrical nodules and is considered to have been the original A and cambic horizons of this soil.

The uppermost soil of the sequence is a weakly developed soil that has formed in a third layer of sandy loess (—b2, Fig. 5, Table 1). This layer also is recognized by its much higher content of sand. This soil consists of two structureless cambic horizons that have a slightly higher chroma than horizons above or below, and scattered cylindrical nodules and filaments ofcarbonate. The lowest horizon is a C horizon that separates the upper soil (- b2) from the middle soil (—b3). The MSH set S tephra lies at the top of the Bwkl b2 horizon.

The Washtucna Soil at the CLY-1 site is subdivided into at least two soil profiles (Figs. 3, 6). The lower of the two soils (—b4: Fig. 6, Table 1) contains a strongly cemented petrocalcic horizon that has weak Stage IV morphology (Bkqmb4). The petrocalcic horizon varies in thickness from 70 to 110 cm and has 11% carbonate (0.15 g/cm^3). Cemented cylindrical nodules that have a continuous coating of carbonate make up about 90% of the horizon volume. Vertical seams of carbonate 2 to 5 mm thick define large 50 to 150 cm polygons. Horizontal seams of carbonate 1 to 2 mm thick form a weak laminar cap. The petrocalcic grades downward into a transitional horizon that has just a few percent nodules and filaments of carbonate (BCkb4, Fig. 6). The original A and cambic horizons of this soil have been overlapped by the upper soil profile of the subdivided Washtucna Soil (Bwkqmb3, Bwkqb3, Fig. 6).

The upper soil profile (—b3: Fig. 6, Table 1) that forms the subdivided Washtucna Soil at the CLY-2 site also has a petrocalcic horizon with weak Stage IV morphology (Bwkqmb3). The morphology of the upper petrocalcic is similar to that of the morphology of the lower one except the upper is thinner, ranging from 50 to 80 cm thick, and has only 6% carbonate (0.08 g/cm^3). The original A and cambic horizons for the soil are the Bwkb2, Bwkb3, and the Bwkqb3 horizons which appear to be cumulic (Fig. 6). The interval between the upper and lower petrocalcic horizons ranges from 40 to 150 cm across the CLY-I exposure (Fig. 3).

The thick zone of cambic horizons (Bwkb2, Bwkb3, Bwkqb3) above the upper petrocalcic horizon may also form part of a third subdivided profile, similar to the uppermost profile at the CLY-2 site (Fig. 5).

Geomorphic control on loess layer thickness

The bifurcation of the Washtucna Soil into two well-developed soils primarily reflects the impact of variable rates of loess deposition and, secondarily, geomorphic position. The interval of loess in which the Washtucna Soil formed, as defined by the stratigraphic position of the MSH set S and C tephras, is significantly thicker at the two Clyde sites than at the CON-1 and WA-5 sites. The greater thickness of the loess at the Clyde sites indicates that the rate of loess accumulation at those sites was much greater than the rate of accumulation at the CON-1 and WA-5 sites during the same interval of time. The presence of two or three buried soils in proximal sites resulted from a series of pulses of deposition during which the landscape surface moved up too rapidly for

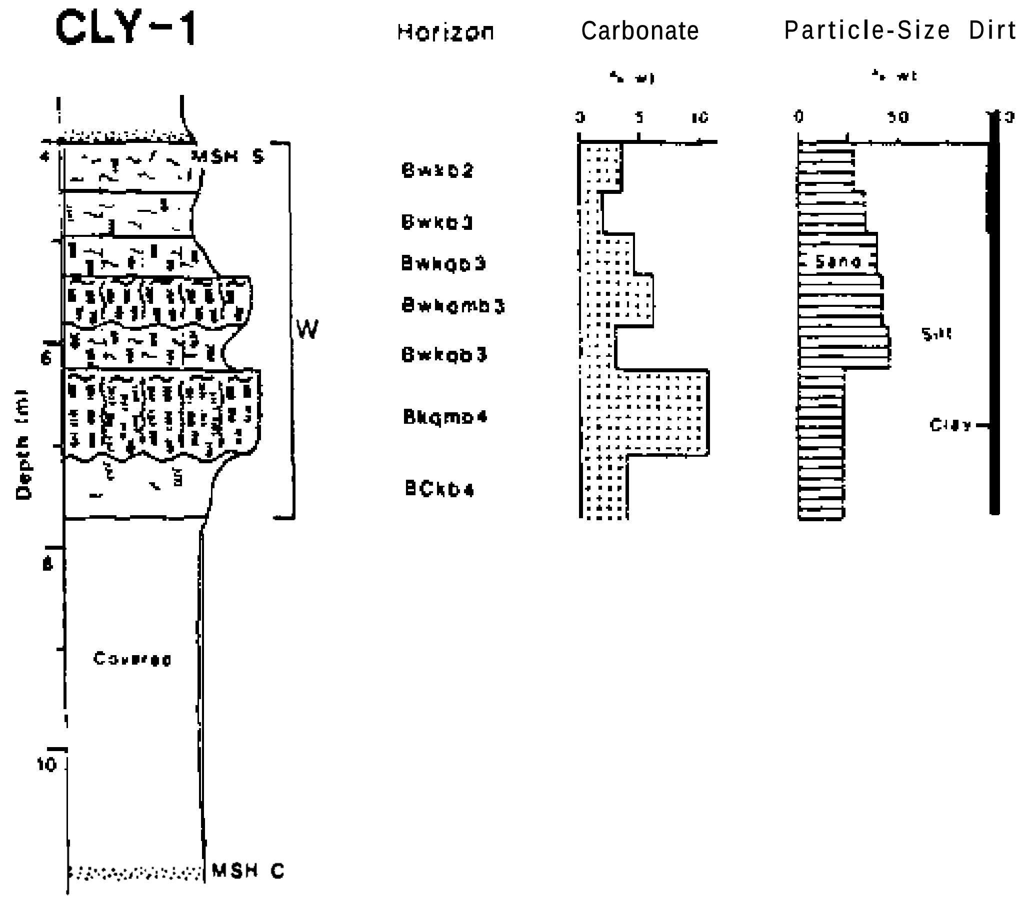

Fig. 6. Schematic stratigraphic column for the CLY-I site. Symbols used are defined in Fig. 2.

soils to form, separated by periods of lower rates of deposition and relative landscape stability during which the multiple Washtucna Soils formed. These discrete pulses of sedimentation apparently did not occur at distal sites.

Dispersal of eolian material by wind from sediment source areas produces regional patterns in the sedimentologic properties of loess deposits. Regional transects of loess in the central U.S. have shown that there is a general thinning of loess layers away from source areas due to a decrease in the concentration and size of windblown particles (Frazee et al., 1970; Kleiss, 1973; Ruhe, 1983; Fehrenbachet et al.. 1986). The thickest (and coarsest) loess in the central U.S. is found immediately downwind of major river valleys. Thicker loess layers at the Clyde site are due to the proximity of the sites to the principal source areas for the loess.

The CLY-I and CLY-2 sites are located immediately downwind of nearby areas of Scabland flood slackwater sediments. The flood sediments are thick sequences of mostly sand and silt that were deposited in the Walla Walla Valley, Pasco Basin, and adjoining low-lying valleys (Fig. 1) where cataclysmic flood waters pondcd before draining to the Pacific Ocean (Brett, 1969; Baker and Bunker, 1985). The Clyde sites are virtually surrounded by valleys that were backflooded during the largest events of scabland flooding; several tens of meters of slackwater sediments were deposited in these adjacent valleys. Regional stratigraphic correlations among exposures of Late Pleistocene loess indicate that loess layers associated with Late Quaternary episodes of flooding thin and fine with distance to the northeast of areas of slackwater sediments due to eolian redistribution by prevailing winds (McDonald, 1987;

Busacca. 1990). The distal positions of the CON-1 and WA-5 sites have thinner loess layers than those at the proximal sites because the distal sites are located many kilometers downwind from the major areas of slackwater deposits.

Hillslope position may also have had an impact on accumulation of thick loess layers. The two Clyde sites are excavated into hills that lie below the crest and on the north (lee) side of a major loessial ridge. Loess layers thicken on the leeward sides of hills in several places in the Palouse and Channeled Scabland, probably because increased deposition of eolian sediment on leeslope positions can result from a decrease in wind velocity and an increase in turbulence on the leeward side of topographic highs.

The CLY-1 road-cut bisects the long axis of a steeply northeast-sloping hill that connects on its uphill end with the main ridge, whereas the CLY-2 road-cut parallels the long axis of a N-S trending hill with a flat summit that is in the lee of the main ridge but is not directly connected to it. The wetter northern slope and long run of hill above the CLY-1 site may have promoted the stronger development of the calcic features there because ofenhanced eluviation-illuviation processes and greater throughflow. The droughty summit position of the flat secondary ridge of CLY-2 may have limited transfer of carbonates and restricted development of the Washtucna Soil.

Accumulation of loessial sediment on hillslopes has probably also been enhanced by secondary transfer of sediment through slopewash and mass movement processes. Loess layers thicken towards the bottom of each hillslope at each site (Fig. 3). Pockets of poorly stratified silty sediment were found in the unaltered loess above the MSH set C tephra on the right side of the CLY-1 exposure (Fig. 3d). The stratification suggests deposition by water or niveo-eolian processes (Koster and Dijkmans, 1988) instead of eolian processes. Newly deposited loess on steep hillslopes could be easily eroded before soil formation or vegetation could stabilize it. Mass movements in the loess might also form thick accumulations on footslope positions. Shallow debris flows are common on loessial hillslopes in the Palouse from freeze-thaw cycles during late winter (Garber, 1965).

Thicker accumulations on the outer hillslope position of the CON-l (Fig. 3b) site may also have been the result of colluviation, or increased deposition of loess on the sideslopes of that hill. Thickening of the loess in these positions appears to have been responding to the pulsed depositional cycles so apparent at the Clyde sites, because two Washtucna Soils have developed in the telescoped loess on the sideslopes.

Pedologic development of an accreting landscape

The bifurcation of the Washtucna Soil provides a means of examining the impact of deposition of new sediment on soil-forming processes, on the development of superimposed soil profiles, and on the time interval during which pedogenesis occurred. Our interpretation is based on two related principles of soil formation in a rising landscape setting: (1) an actively forming soil will have a systematic sequence of eluvial and illuvial zones, and these will have upper and lower boundaries: and (2) superimposed soil profiles will form largely as a result of episodic rise in the land surface because additions of sediment will raise the active zone of soil development by the amount of the additions, allowing zones of pedogenesis to overlap. Our analysis of the physical, chemical, and morphological data for the bifurcated Washtucna Soil in proximal locations along with our knowledge of regional geologic events and bracketing ages has led us to the rather surprising set of conclusions or hypotheses presented below as to the age of the Washtucna Soil and the very brief time necessary for its formation.

Loess deposition and initial pedogenesis in proximal sites

The cycle of loess deposition in which the lower Washtucna Soil formed was triggered by an episode of glacial-outburst flooding that occurred during the early or middle Wisconsin (McDonald, 1987; McDonald and Busacca, 1990).

Rates of deposition generally exceeded minimum rates of soil formation during the time that the first 5 to 7 m of loess were deposited in proximal sites like CLY-1 and CLY-2. This is because most of this thickness is only very weakly altered, although at least one slightly reddened cambic soil named the Old Maid Coulee Soil (McDonald and Busacca, 1990) formed (Fig. 7a).

The first phase of soil development for the lower Washtucna Soil at proximal sites began when the influx rate of sediment slowed, which in turn caused a slower rise of the land surface and of the zone of active soil formation. During this period of relative landscape stability, soil-forming processes began to dominate over those of loess deposition. We conclude a slowing of loess deposition rates occurred because this would allow organisms such as cicadas to more thoroughly burrow a given volume of sediment. Buried soils in the loess that have petrocalcic horizons, such as the Washtucna Soil, commonly have fossil burrows in more than 90% of their volume, whereas unaltered loess (see, e.g., Fig. 7a) that we think must have been deposited relatively rapidly generally has less than 5% burrows. The soil that formed in the uppermost part of the loess during this first phase of Washtucna Soil formation consisted of burrowed A and cambic horizons and a weak calcic horizon (Fig. 1b).

We do not know why or when the slowing of loess deposition began that led to the onset of development of the Washtucna Soil. One possible explanation may be that the supply of eolian sediment from slackwater deposits decreased because of substantial depletion of the flood deposits by fluvial erosion and eolian redistribution.

Formation *of the* petrocalcic *horizon*

The formation of the petrocalcic horizon in the lower Washtucna Soil at proximal sites is a direct result of a renewed rapid rate of loess deposition that forced the land surface and the zone of accumulation of secondary carbonates to move upward into the position of the A and cambic horizons that had been heavily burrowed by cicadas (Fig. 7c). This added layer of loess at the CLY-2 site was coarser than the loess it covered having almost 15% more sand (Fig. 5); this added layer at the CLY-1 site is also coarser than the underlying loess with sand content doubling to almost 50%. Micromorphology of calcic and petrocalcic horizons (E. McDonald, unpubl. data) indicates that the interiors of individual cicada burrows were tint cemented with pedogenic carbonate to form the cemented cylindrical nodules. Cementation probably began when the burrows were initially engulfed by the rising zone of carbonate accumulation. As the accumulation of pedogenic carbonate continued, carbonate was then preferentially precipitated as nearly continuous coatings on the exterior surfaces of the cylindrical nodules. Vertical seams formed by accumulation of pedogenic carbonate along prismatic ped faces. The transfer of much of the carbonate downward along prismatic ped faces appears to have been instrumental in forming petrocalcic horizons because the degree of carbonate cementation decreases away from the vertical seams. The petrocalcic horizon was completed when the abundant cylindrical nodules became cemented together. A weak laminar cap of thin horizontal seams formed over the top of the now-impermeable horizon. During the formation of the petrocalcic horizon, new A and cambic horizons with prismatic and blocky soil structure and cicada burrows were forming in the overlying loess (Fig. 7c).

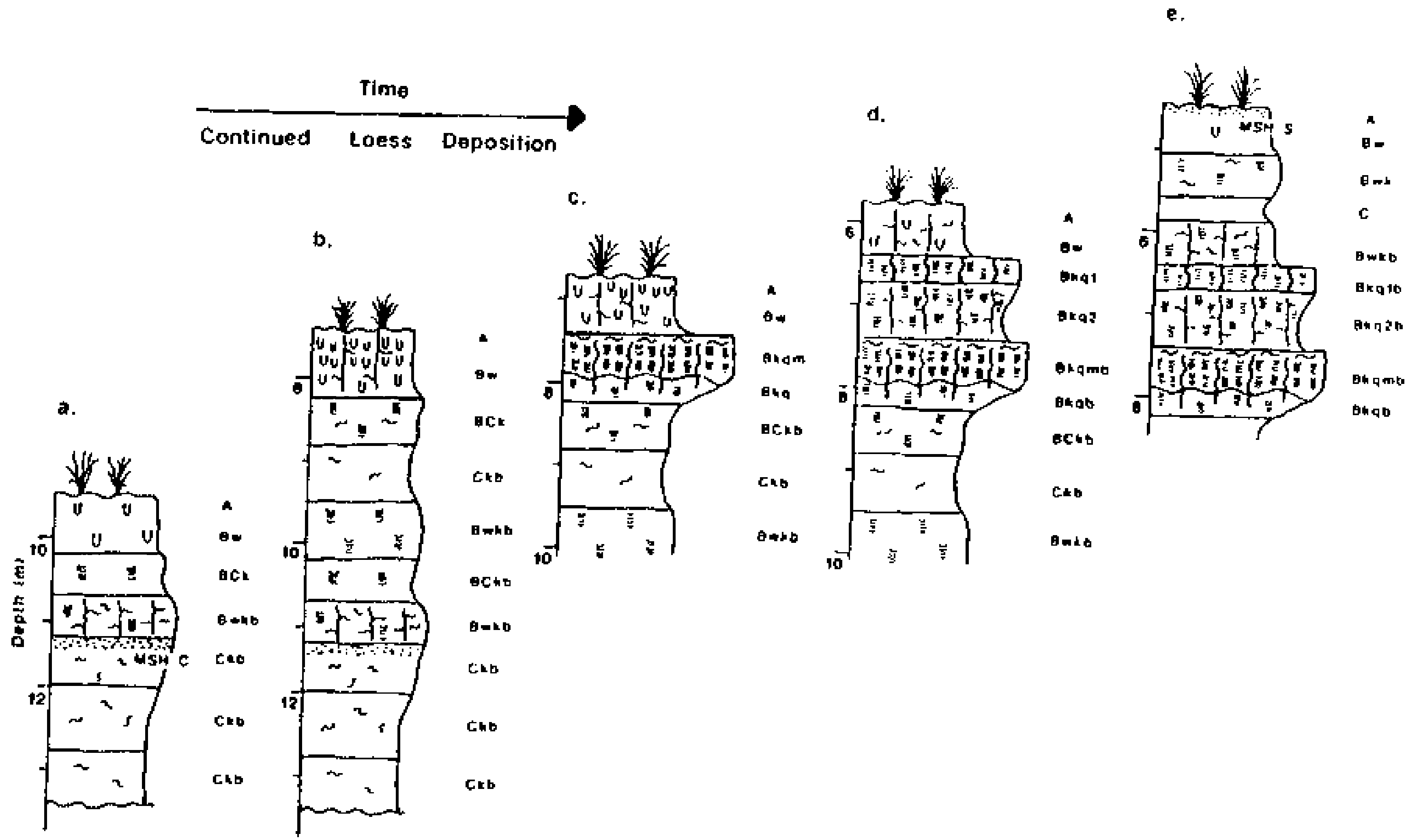

Fig. 7. Schematic diagram showing sequence of five phases of soil development and continued loess deposition that formed the soil stratigraphy at the CLY-2 site. Symbols used are defined in Fig. 2.

At distal sites such as WA-5 (Fig. 2) and in-deed over the majority of the loess area that receives less than 400 mm of annual precipitation today (Fig. 1), only a single Washtucaa Soil is seen, and it has a morphology and carbonate content much like that of the lower Washtucna Soil in proximal sites.

Bifurcation of the Washtucna Soil

One or more additional cycles of loess deposition occurred during and after the formation of the lower Washtucaa Soil at the proximal sites but apparently did not occur at more distal sites such as WA-5. Renewed deposition of sand-rich loess buried the A and cambic horizons that formed with the petrocalcic horizoo of the lower Washtucaa Soil. As a result. this cicada burrowed zone of the A and cambic horizons was also engulfed by the zone of carbonates (Fig. 7d). Cicada burrows in the former A and cambic horizons of the lower soil first became cemented to form cylindrical nodules, then carbonate preferentially precip itated along the exteriors of the burrows. Development of seams of carbonate completed superimposition of the upper Washtucna Soil over the older A and cambic horizons of the lower Washtucna soil. A petrocalcic horizon formed as part of the upper Washtucaa Soil at the CLY-1 site, whereas at the CLY-2 site, the soil only has an incipient petrocalcic horizon. Exposures of the upper Washtucna Soil at other proximal sites indicate that the upper soil often contains a petrocaicic horizon.

Continued deposition of sand-rich loess caused the landscape to rise once again, resulting in the formation of a third, very weakly developed soil. At the CLY-2 site, the third soil formed within a meter of very sandy loess (> 65% sand, Fig. 5). The MSH set S tephra occurs in the loess that overlies this uppermost Washtucaa Soil (Fig. 7e), providing a minimum age estimate of 13,000 yr B.P. for the last phase of development of the Washtucna Soil.

Timing of soil formation

Determining the age of the Washtucaa l Soil(s), and in turn, the rates of pedogenesis. is problematic because of a lack of numerical age control for the onset of soil formation and because regional stratigraphic relationships among exposures of Late Quaternary loess suggest different lengths of time for the formatioa of the Washtucna Soils.

Development of the Washtucaa Soils may have occurred during much of the time interval after the early or middle Wisconsin episode of flooding (75,000 to 40,000 yr B.P.) and before the end of the Late Wisconsin episode of flooding (17,000 to 13,000 yr B.P.). An iaitial period of relatively rapid loess deposition and formation of the weakly developed Old Maid Coulee Soil prevailed for perhaps 5000 to 10,000 years following the older episode of flooding. The remaining balance of time would provide as much as 57,000 or as little as 13.000) years for the periods of landscape stability that led to the development of the Washtucaa Soils, depending on whether the older episode of flooding occurred during the early or middle Wisconsin. If formation of the Washtucaa Soil was constrained to this period of relative landscape stability, it is unclear what caused additional cycles of loess deposition at the proximal sites.

An important question is what was the origin of the pulses of sandy loess at the Clyde sites that are associated with the dual Washtucaa soil in proximal locations. Development of the superimposed soil profiles resulted from major influxes of sand-rich loess sometime during Washtucna-Soil time to force the single soil of more distal sites to separate into two or more at proximal sites. The combination of an increase in the coarseness of the loess and the pulses of renewed deposition indicate that a significant change occurred regarding landscape stability and processes controlling loess deposition.

Different possible origins of these sediments

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suggest different age constraints on the timing of the formation of the Washtucna Soil. Stratigraphic relationships observed across the Scabland between episodes of flooding and cycles of loess deposition suggest our favored explanation for the origin of the sandy loess. A layer of sandy loess overlies the lower petrocalcic horizon of the lower Washtucna Soil at the Clyde sites (Figs. 5, 6). The basal layer of sandy loess at each site was the parent material in which the A and cambic horizons of the lower Washtucna Soil formed and was probably the principal source of the carbonates that were translocated to form the petrocalcic horizon of the lower Washtucna Soil. As such, this sandy loess had to be emplaced before the petrocalcic horizon of the lower Washtucna Soil could form.

The sandy texture of the loess implies that eolian deposition occurred mainly by saltation and modified-saltation processes from a nearby source of sediment (Pye, 1987). At many sites in the Scabland system and in several ages of loess from Holocene to Early Pleistocene, we have found that episodes of Scabland flooding occurred with and perhaps triggered cycles of loess deposition (McDonald and Busacca, 1988). At many of these sites, the basal bed of sediment that overlies flood-cut unconformities is sand-rich loess or dune material that was deposited by saltation and modified saltation from nearby flood channels. These sand-rich layers, in turn, fine upward into silt-rich loess. Abrupt coarsening of the loess that we attribute to the onset of late Wisconsin flooding occurs *within* the Washtucna Soils at 6.2 m in CLY-1 (Fig. 6) and 7.4 m in CLY-2 (Fig. 5), and these sand-rich layers fine upward gradually (CLY-1) or in a series of pulses (CLY-2) through the position of the MSH set S tephra and above it. We think that the sand-rich layers in the Washtucna Soils were carried by saltation from flood slackwater sediments that had been deposited in adjacent valleys. The gradual fining from sand-rich to silt-rich loess occurred when the supply of coarse near-source sediment in adjacent valleys decreased or was stabilized. but eolian transpon (suspension) of finer materials continued from the much larger areas of thick slackwater sediments that are upwind in the Walla Walla Valley and Pasco Basin. The proximity of the Clyde sites to areas of slackwater sediments from giant floods (Fig. 1) and the relationship between episodes of flooding and cycles of loess deposition strongly suggests that the beds of coarse loess here were triggered by the onset of late Wisconsin floods in the Channeled Scabland.

The sandy-loess layers have been incorporated into the lower Washtucna Soil, so if this hypothesis is correct, formation of the soil at the proximal sites would have started with the onset of late Wisconsin Scabland flooding. This latest episode of flooding in the Channeled Scabland is thought to have begun about 16,000 (Atwater, 1986) or perhaps 17,000 yr B.P. (Waitt, 1985) when the Cordilleran Ice Sheet first impounded late Wisconsin glacial lake Missoula. This interpretation suggests the startling conclusion that the major development of the lower and upper Washtucna Soils (stages c to e, Fig. 7) may have occurred over only about 4000 years between 17,000 and 13,000 years B.P. This suggested origin of the pulses of sand-rich loess thus requires very rapid rates of formation for the Washtucna Soil.

That the single or dual Washtucna Soils could have formed in a few thousand years is supported by the very weak expression of other kinds of pedogenesis in these soils, such as low amounts of secondary iron oxides from mineral weathering, and lack of even incipient development of argillic horizons. These accessory features of soil development are almost absent in the Washtucna Soils. For example, the upper and lower Washtucna Soils at CLY-2 have only 0.45 and 0.50% dithionite-extractable Fe, respectively, as compared to about 0.37 and 0.44% Fe in the unaltered loess beneath each soil. Soil development completed in a few thousand years would provide one explanation for these observations.

An alternative hypothesis for the origin of the coarse loess layers is that they were triggered by changes in climate or vegetation that affected landscape stability and the supply of eolian sediment at the onset of Late Wisconsin glaciation in the Pacific Nonhwest. A pollen record from Carp Lake in south-central Washington suggests that the Columbia Plateau was colder and more arid between 2 1,000 and 8 500 yrs B.P. These changes at the start of late Wisconsin glaciation may have caused a decrease in the vegetative cover on loess deposits across the plateau, and in turn triggered the initial cycle of eolian deposition. Additional increments of sandy loess may have been added by eolian redistribution of late Wisconsin flood sediments beginning at about 17,000 to 16,000 yr B.P. This interpretation also requires rapid rates of soil formation, although it does allow more time for the formation of the Washtucna Soil at distal sites between the onset of degrading climate and the end of the late Wisconsin Scabland flooding. This interpretation also would provide for continued loess deposition for the bifurcation of the Washtucna Soils. Although it is plausible that cycles of deposition of sandy loess that are incorporated in the Washtucna Soils resulted from vegetative or climatic changes, this linkage remains to be documented in the Scabland loess deposits.

Other hypotheses may explain the origin of the pulses of sand-rich loess and provide different constraints on the timing on the development of the Washtucna Soil; however, the scenarios presented here best explain our current knowledge of linkages among flooding, loess deposition, and soil formation in the Channeled Scabland. We are testing the proposed time intervals for the formation of the Washtucna Soil by (1) applying a model that estimates the accumulation of pedogenic carbonate (Mayer et al., 1988), and (2) numerical dating by the thermoluminescence method of the loess in which the soils formed.

Implications and conclusions

Rates of soil development

The stratigraphic relationships of the Washtucna Soil among the sites discussed in this paper indicate that in areas of deep loess accumulation, two well-developed soil profiles were formed during the same time interval in which only a single soil profile was being formed throughout the rest of the Channeled Scabland. Evidence for this is the consistent stratigraphic position among the Washtucna Soil(s) and the two MSH tephras at all sites. This indicates that the base of the Washtucna Soil where it consists of two soil profiles is not time-transgressive to the degree that soil development began much earlier in areas of thick loess and continued for a period of time significantly longer than in areas where only one soil profile was formed. In addition. it seems unlikely that a longer period of landscape stability and soil development would occur in areas close to the loess source area where loess accumulation is very rapid and deeper than in areas of thin loess at greater distances.

The formation of two well-developed soils in proximal areas during the same time interval in which only one well-developed soil was formed in distal areas indicates that, at the least, rates of soil formation were much different between distal and proximal sites. The differences in the rates of soil development perhaps can best be explained through the concept of pedologic thresholds. The development of the Washtucna Soils represents the combined effects of extrinsic and intrinsic thresholds (Schumm, 1979). An extrinsic pedologic threshold was created when an external event caused pulses of eolian sedimentation that forced the landscape to rise, which led to the formation of overlapping soil profiles. An intrinsic threshold was crossed when the rising zone of carbonate accumulation engulfed former A and cambic horizons of the previous, now-buried soil that had been profusely burrowed by cicadas, leading to rapid formation of the petrocalcic horizon. The initial translocation of carbonate resulted in the cementation of the cicada burrows. Continued translocation of carbonate caused the carbonate to be preferentially precipitated on burrow exteriors: because of their great abundance, the burrows, in turn, quickly became cemented together, forming a petrocalcic horizon.

An imponant aspect of the development of the cemented cylindrical nodules is that they decreased the surface area-to-volume ratio in the horizon, therefore decreasing the quantity of pedogenic carbonate required to cement the horizon together. Evidence for this is the small amount of carbonate measured in the petrocalcic horizons (generally only 6 to 12%). Carbonate content for the Washtucna Soils is nearly two to six times lower than the carbonate content in soils described in the southwest U.S. that have Stage III or IV morphology (Machette, 1985). The small quantity of translocated carbonate in the petrocalcic horizons of the Washtucna Soils is consistent with our suggestion that they formed in a very short time.

The role of cylindrical nodules in the formation of soils in the loess is similar to that of gravel in coarse-textured soils, where the gravel decreases the amount of carbonate required to cement the interstitial matrix. Gile et al. (1966) have suggested that the pedogenic accumulation of carbonate proceeds at a faster rate in coarse-textured soils than it does in fine-textured soils.

It has been disturbing to us that the single Washtucna Soil at distal sites is only about as strongly developed as one of the two Washtucna Soils at proximal sites, sometimes even less so (compare Figs. 2, 5, 6), even though the single soil would have been forming on the land surface for about the same period of time as the dual soil. We think that the threshold concept applies to explain this as well. At the distal sites, only one burrowed zone was engulfed to trigger the formation of the single petrocalcic horizon. At the proximal sites during this same time interval. deposition of additional loess caused a second zone of cicada burrows to be engulfed. The translocation of carbonate from this new sediment allowed the second Washtucna Soil to quickly form at proximal sites; conversely, the absence or additions of only small amounts of sediment at distal sites added little more carbonate to the Washtucna Soil in those areas away from the sediment source.

Impact on soil stratigraphy

The different and perhaps rapid rates of pedogenesis exhibited by the bifurcated Washtucna Soil has important implications for the Paiouse loess as well as for soil-stratigraphic studies in general.

Soil formation during periods of glacial climate is important to soil-stratigraphic studies because of the widespread belief that conditions favorable for rapid soil development occur only during ioterglaciations (cf. Birkeland and Shroba, 1974; Morrison, 1978). An interesting hypothesis first proposed by Foley (1982) was that at least some of the buried soils in the Palouse loess may have been formed during glacial stages. Stratigraphic relationships suggest that the Washtucna Soil may have developed during the late Wisconsin, or a time of glacial climate. Recognition of other soils that may have formed during glacial periods would provide a powerful tool for linking the Palouse stratigraphy to the deep-sea oxygen isotope curve. That the Washtucna Soil and others in the loess may have formed during times of glacial climate is in opposition to the concept of soil-forming intervals (Morrison, 1967), which holds that soil-forming processes are relatively inactive during times of glaciation and that unique and optimal climate conditions during the brief times of interglaciations are responsible for the bulk of soil formation.

Soils that can form very rapidly if a pedologic threshold is exceeded could lead to very incorrect estimates of the age of that soil and of its geomorphic surface, or in incorrect soil-stratigraphic correlations. For example, calcic soils in the southwestern U.S. that have Stage III to Stage IV morphology are generally found on surfaces thought to be Middle to Late Pleistocene or older than 100,000 yr B.P. (Gile et al.. 1966; Machette, 1985). The ages of these soils. however, are poorly constrained. The weak Stage IV morphology of the Washtucna Soil has formed in a considerably shorter time. We are not suggesting that all calcic soils formed this fast; however, there is still a great deal we do not know about rates of accumulation of pedogenic carbonate and of soil formation. especially once threshold conditions are established. The results reported here do suggest. however, that extreme caution is required when estimating ages of geomorphic surfaces based on the stage of carbonate morphology because of the possibility that rates of soil formation can be very different under different circumstances. The concept of pedologic thresholds is not new (Birkeland, 1984: Busacca, 1987), but little is known about what types of geologic and pedologic environments can be conductive to promoting rapid soil formation.

Many soils form in dynamic environments where, as a result of episodic sedimentation, the morphologic propenies of a pre-existing soil may have an important impact on a subsequent period of soil development. The development of a zone of cicada burrows in one phase of soil development that was subsequently engulfed by pedogenic carbonate under a rising landsurface, along with the rapid development of gravel-like cemented cicada burrows. seems to have greatly accelerated the development of petrocalcic horizons. Recognition of the effects of overlapping periods of soil development is always a concern in stratigraphic investigations of buried soils: however, continued eolian additions to surface soils are more difficult to detect and evaluate.

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Long Quaternary Record in Eastern Washington, U.S.A., Interpreted from Multiple Buried Paleosols in Loess

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ABSTRACT

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Loess that is from a few meters to 75 m thick covers an area of more than 20,000 km² on the Columbia Plateau in Washington, Idaho and Oregon. The region of deepest loess is in eastern Washington and is called "The Palouse". The Palouse is downwind of the Channeled Scabland, through which massive outburst floods from Glacial Lake Missoula flowed repeatedly during glacial stages of the Pleistocene. The deepest stratigraphic section yet studied is in a remnant of the once continuous loess cover that is surrounded by Scabland channels. A normal-over-reverse magnetic polarity zonation in this section supports an age of more than 790,000 yr, but 15–35 m of loess may be present beneath this section, so a total of 1.5–2 million yr is possible. Upward fining of texture in some layers in the loess at this site and stratigraphic evidence at nearby sites suggest that at least some pulses of loess deposition were triggered by episodes of cataclysmic floods. Nineteen or more individual paleosols can be recognized in 26 m of section based on field morphology, physical and chemical properties, and micromorphology. The paleosols consist of calcic, petrocalcic and duripan horizons, many of which are associated with cambic horizons. Less strongly developed soils in this and other sections have been obscured by partial overlap of soil development in an episodically rising loess landscape. Paleosols in the loess at other sites reflect a dry-to-moist climatic gradient from west to east across the region during the Pleistocene that was grossly similar to today's. Accumulation of pedogenic carbonates and silica dominates in a western zone where the present-day mean annual precipitation is less than about 450 mm. Translocation of silicate clays and leaching of carbonates dominate in a central steppe zone where precipitation is between 450 and about 700 mm. Fragipans are common in an eastern zone along the steppe–forest transition at present-day precipitation of over 700 mm. Reconnaissance study suggests that these climatic–pedogenic zones have been somewhat stable during many of the episodes of soil development preserved in the loess, although some paleosols have different features from the majority of the paleosols in that zone, e.g., paleosols with fragipans in a sequence of paleosols with argillic horizons, which suggests that some episodes of soil development took place under different climatic conditions.

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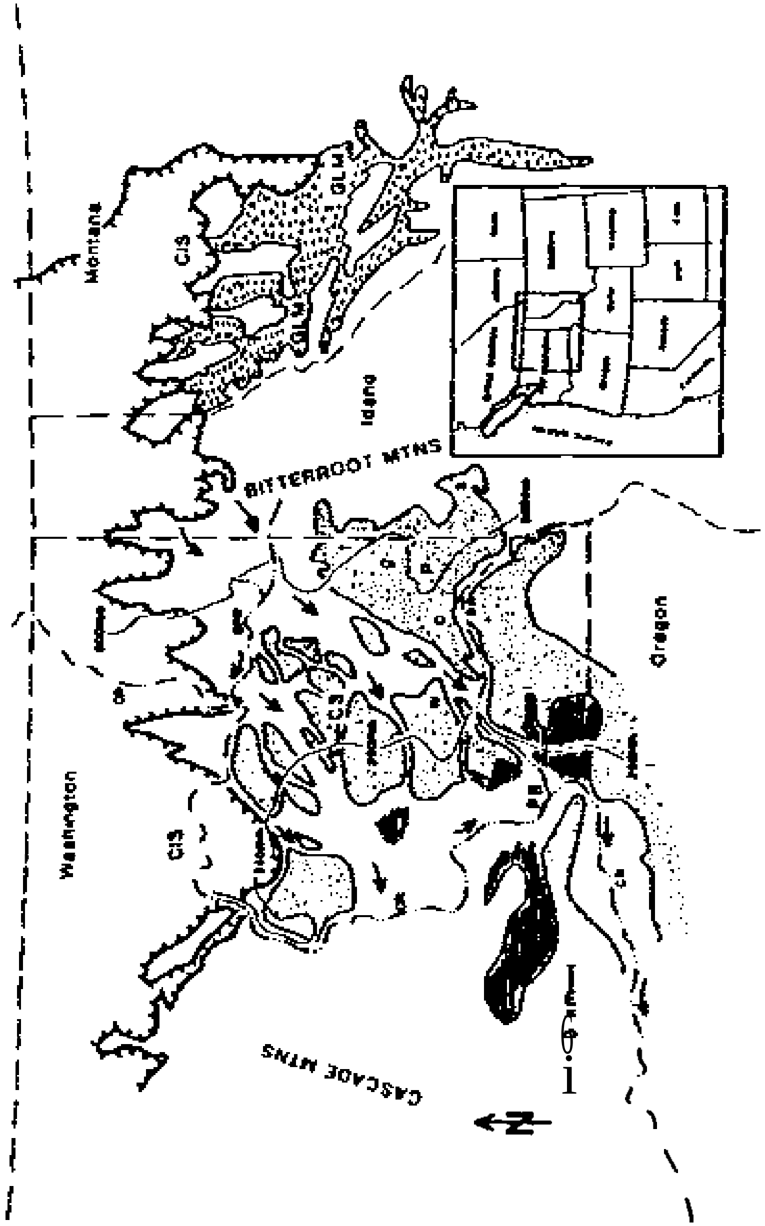

INTRODUCTION

The deepest and most continuous loess deposits in the northwestern U.S.A. are centered on eastern Washington state in a region called "The Palouse". The Palouse loess may help us lo belter understand the Quaternary history of North America because it is very near the southern margin of the Cordilleran Ice Sheer (Fig. I) and because some of the cycles of loess deposition were triggered by cataclysmic glacial outburst floods fmm Glacial lake Missoula in western Montana (McDonald and Busacca, 1988; Busacca, 1989) that created the Channeled Scabland in central Washington (Baker and Bunker. 1985). Recent research has demonstrated that there were at least six and perhaps more episodes of giant floods during glacial maxima of the Pleistocene Epoch (McDonald and Busacca, 1988). A thick Cordilleran Ire Sheet extending into southern Canada or the northern U.S. is required to block drainages and generate these large-scale floods, so the stratigraphic record in the loess one day may he one of the best terrestrial proxy records of glacial-climatic cycles in North America.

Paleomagnetic measurements prove that the geologic record in the loess spans at least the last one million years (Packer, 1979; Kukla end Opdyke. 1980; Foley. 1982; Busacca, unpublished data). Thin layers of volcanic ash from the Cascade volcanic mountain chain to the west are interstratified in the loess, and some of these have been correlated to known and dated eruptions (Foley. 1982; McDonald and Busacca, 1988; Nelstead, 1988).

Within lhe Palouse loess are interstratified dozens of buried ancient soils (paleosols). The paleosols are the record of episodes of relative landscape stability and the beds of loess are the record of episodes of rnpid eolian sedimentation. Early work on the stratigraphy of the Palouse loess conducted by Roald Fryxell (Fryxell et al., 1965; Richmond et al.. 1965) was cut offhy his untimely death in 1974. It is known. however, that paleosols in loess sequences can be

Fig. 1. Location map of the Palouse (P) and Channeled Scabland area (CS) with a schematic representation of Quaternary features discussed in text. Maximum extent of the Cordilleran Ice Sheet (CIS) during the late Wisconsin is shown by the heavy hatchured line; maximally developed Glacial Lake Missoula (GLM) during the late Wisconsin shown by patterned area in western Montana. Areas of thick loess are shown by the stipple pattern; the Palouse is the roughly triangular area on the Idaho Washington border. Major pathways of glacial outburst floods illustrated by arrows, significant deposits of quiet-water silt and sand from floods are shown by pattern of closely spaced horizontal lines. Pasco Basin (PB), Columbia River (CR), Snake River (SR), and Spokane River (SPR) also shown. W denotes the location of the Washtucna site, O the Olighant site, T the Thatuna site; S the Santa site, G the town of Garfield. The Washtucna stratigraphic exposure is 46°46'00" N 118°20'50" W, elevation 500 m, the Olighant pedon is 46°42'32" N 117°46'45" W, elevation 550 m; the Thatuna pedon is 47°13'31" N 117°6'37" W, elevation 880 m, and the Santa pedon is 46°50' N 116°36'45" W, elevation 915 m. Isohyets of 250 mm and 500 mm of present-day mean annual precipitation plotted for the Palouse and Scabland areas only.

excellent indicators of pad climates (see. for example. Liu. 1985), can he wed as stratigraphic markers for regional correlations (e.g. Ruhe, 1976), and, in a few cases, paleosol-and-loess sequences have been used to reconstruct glacial–interglacial cyclical patterns (e.g. Kukla. 1975. 1977; Kukla et al.. 1988), so further work on the loess of the Palouse is clearly warranted.

A new phase of march on the history and origins of loess and paleosols in the Palouse region has been underway for several years, and a picture is beginning to take shape of the nature of the paleosols in the loess and theirclimatic and stratigraphic significance. The purpose of this paper is to show some of the results of this recent work and to discuss new ideas and hypotheses.

METHODS

Stratigraphic and soil descriptions

One deep stratigraphic exposure in the drier part of the region and thm surface pedons from progressively wetter zones were studied and are discussed below. The large section was selected because it is one of the deepest excavations in the loess. The description was made from a hand-dug. stepped trench in a roadcut 3.3 km northwest of the town of Washtucna, Washington (W in Fig. I). The site is at the crest of a north-south trending hill at an elevation of 490 m. The roadcut exposes the upper 26 m of section. The hill is part of a "loess island", a remnant of the deep loess cover that is surrounded by channels of the Scabland system. The trenching extended 0.5–1.5 m back from the face of the roadcut to expose fresh material. Individual loess strata and paleosol horizons were described using standard methods for soils (Soil Survey Staff, 1981) that were supplemented with additional terms to describe sedimentological features, tephra layers and unusual morphologic features that resulted from bioturbation.

Pedons of the surface soils discussed below were selected to illustrate the great changes in pedogenic character across the Palouse region. They were described from freshly ● xcwMed backhoe pits. The soils were described using standard methods for soils (Soil Survey Staff, 1981). The Oliphant, Thatuna and Santa sites are 45 km east, 113 km east-northeast, and 137 km east of the Washtucna site, respectively (Fii. ı). Each of the three sites was on the convex upper part of a loess hill with southwesterly (Oliphant series), northeasterly (Thatuna) and westerly (Santa) aspects and slops of less than seven degrees The three sites are all within the main body of the Palouse loess geographically and are therefore not near any Scabland channels.

Sampling and analysis

Bulk samples of each soil and paleosol horizon and loess layer were collected for analysis. Sampling intervals at the Washtucna and other sites ranged from 10 to 100 cm. Oriented undisturbed blocks of paleosols and loess layers were collected from the Washtucna site. These were impregnated with resin and thin sections were made and then examined with a petrographic microscope. Pedogenic calcium and magnesium carbonates were analyzed by treating samples for 30 min with a sodium acetate buffer solution (0.5 *M* NaOAc in 13% HOAc) heated lo 90°C; the calcium and magnesium were analyzed by atomic absorption spectroscopy. Samples for the determination of particle-size distribution were pretreated twice using the same procedure as above to remove carbonate cements. The samples were then dispersed by sonicating them for 15 min in a 3% Na_2CO_3 solution in a cup-type ultrasonic vibrator (Busacca et al., 1984). Sands were first separated from silt and clay by wet sieving. then dried and weighed. Clay content was determined by pipette method (Jackson. 1975) and sill hy subtracting the weight of sand and clay from the oven-dry weight of the pretreated sample. Organic carbon content of the pedons of surface soils was determined by an acid-dichromate digestion procedure (Soil Survey Staff, 1984, 6A1C); extractable iron was determined for the Oliphant and Thatuna pedons by a dithionite-citrate procedure (Soil Survey Staff, 1984, 6C2).

RESULTS AND DISCUSSION

Washtucna deep stratigraphic exposure

Deep roadcuts in the Palouse expose multiple paleosols interstratified with sheets of loess. One of the deepest and most extensively studied roadcuts is 3.3 km northwest of Washtucna, Washington. Twenty-six meters of stratigraphic section is exposed; the total depth appears to be 40–60 m based on interpretation of topographic maps. The sediments in the lower one-half of the exposed section are reversely magnetized (Fig. 2) (Kukla and Opdyke, 1980; Foky. 1982; Busacca, 1989), implying deposition before the Brunhes Normal Polarity Chmn and therefore an age greater than 790,000 yr B.P. (Johnson. 1962).

The paleosols in this section have cambic, calcic, petrocalcic and duripan horizons, as do paleosols in other exposures in the semiarid western Palouse and Channeled Scabland. Present-day mean annual precipitation (MAP) and mean annual sir temperature (MAT) at the Washtucna site are 280 mm and 10.5°C, respectively. The native vegetation in the area surrounding the site was sagebrush steppe before settlement (Daubenmire, 1970). Holocene surlace soils are Mollisols that are intergrading to Aridisols (Soil Survey Staff. 1975).

Calcium nnd magnesium carbonates in relatively unaltered loess layers range from 1 to 5% (Fig. 2); grains of detrital limestone or marble are seen in thin section. Pedogenic horizons have 7 to almost 40% carbonates. The carbonates occur as thin filaments, soft masses, cemented insect burrows (earthworm and

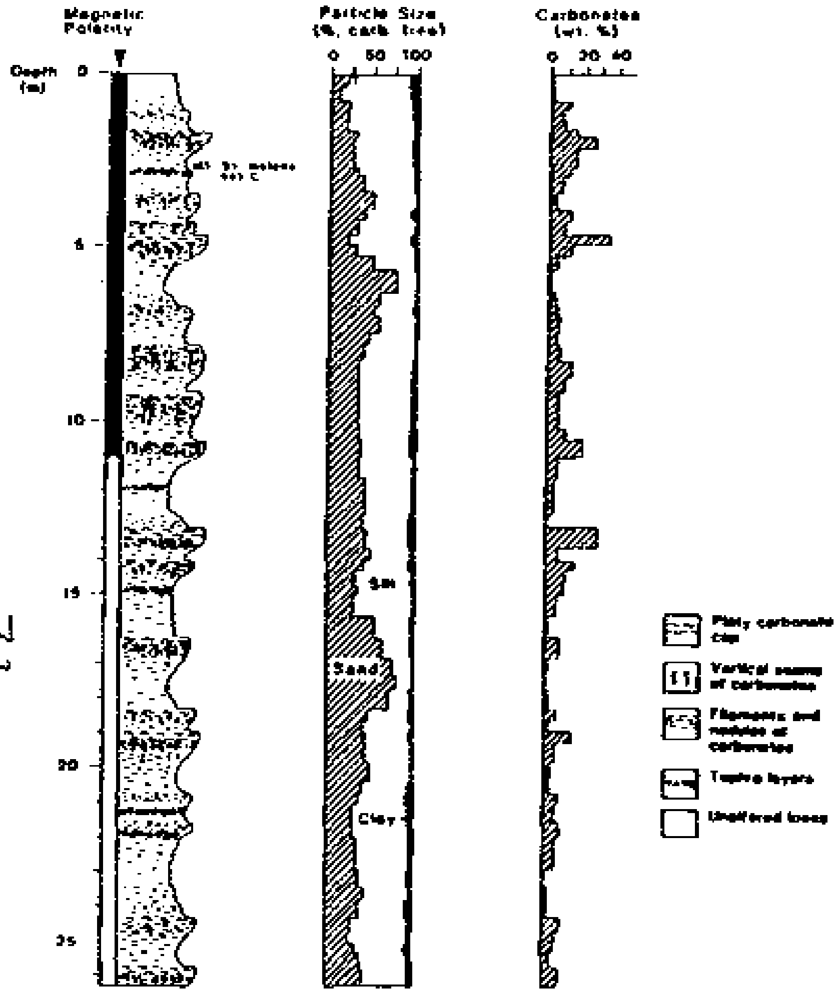

Fig. 2. Stratigraphic-pedologic reconstruction of the deep exposure at Washtucna, Washington. Magnetostratigraphy of the section is shown at left; black is normal magnetic polarity and white is reversed magnetic polarity. Paleosols are shown in schematic form in which closer spacing of symbols and greater distance out from the origin represent greater degree of soil development. Symbols show morphologic features resulting from accumulation of carbonates and silica

cicada), horizontal laminar caps and vertical seams. Several forms can occur together in individual paleosols.

Secondary silica contributes significantly to the cementation of some of the

paleosols at Washtucna and other sites in the semiarid part of the Palouse even though amounts rarely exceed 1.5% on a carbonate-free basis (S.A. Feldman and A.J. Busacca, unpublished data). Strongly developed paleosols can have dominantly carbonate cements, both carbonates and silica, or in a few cases, dominantly silica. The paleosol at 24 m, for example (Fig. 2), has low carbonate content yet apparently because of silica cementation is one of the most strongly cemented paleosols in the exposure.

Camhic horizons are present above about one-half of the calcic and petrocalcic horizons and duripans. Cambic horizons have higher color chromas than do horizons above and below them; in thin section, they exhibit greater weathering of primary minerals and more secondary iron oxide coatings. Cambic horizons also have slightly higher amounts of dithionite-extractable iron than do non-cambic horizons (about 0.6% versus about 0.3%, on a carbonate-free basis). Even though the amounts are small, the relationship between Fe, and cambic horizons is consistent enough that it is probably the result of pedogenesis in most cases. Although there are variations in clay content with depth (Fig. 2), field morphology and study of thin sections suggest argillic horizons in this stratigraphic section only for the paleosols at 13 and 24 m. The variations in clay content, therefore, are due principally to depositional processes, perhaps with some contribution by in-place weathering in some horizons.

Zones darkened by humified organic matter or other buried plant remains are not found at this site, and in fact are extremely rare even in the areas of higher precipitation to the east. There is evidence at some sites that A and cambic horizons have been stripped down to duripans and calcic horizons by slope erosion and, in the Channeled Scabland, by flood erosion. More commonly, however, the zones that were the A horizons when soils were actively forming probably are still present in the stratigraphic sequence. They now have the appearance of being part of C horizons, cambic horizons, or calcic horizons of the next overlying paleosols. A horizons may have simply lost their organic matter by oxidation after burial in this dry environment, or, in this landscape that has risen episodically by deposition of new loess, each increment may have been, in turn, the A, then the cambic, then the calcic horizon for successive soil profiles.

Particularly when increments of new loess have been less than about 1 m, the calcic or duripan of the newly forming surface soil has overprinted its features on the former A and cambic horizons of the previous soil. For example, at 5 m in the Washtucna profile, the carbonate enriched horizons from two different episodes of soil development are closely superimposed and the pan of the upper apparently has been formed in the former A horizon of the lower one (Fig. 2). Chemical data, field morphology and micromorphology support this interpretation of partial overlap of soil development for about half of the paleosols at the Washtucna site (Busacca and Feldman, 1985). Several terms such as welded soil (Ruhe and Olson, 1980), compound and composite geosol

(Morrison, 1978) and superimposed soil (Busacca et al., 1965) have been proposed for various forms that overlap can take in specific geologic and pedogenic settings.

Soil structure formed hy burrowing organisms such as earthworms and cicadas is very common in paleosols throughout the semiarid and arid climatic zones of the Palouse and Scabland. The most heavily burrowed horizons, which I describe as having a "cylindrical" soil structure, would seem to delineate the positions of former A and cambic horizons because of the known life habits of these organisms (Hugie and Passey, 1963), but they are almost invariably also part of the moat strongly cemented horizons in the paleosols. Root casts of grasses and shrubs that are now strongly cemented by carbonates are also common. These observations are consistent with a complex genesis of the soils in which the A and cambic horizons of a soil are eventually engulfed by carbonate and silica cements as the zone of precipitation of carbonates and silica rises in an episodically accreting loess landscape. As individual loess beds thin to the north and east of source areas in the Pasco Basin and environs (McDonald. 1987; Busacca, 1969). the overlap becomes more severe and the problem of distinguishing individual paleosols becomes more severe. Much remains unknown about the exact sequence and timing of episodes of soil development in the Palouse, yet these observations tell us that the origin of the paleosols has been complex.

Particle-aia analysis of strata at the Washtucna roadcut and at other sites within and near the Channeled Scabland show much wider ranges in texture, end in particular higher sand contents. than is typical of loess. The sand content of loess in the Scabland (dominantly very tine sand) ranges from 10 to more than 75% (Fig. 2). In contrast, Frazee et al. (1970) reported sand to be less than 5% for Peoria Loess in Illinois. except within 1 km of the Mississippi and Illinois riven. Even in these very near-source areas, sand was less than 16%. Loess in the main Palouse is finer in texture, ranging from about 2 to 30% sand and 25 to 5% clay, and is more typical of loess reported elsewhere, presumably because of much greater distances from source areas.

Giant floods in the Channeled Scabland may have been responsible in part for the coarse texture of the loess then by triggering cycles of loess deposition when flood sediments could have been remobilized and winnowed by strong prevailing southwesterly winds: it is known that floods deposited gravel. sand, and silt in and adjacent to channels or "coulees" within the Scabland and deposited silty and clayey quiet-water sediment in the Pasco Basin and surrounding valleys (Fig. 1), where floodwaters ponded before draining to the Pacific Ocean (Baker and Bunker. 1965). It is also known that there have been several episodes of flooding during the Pleistocene (Patton and Baker, 1978; McDonald and Busacca, 1988), each episode consisting of many individual flood bursts from Glacial Lake Missoula and spanning perhaps several thousand years during a glacial maximum (Waitt, 1985; Atwater, 1966). Loess beds

associated with Late Quaternary episodes of flooding thin and tine with distance away from the Pasco Basin and surrounding valleys (Busacca, 1989; McDonald nnd Busacca, 1989).

Large erosional unconformities cut into loess adjacent to flood coulees have been correlated to earlier episodes of floods by stratigraphic position within the loess, hy flood sediments that overlie some unconformities and by marker beds of volcanic ash (McDonald and Busacca, 1988). Al many sites. loess that overlies these unconformities grades upward in texture from coarse to fine (McDonald and Busacca, 1966). This suggests a shifting balance of sources through time after episodes of flooding: coarse saltated sediment from nearby coulees dominating soon after floods, and finer suspended sediment (true loess) from distant source areas dominating later. The coarse basal parts may be a highly localized form of cover sands or sand sheets reported from a variety of ancient and modern environments (e.g. Ruegg, 1963; Kocurek and Nielson, 1966; Schwan, 1966). Paleosols that cap these beds suggest a return to landscape stability and very low rates of loess deposition some time, probably thousands to perhaps ten thousand years, after each flood episode.

At Washtucna and other such sites in the Scabland that do not have obvious unconformities. some of the loess beds also an very sandy (e.g. at 4.6.14. and 16–18 m, Fig. 2). These appear to be correlative to some of the flood-triggered loess beds described above (Busacca, 1969).

Because the Channeled Scabland consists of a system of anastomosing or hrnided channels that covers thousands of km² (Fig. 1). region-ride patterns of particle size and thickness for loess beds within the Scabland that were triggered hy floods, such as Holocene loess, are quite complex (E.V. McDonald and A.J. Busacca, unpublished data) and represent a striking contrast to most other loess regions that have line sources such as major rivers.

It is not known how many of the loess–paleosol cycles in sections such as Washtucna could have been triggered by episodes of cataclysmic flooding. There have been a minimum of six episodes of floods during the Pleistocene (McDonald and B-s. 1966). however. so floods have probably generated at least six loess beds. including the Holocene loess cap that forms the modern surface soil. which was deposited following the last glacial floods. The existence of such a large total number of loess be& and paleosols at sites such as Washtucna (Fig. 2) suggests that climatic cycles or oscillations may have exerted an influence on loess deposition through several other proxies, such as changes in vegetation or in rind direction or intensity, in addition to glacier-dammed lakes.

Paleoclimatic significance of the Palouse loess

Soils developed in the layer of Holocene or "post-Scabland flood" loess in the Channeled Scabland and Palouse reflect the xirtencr of climatic and vegetational gradients across the region during their development, because ochric epipedons, cambic horizons, and calcic horizons have formed in the driest area that is centered on the Pasco Basin and these features are progressively replaced by mollic epipedons, cambic and then weak argillic horizons. albic horizons, and fragipans with increasing distance to the north and cast into areas of higher precipitation. Paleosols across the same region show grossly similar trends, suggesting that gradients of climate and vegetation also existed during the Pleistocene Epoch. There is neither sufficient stratigraphic control nor adequate numbers of exposures at present to take full advantage of the possibilities of reconstructing paleoclimates for individual time periods; however, I will present data and interpretations from three pedons that span today's climatic range and discuss the potential for eventual paleoclimatic reconstructions based on • reconnaissance of stratigraphic exposures of paleosols.

The geographic and physiographic setting of the loess is important to understanding the climatic and pedogenic gradients. The Miocene Columbia Plateau Basalt serves as a gently eloping platform on which the loess was deposited; the elevation of the lowest part of the Pasco Basin is about 150 m above sea level and tk elevations of the tops of the loess hills increase from about 200 m on tbe southwest to more than 900 m on the northeast. Present-day mean annual precipitation is as low as 150 mm in Columbia Basin and increases northeastward to more than 1000 mm in the Bitterroot Mountains of north Idaho due to an orographic effect on the cyclonic storms that are carried by westerly winds. Present-day mean annual air and soil temperatures decrease along this transect due to increasing elevation. Native vegetation before arrival of large numbers of American settlers in the late nineteenth century was a sagebrush steppe in the driest southwestern part of the region, a steppe consisting of perennial bunchgrasses in the main body of the Palouse, and conifer forest along the eastern edge of the loess field in northern Idaho (Daubenmire, 1970).

Cambic, calcic, petrocalcic and duripan horizons dominate in paleosols that occur to the west and southwest of the 450 mm isohyet (Fig. I) of present-day mean annual precipitation; albic, cambic, argillic end occasional week calcic horizons occur in paleosols that lie geographically approximately between the 450 and 700 mm isohyets; and albic, argillic and fragipan horizons dominate in a zone about '20 km wide to the east of the 700 nun isohyet.

Because of the complex landscapes. variable thickness of the youngest layer of loess (Holocene and latest Pleistocene in age or about 13,000 yr old; McDonald, 1987; Busacca, 1989). and the ubiquitous presence of paleosol horizons beneath this cover of young loess, about one-half of the upland soil series mapped in the Scabland and Palouse have superimposed profiles (Busacca et al., 1985). Mollic or ochric epipedons, cambic and/or weak calcic horizons have been formed in the young loess layer and these features overlie and merge in development with cambii. calcic, petrocalcic, duripan, albic, argillic, or fragi-

pen horizons of paleosols. Superimposed profiles are a widespread feature of soils in a thin loess cover in which the solum of the surface soil forms throughout the entire thickness of the cover and into the solum of a buried soil formed in an older material. Ruhe and Olson (1980) called thia process "soil welding" and such soils "welded soils".

I selected the Oliphant, Thatuna, and Santa series soils (Fig. 3; Table I) to represent welded soil profiles with components of both Holocene and earlier episodes of soil development and to illustrate dominant pedogenic processes in the low-precipitation part of the bunchgrass zone, the high-precipitation part of the bunchgrass zone, and the high-precipitation forest zone, respectively.

The Oliphant series soil has a mollic epipedon and a cambic horizon that have been formed in the layer of youngest loess. A calcic horizon appears to have formed into former A and cambic horizons of the buried paleosol (Fig. 1, Table I). Underlying these horizons is a petrocalcic horizon of the paleosol. Carbonates are in the form of horizontal laminae, vertical seams, soft masses and filaments. No translocation of clay is evident from laboratory data (Table I), although the A and cambic horizons have larger amounts of extractable iron thnn deeper horizons. presumably due to greater weathering of the near-surface zone.

The Thatuna series soil has a higher organic matter content than does the Oliphant soil (Table I). which is a result of the higher mean annual precipitation and greater biomass production on the Thatuna site. A cambic horizon underlies the mollic epipedon. As with the Oliphant soil, the upper sequence of horizons in thought to have been formed in Holocene and latest Pleistocene loess. Carbonates generally have been fully leached from soils such as thm of the Palouse series in this precipitation zone, except that they are not completely removed from thin soils on hill summits that shed waler.

Even in this part of the Palouse where present-day MAP is 560 mm. 10–

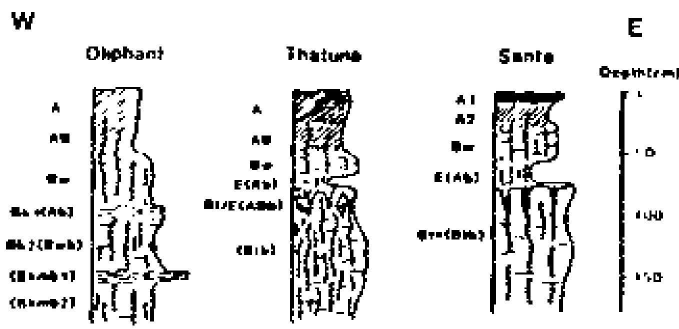

Fig. 3. Schematic diagrams of the Oliphant, Thatuna, and Santa pedons. Horizon nomenclature is from Soil Survey Staff, 1981.

TABLE I

Environmental, physical, and chemical data for the Oliphant, Thatuna and Santa series soils

Soil series, great group	Horizon	Basal depth (cm)	MAP*¹ (mm)	MAT*¹ (°C)	Native vegetation*²	Particle size*³ (%) sand	silt	clay	Fe_d*⁴ (%)	Carbonate content (%)	Organic carbon (%)
Oliphant, Haploxeroll	A	33	360	10.0	B	18	71	13	1.0	0	1.1
	AB	51				16	71	13	1.0	0	0.8
	Bw	94				13	78	9	0.9	0	0.5
	Bk1(Ab)*⁵	112				21	70	9	0.5	23	0.5
	Bk2(Bwb)	147				18	76	6	0.7	5	0.5
	(Bkmb1)	152				27	68	5	0.3	30	0.3
	(Bkmb2)	162				19	78	3	0.3	21	0.2
Thatuna, Argialboll	A	38	560	8.9	B.S	6	71	23	1.0	0	2.0
	AB	54				8	70	24	1.0	0	1.0
	Bw	72				7	71	22	1.0	0	0.7
	E(Ab)	83				8	79	13	0.8	0	0.4
	Bt/E(ABb)	117				6	66	28	1.2	0	0.3
	(BtB)	178				3	66	31	1.0	0	0.2
Santa, Fragixeralf	A1	13	720	6.5	C	10	73	17	nd.*⁶	0	4.0
	A2	23				6	74	18	nd.	0	0.8
	Bw	53				8	74	18	nd.	0	0.5
	E(Ab)	74				8	79	13	nd.	0	0.3
	Btx(Btb)	168				7	65	28	nd.	0	0.2

*¹MAP = mean annual precipitation; MAT = mean annual air temperature; climate estimates from Donaldson (1980) and Barker (1981); all sites have xeric moisture regimes.
*²B, perennial bunchgrass; B.S bunchgrass and mesophytic shrubs; C, conifer forest.
*³Calculated on a carbonate-free basis.
*⁴Fe_d = dithionite extractable iron.
*⁵Horizon designations in parentheses are interpretations of paleosol horizon types before Holocene episode of loess deposition and soil development (see text).
*⁶nd. = not determined.

15,000 yr apparently is insufficient lime to form a" argillic horizon in the Holocene loess under a xeric climate. although the cambic horizon shows macro- and micromorphologic evidence in the form of weak argillans and interstitial pore fillings that clay transformation and translocation are taking place in the material.

A strong albic and argillic horizon sequence underlies the young loess in the Thatuna soil. The albic horizon has been formed by lateral water flow over the upper surface of the less permeable argillic horizon (Rieger and Smith. 1955). The argillic horizon has thick or prominent argillans on ped faces and lining tubular pores. Imn-manganese concretions up to several millimeters in diameter are common in the albic and argillic horizons. Translocation of extractable iron as well as clay is evident from a comparison of the albic and paleosol argillic horizons (Table I). The albic and argillic horizons are good examples of the welding process (Ruhe and Olson, 1980) because contemporary processes associated with the modern land surface have extended into what probably was the former A horizon of the paleosol to form the albic (Fig. 3). Degradation of the upper part of the argillic horizon (Fig. 3) and possibly clay translocation appear also to be contemporary processes.

The Santa series soil has an ochric epipedon because it has been formed under a mixed conifer canopy instead of under perennial grasses. It is an Alfisol (Fragixeralf) that is part of a belt of Alfisols and Inceptisols that formed in forest near the forest-steppe boundary in the distal part of the loess field. The ochric epipedon and cambic horizon have been formed in young loess. They overlie a strong albic horizon and an argillic horizon of a paleosol. The albic nnd fragipan horizons apparently formed during the Holocene as a" overprint on the A and argillic horizons, respectively, of the paleosol. The albic and fragipan horizons serve lo "weld" the paleosol to the surface soil. They have im" mottles and manganese concretions, indicating alternating conditions of oxidation and reduction in these horizons.

Fragipans are dense. brittle. reversibly cemented subsoil horizons (Grossman and Carlisle, 1969; Soil Survey Staff, 1975). In northern Idaho, as elsewhere, fragipans have a distinct morphology but a poorly understood genesis. Here they occur in a zone only about 20 km wide (Barker, 1981) that is approximately parallel to precipitation isohyets, temperature isotherms, and astride a particular forest habitat type. The steppe-forest transition zone may have been coincident with the zone of fragipans during the driest phases of the Holocene (H.W. Smith, pers. commun., 1984). The parallelism of the fragipan zone end isolines of climate and vegetation suggest a causal relationship but the mechanism(s) are unknown at this time.

It is the zones of transition or "pedogenic tension" between these areas of dominant soil-forming processes (e.g. calcic to argillic. argillic to fragipan) that have the beat potential for reconstructing paleoclimates. Have the climates during episodes of soil development in loess been similar for some or all of the paleosol units? That is. for example, have all of the soils in the stratigraphic sequence of the Palouse loess formed under similar climates during interglacial stages or might some of the soils have formed under very different climates during glacial stages? One way to address questions such as these would be to determine whether the geographic position of the key pedogenic transition zones stayed the same or changed between episodes of soil development, as recorded in the properties of paleosols in the stratigraphic sequence of the loess. Two examples fmm the Palouse will serve lo illustrate this point.

A reconnaissance of roadcuts across the zone of fragipans showed as many as seven buried paleosol fragipans in vertical sequence, with more of them likely to be preserved beneath the deepest level of the roadcuts. This observation points lo a recurrence across a narrow geographic zone, through al least a part of the Pleistocene. of a rather specific though unknown set of pedogenic or environmental conditions during episodes of soil development. A backhoe trench near the town of Garfield, Washington exposed a paleosol fragipan nearly 20 km west of the zone of fragipans delineated during soil survey (Barker, 1981), which would be the fragipans developed during the Holocene. Given the large gradients of moisture. temperature. and elevation on the eastern edge of the Palouse, this would represent a large shift in the location of the steppe-forest boundary during al least one episode of soil development if my assumption is correct that this ecological boundary is involved in the development of fragipans in northern Idaho. The topographic position of the soil site near Garfield suggested the paleosol fragipan was near the bottom of the loess stratigraphic section and might have represented a period of soil development during the Middle or even Early Pleistocene. One possibility is that this soil and others of great age in the loess formed under a wetter Early Pleistocene climate that might have caused climatic and vegetation zones lo have been situated farther to the west than they are today. This could have been caused by a significantly reduced rain shadow effect (and therefore higher precipitation) from an ancestral Cascade Range whose crest had not yet been uplifted to its Late Pleistocene and Holocene elevations. or perhaps by a postulated global secular change from warm and moist to cooler and drier from the Late Pliocene to the present (Dodonov, 1979, 1986).

Reconnaissance of sites across the "pedocal-pedalfer" (calcic-argillic) boundary in the central part of the Palouse produced sequences of paleosols that are transitional in character. i.e. buried profiles that have both argillic horizons and cakic horizons. Here also. examination of exposures on both sides of the transition zone produces some paleosols that appear to be anomalous in development compared lo other soils in the exposures, suggesting limes when critical soil-climatic boundaries had shifted significantly during development of several paleosols within a stratigraphic sequence. Al present. the detailed stratigraphic and chronologic controls are lacking and fresh roadcut • qxxwres are generally loo infrequent lo be able lo postulate a chronology of climatic

swings in the Palouse; however. research is in progress to establish these controls (McDonald, 1987; Nelstead, 1988; Busacca, 1989; McDonald and Busacca, 1989), at firs1 for late Quaternary loess.

Paleosols in exposures in the driest zones of the Palouse and Scabland, such as at Washtucna, are somewhat similar in their key pedogenic features. By this I mean that the commonly observed pattern is a cambic horizon over a cakic horizon, a pet rocalcic, or a duripan. large differences do exist in the degree of development of these features (Fig. 2). but these differences may be due lo differing lengths of time of soil development as well as differences in climate. Paleosols in the lower part of this stratigraphic section and deep in other sections that appear to he Middle or Early Pleistocene generally have smaller accumulations of carbonates (Fig. 2), larger accumulations of silica. nnd redder color hues then paleosols higher in the section, and some have cambic horizons that horder on argillic character; a few are argillic. It could be speculated, without conclusive evidence at this lime, lhal these soils also reflect a generally higher rainfall during their development as part of a secular change from welter to drier climate during the Quaternary. The lack of well developed argillic horizons in any paleosols in the exposure at Washtucna, which today has an MAP of 300 mm. suggests that this site has not experienced any significant periods of soil development when effective precipitation was as much as twice what it is today because argillic horizons would he expected lo have formed.

CONCLUSIONS AND IMPLICATIONS

About nineteen paleosols can be recognized in the 26-m section at Washtucna based on physical. chemical. morphological (Fig. 2) and microscopic data; some of the less strongly developed soils have been obscured by overlap of soil development in this episodically rising loess landscape (Busacca and Feldman, 1985). Attempts to date tephra layers in the middle and lower part of the Washtucna section (Fig. 2) and other deep exposures by the fission-track method have been unsuccessful (Foley. 1982; A.J. Busacca, unpublished data); nevertheless, the exposed part of the section et Washtucna must span more than one million years based on magnetostratigraphy and based on the fact that as many as 15-35 m of loess may underlie this exposure.

The very great number of paleosols in the loess and the complex erosional and depositional histories of individual hills within the loess so far have thwarted attempts to establish correlations among deep exposures. For example, a deep exposure WAS studied about 40 km to the northeast of Washtucna because it was thought that the section might be correlative in age and sequence lo that al Washtucna. Although the 23-m section has about 25 buried paleosols of grossly similar character to those at Washtucna, the entire 23-m section is normally magnetized (Busacca, 1989), whereas the Washtucna section is reversely magnetized below 12 m (Fig. 2). I tentatively interpret this entire normally magnetized section as having been deposited during the Brunhes Normal Polarity Chron. At best. the section in only partially correlative with that at Washtucna. Because of the great thickness of normally magnetized loess at this second section compared to that at Washtucna, a further implication is that the normally magnetized part of the Washtucna section may have subtle disconformities and that an unknown portion of the geologic record may be missing from this interval. This points further to the need for caution in trying to establish correlations among sites.

Greater success has been obtained in younger loess because there are more exposures and the geologic record is not as fragmented as it is in older loess: loess and paleosols that span about the last 100,000 yr have been correlated among sites within a radius of shout 70 km around Washtucna (McDonald. 1987; McDonald and Busacca, 1987; McDonald and Busacca, 1989), based on recognizable pedostratigraphic units and correlated tephras.

Clearly. based on a potential age of 1-2,000,000 yr and on its extraordinary pedostratigraphic record, the Palouse loess must be ranked among the most significant deposits for understanding the Quaternary of North America. but much work remains to bring thii record to light.

The somewhat consistent distributions of climatically controlled pedogenic features within loess-stratigraphic sections (based on reconnaissance observations)at sites across the region suggests to me not that the Palouse escaped severe changes in climate during the Pleistocene. but rather that many of the episodes of soil development may have taken place during a consistent part of each glacial-interglacial climatic cycle. If thii is true. one of the key questions becomes: *which part* of each cycle experienced stable landscapes. low rates of loess deposition. and soil development.

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Soil-Plant Community Relationships in the Selkirk Mountains of Northern Idaho

Abstract

Soils and the native plant communities they support often exhibit a strong mutual dependence within geographically similar areas. In mid- to high-elevation forests of northern Idaho, volcanic ash is an important soil parent material and has had a major impact on soil properties and the distribution of vegetation. As a result, there are several well-expressed soil-plant community type associations within this region. This study compares the properties and classification of soils and plant communities along a south-facing elevational gradient in the Selkirk Mountains of northern Idaho. Cold, moist soils of the higher elevations, corresponding to the *Abies lasiocarpa* (subalpine fir) series, are strongly influenced by volcanic ash. These soils have undergone intense podzolization and are classified as Spodosols. The intermediate moisture and temperature conditions associated with the middle elevations support plant communities of the *Tsuga heterophylla* (western hemlock) series. Associated soils exhibit progressively less influence of volcanic ash with decreasing elevation. Accordingly, soils of the upper end of the western hemlock zone are classified as Andisols and those of the lower end are classified as intergrades to the Andisols. At relatively low elevations, the warmest and driest soils of the climatic gradient support communities of the *Pseudotsuga menziesii* (Douglas-fir) series. These soils contain little or no volcanic ash and are classified as non andic Inceptisols and Entisols. Results from this study indicate that increased sensitivity of Soil Taxonomy to ash-influenced soils helps distinguish several of the important soil-vegetation interactions that have been operative in this region. As a result, interrelationships between soils, their classification, and associated plant communities can be clearly demonstrated for these and, presumably, similar forested ecosystems of the Pacific Northwest.

Introduction

Interrelationships between soils and the vegetation they support are often observed by field soil scientists and plant ecologists. In recognizing the close relationship between plant communities and soil-forming processes, Jenny (1941) included organisms (primarily vegetation) as one of the five soil-forming factors in his widely used model of soil genesis. Major (1951) used a similar set of independent variables to define a climax plant community. Thus soil- and climax plant communities can both be thought of as products of the same set of environmental variables – climate, organisms, relief, parent material, and time – and an interdependence therefore exists between a specific soil body and its climax vegetation (Hironaka *et al.* 1991). Considerable research in forests and rangelands of the western U.S. has been directed at identifying and even attempting to quantify the relationships between soils and the native climax communities they support (Daubenmire 1970; Steele *et al.* 1981; Hironaka *et al.* 1983; Tisdale and Bramble-Brodahl 1983; Cooper *et* al. 1991).

The habitat type (h.t.) approach to classification of land areas was first introduced by Daubenmire (1952) and is based on identification of potential climax plant communities. This system has been widely used to stratify and classify forest lands in the western U.S. (Pfister *et al.* 1977; Steele *et al.* 1981; Cooper *et al.* 1991). Habitat types represent a "type" rather than "continuum" approach to classification – they are identified by a specified combination of indicator plant species that reflect a modal type. Soil classification also represents a "type" approach. Soil taxa are defined in Soil Taxonomy by a discrete set of diagnostic chemical, physical, and morphological properties, many of which influence or are a product of the native vegetation (Soil Survey Staff 1975).

Given these similarities between soil and habitat type classification schemes, soil classification should be related to a habitat type classification within a given environmental setting. However, efforts to correlate soil and habitat type classifications have not been entirely successful. Potkin (1991) found that many soil properties which are important to plant community distributions in high-elevation environments are not utilized by Soil Taxonomy for classification purposes. Neiman (1986) examined 89 forested sites throughout northern Idaho and found little quantitative relationship between h.t.'s and soil physical properties and taxonomic classes. These studies suggest that within some environmental settings, soil classification does not emphasize or consider characteristics that are important to the distribution of plant communities. Furthermore. Hironaka et al. (1991) have cautioned that at any scale beyond a very localized application. a universal correlation does not exist between soil properties and vegetation attributes.

In northern Idaho. volcanic ash has had a significant impact on many soil properties and is believed to strongly influence the distribution of vegetation (Steele *et* al. 1981). Recent changes in Soil Taxonomy (Soil Survey Staff 1975) have placed more importance on the unique properties of ash-influenced soils. Once ash has been deposited across a region, it is exposed to various soil weathering environments and surficial processes such as erosion. As a result, the impact of the ash on soil properties may be quite variable within a relatively small geographic region. Accordingly. the Andisol order has been added along with Andic and Vitrandic intergrades of other orders to better reflect a range in ash-influenced soil properties (Soil Survey Staff 1992).

Given the importance of volcanic ash as a soil parent material in many forested areas of the Pacific Northwest and the increased taxonomic sensitivity to ash-influenced soils, the objective of this study is to illustrate some of the interrelationships that exist between soils and plant communities in this region. Specifically, this paper compares the properties and classification of soils and vegetation along a south-facing elevational gradient in the Selkirk Mountains of northern Idaho.

Methods And Materials

Study Area

The study area is located in the Trout Creek drainage of the Selkirk Mountains in northern Idaho (Figure 1). Trout Creek flows from Pyramid Lake to the Kootenai River, dropping approximately 1300 m in elevation over a distance 0120 km. The general topography of the drainage becomes steeper at lower elevations as Trout Creek has incised more deeply into the underlying substrate. Two contrasting geologic substrates occur in this area of the Selkirks. Steeply dipping Precambrian metasediments flank the range on the east side and granitic rocks of the Kaniksu Batholith make up the core of the range (Conners 19761. Pleistocene glacial deposits overlie both substrates and thus constitute one of the major soil parent materials of the area. During the Holocene. large quantities of volcanic ash from the cataclysmic eruption of Mount Mazama (approximately 6700.6800 yrs BP) were deposited throughout the region (Fryxell 1965: Fosberg *et* al. 1979; Bacon 1983). Some of this ash has been retained in modern soils either as a relatively undisturbed surficial mantle or as an admixture with coarser-textured granitic materials. The 1800 AD eruption of Mount St. Helens added an additional l-3 cm of ash (Layer T) to many soils of the area (Smith *et* al. 1968: Okazaki *et al.* 1972: Smith *et* al. 1975; Mullineaux 1986). This thin ash layer has been preserved in many of the soils, indicating relatively little surface disturbance has taken place over the past 200 yrs. Ash from the 1980 Mount St. Helens eruption was not observed in this area.

The climatic regime of the Trout Creek area is an inland expression of the Pacific Coast maritime climate. The closest weather station is located approximately 1 l km south of the study area at 1677 m elevation. Data from this station indicate annual precipitation averages 1180 mm and mean annual air temperature is 2.6°C (Cooper *et al.* 1991). Along the Trout Creek elevational gradient. precipitation is estimated to range from 560 to 2000 mm and falls primarily in the spring. fall. and winter (Houston 1988). Summers are generally warm and dry.

Study sites within the Trout Creek drainage were selected to represent the variation in soils and habitat types observed along elevational gradients in this part of the Selkirk Mountains. Sites chosen for sampling were restricted to those having ma. ture vegetation stands that were relatively undisturbed by logging or fire. Of the 30 sites sampled and described by Houston (1988). we will report data from four sites which collectively encompass the range in observed soil characteristics and potential climax plan! communities (Figure 1). AU four sites are located on south-facing. relatively stable ridge slopes.

Soils

Within each of the climax plant communities. soils were examined using road cuts and shallow

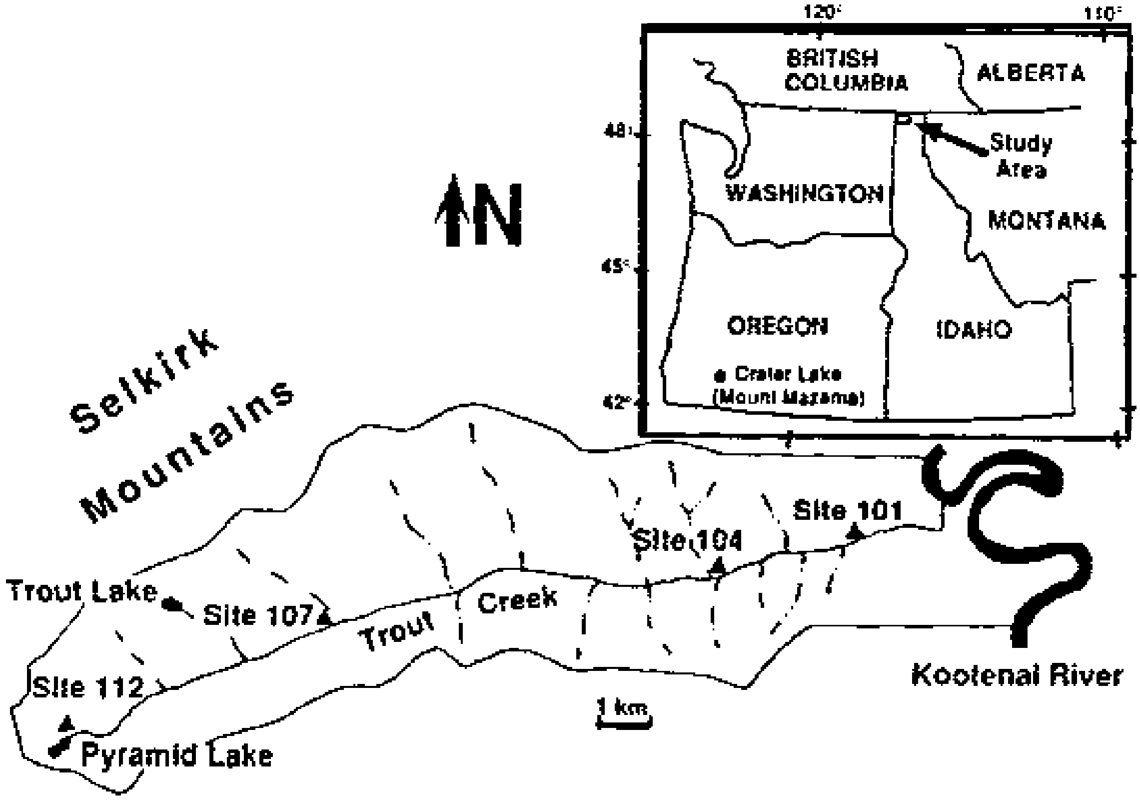

Figure 1. Map showing location of study area (inset) and sampling sites within the Trout Creek drainage.

hand-dug pits to determine representative morphological characteristics. A sampling pit was then located near the center of the plant community and dug to a depth of approximately 1 m. Soil profiles were described using standard horizon designations and descriptions (Soil Conservation Service 1984; Soil Survey Staff 1992). Soils were sampled by genetic horizons and classified to the family level according to Soil Taxonomy (Soil Survey Staff 1992) using appropriate laboratory and soil climate data. Samples were air dried and crushed with a rubber-tipped pestle to pass a 2-mm sieve. Laboratory analyses were performed using the following methods: particle-size analysis by pipette and centrifugation procedures (Jackson 1975; Gee and Bauder 1986); water retention at 1.5 MPa of soil moisture tension using pressure-plate extraction (Klute 1986); organic carbon by rapid dichromate oxidation (Nelson and Sommers 1982); pH (1:1 soil:water) and NaF pH using a combination glass electrode (Soil Conservation Service 1984); P retention by colorimetry (Blakemore *et al.* 1981); and Fe and Al contained in short-range order minerals by extraction with acid ammonium oxalate (Soil Conservation Service 1972). Glass contents were determined on very fine sand fractions by counting between 100 and 200 grains using a petrographic microscope.

Vegetation

A 375m² circular vegetation plot was established at each soil sampling location. All vascular plant species present within this area were identified according to Hitchcock and Cronquist (1973) and their abundance recorded by canopy coverage class (Cooper *et al.* 1991) (Table 1). Habitat types and phases were identified using a forest habitat type guide for northern Idaho (Cooper *et al.* 1991).

Results and Discussion

The distribution of soil and forest climax community classifications along the Trout Creek climatic gradient are summarized in Figure 2. The approximate ranges of soil moisture and temperature regimes are also given. These regimes are based on data collected at the sites (Fosberg, unpublished data) and related studies in northern Idaho by Schauer (1976). Cryic and frigid soil temperature

TABLE 1. Species list and coverage classes[1] for Trout Creek sites.

	Site 112	Site 107	Site 104	Site 101
Trees				
Pinus ponderosa	0	0	0	2
Pseudotsuga menziesii	0	T	T	3
Larix occidentalis	0	T	0	0
Pinus monticola	0	T	0	0
Thuja plicata	0	3	4	0
Tsuga heterophylla	0	1	3	0
Picea engelmannii	2	1	0	0
Abies lasiocarpa	3	2	0	0
Pinus albicaulis	3	0	0	0
Shrubs				
Holodiscus discolor	0	0	0	3
Physocarpus malvaceous	0	0	0	4
Philadelphus lewisii	0	0	0	2
Spirea betulifolia	0	0	0	T
Symphoricarpus albus	0	0	0	2
Berberis repens	0	0	T	3
Amelanchier alnifolia	0	0	T	1
Rosa gymnocarpa	0	0	0	1
Acer glabrum	0	0	1	0
Vaccinium myrtillus	0	0	T	0
Pachistima myrsinites	0	1	1	T
Lonicera utahensis	0	1	T	0
Linnaea borealis	0	1	T	0
Vaccinium globulare	3		0	0
Sorbus scopulina	T	0	0	0
Rhododendron albiflorum	5	0	0	0
Forbs				
Aralia nudicaulis	0	0	T	T
Disporum hookeri	0	T	T	T
Smilacina stellata	0	T	T	0
Achillea millefolium	0	0	0	T
Smilacina racemosa	0	0	T	T
Hieracium albiflorum	0	0	0	T
Goodyera oblongifolia	0	T	T	0
Chimaphila umbellata	0	0	T	0
Trillium ovatum	0	0	T	0
Pyrola secunda	0	T	T	0
Clintonia uniflora	0	T	T	0
Chimaphila menziesii	0	T	0	0
Tiarella trifoliata	0	T	0	0
Osmorhiza chilensis	0	0	T	0
Viola orbiculata	0	T	T	0
Mitella breweri	T	0	0	0
Xerophyllum tenax	1	0	0	0
Graminoids				
Agropyron spicatum	0	0	0	1
Calamagrostis rubescens	0	0	0	2
Carex geyeri	0	0	0	T
Bromus vulgaris	0	T	0	T
Luzula hitchcockii	3	0	0	0

[1] 0 = not present, T = 0-1% canopy coverage, 1 = 1-5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5 = 75-95%; 6 = 95-100%

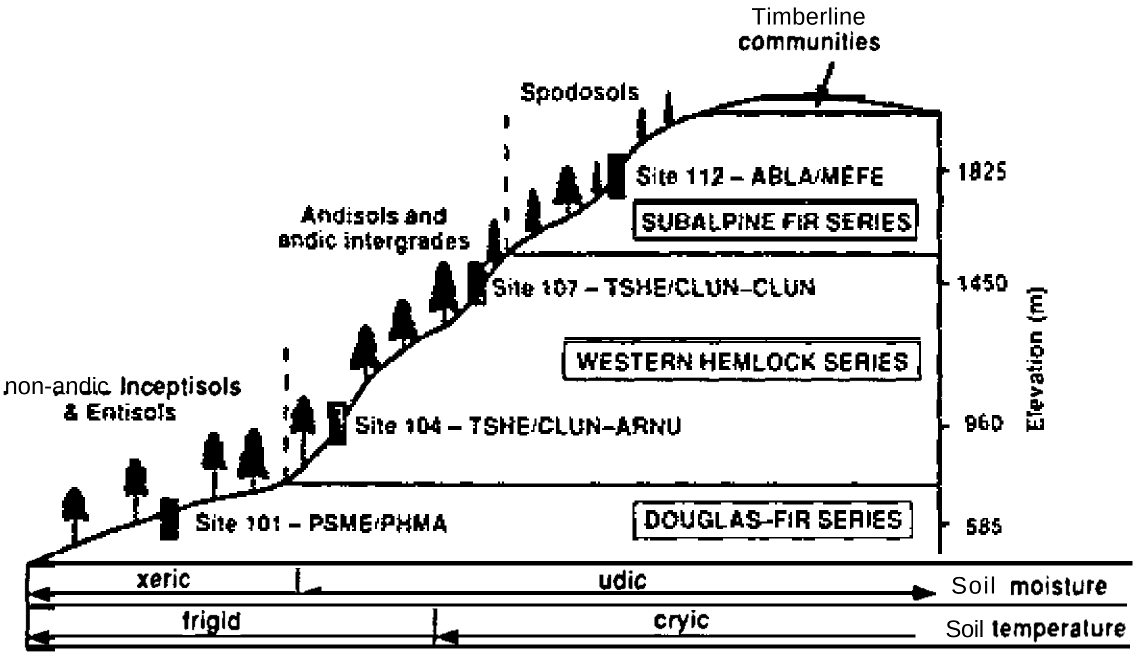

Figure 2. Generalized soil-plant community relationships on a south-facing slope in the Trout Creek drainage. Abbreviations: ABLA/MEFE = *Abies lasiocarpa/Menziesia ferruginea* h.t., TSHE/CLUN-CLUN = *Tsuga heterophylla/Clintonia uniflora* h.t., *Clintonia uniflora* phase, TSHE/CLUN-ARNU = *Tsuga heterophylla/Clintonia uniflora* h.t., *Aralia nudicaulis* phase, PSME/PHMA = *Pseudotsuga menziesii/Physocarpus malvaceus* h.t.

regimes are both characterized by a mean annual soil temperature < 8°C, but the cryic regime has cooler summer temperatures (Soil Survey Staff 1992). Udic and xeric soil moisture regimes differ in the length of time that the soil is dry during the summer months—xeric soils are subject to longer periods of dry conditions than are udic soils (Soil Survey Staff 1992). In the Trout Creek drainage, the change from cryic to frigid temperature regimes occurs somewhere within the *Tsuga heterophylla* zone. The change from the udic to xeric moisture regime appears to coincide with the change from the *T. heterophylla* series to the *Pseudotsuga menziesii* series.

The highest elevation sampling location, Site 112, is located at an elevation of 1830 m on a 10% slope and represents the coldest and moistest end of the climatic gradient. Climax vegetation is classified as an *Abies lasiocarpa-Menziesia ferruginea* (fool's huckleberry) h.t., *Luzula hitchcockii* (smooth woodrush) phase. The soil has formed in a mantle of Mazama ash overlying coarse-textured glacial drift (Figure 3). The dominant feature of this soil is the morphological evidence of podzolization. In the podzolization process Fe and Al move as soluble metal-organic and inorganic complexes, giving rise to a light-colored E horizon which overlies a brown to reddish-brown Bs (or Bhs) horizon. Sufficient quantities of Fe and Al have been translocated at Site 112 to form an albic (E)—spodic (Bs) horizon sequence (Figure 3; Table 2). Accordingly, this soil is now classified as a Spodosol, which is defined in Soil Taxonomy as a soil in which substantial quantities of amorphous Al and Fe (oxalate extractable) have accumulated beneath an albic E horizon (Soil Survey Staff 1992). Previously this soil had been classified as an Andisol (Soil Survey Staff 1990) and an Andept (Soil Survey Staff 1975).

In the Trout Creek drainage, we have observed the E-Bs horizon sequence (and Spodosols) only in association with the subalpine fir series. Similar associations have been reported elsewhere in the Pacific Northwest (Smith *et al.* 1968; Hunter 1988; Dahlgren and Ugolini 1991). This soil-plant community association exists because the conditions required for subalpine fir climax are also conducive for podzolization. The vegetation and climate interact in a manner to provide soluble organic chelating compounds and relatively large quantities of soil moisture that cause downward

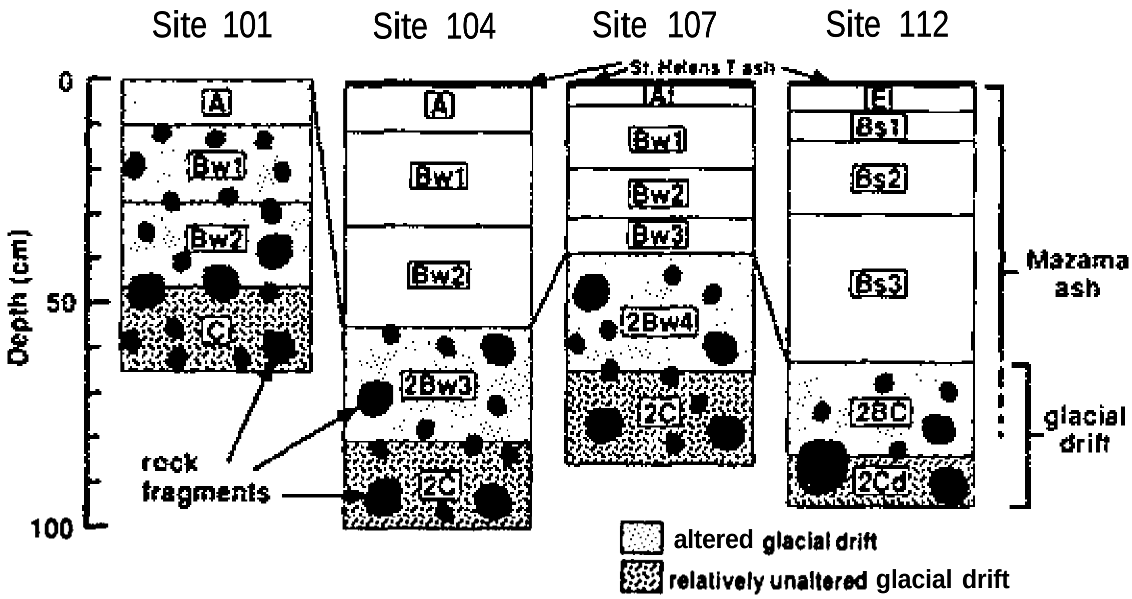

Figure 3. Comparison of parent material and horizon sequences in Trout Creek soils sampled along a bioclimatic gradient

migration of organic and inorganic metal complexes.

The Site 112 soil is the most strongly arid and contains the largest quantities of organic matter of any of the soils in this study (Table 2). NaF pH values >10, high P retention, and comparatively high glass contents in the very fine sand fractions all indicate a strong volcanic ash influence and result in classification of this Haplocryod as an Andic intergrade. Relatively large quantities of oxalate-extractable Fe and Al in the Bs horizons reflect the greater intensity of weathering and podzolization processes in this soil compared to those of the other sites.

Site 107 is located on a 35% slope at an elevation of 1450 m. Vegetation fits the *T. heterophylla-Clintonia uniflora* (queencup beadlily) h.t., *Clintonia uniflora* phase. The presence of *Abies lasiocarpa* and *Picea engelmannii* (Engelmann spruce) at this site suggest it occupies the cooler, moister end of the *T. heterophylla* series. The soil has formed in similar parent materials to those at Site 112, as high NaF pH values, high P retention, and comparatively high glass content all indicate a strong volcanic ash influence (Figure 3, Table 2). The major morphological difference is that podzolization processes have not been sufficient to produce an E-Bs horizon sequence. The Bw horizons do, however, exhibit sufficient development to meet the requirements of a cambic diagnostic horizon. The strong influence of volcanic ash and the lack of a spodic horizon result in classification of this soil as an Andisol (Soil Survey Staff 1992). This soil had previously been classified as an Andept (Soil Survey Staff 1975) and was therefore not distinguished from the Site 112 soil at the higher levels of Soil Taxonomy despite major differences in soil-forming processes.

Site 104 is located on a 55% slope at an elevation of 960 m and represents the lower-elevation end of the *T. heterophylla* series. Vegetation is classified as a *T. heterophylla-C. uniflora* h.t., *Aralia nudicaulis* (wild sarsaparilla) phase. Cooper *et al.* (1991) described this as the warmest and generally moistest phase of this habitat type, but also observed relatively dry stands that are barely able to support the moist-site species. Even though this site has the same h.t. classification as Site 107, the absence of *A. lasiocarpa* and *Picea engelmannii* indicates comparatively warmer and drier conditions. The sandy textures and relatively low water content at 1.5 MPa of soil moisture tension further suggest that this is a droughty site (Table 2). We feel the *A. nudicaulis* phase at Site 104 represents a warmer, drier environment than does the *C. uniflora* phase at Site 107. Cooper *et al.* (1991), however, describe the *C. uniflora* phase as the driest and warmest phase of the *T. heterophylla-C. uniflora* h.t.

TABLE 2. Selected morphological, chemical, and physical properties of Trout Creek soils described in this study

Horizon	Depth (cm)	Color moist	Color dry	Sand	Silt	Clay	pH H_2O	pH NaF	Organic carbon	1.5 MPa H_2O	P retention	Oxalate-extractable Fe	Oxalate-extractable Al	Glass vfs*
				-----	%					....	..%..			
Site 112 medial over loamy-skeletal Andic Haplocryod														
Oi, Or	5.0													
C	0-1	2.5Y 5/2	10YR 7/2 (St. Helens T ash)											
E	1-6	10YR 4/2	10YR 6/1	38.3	56.2	5.5	3.7	7.3	4.8	14.6	20.1	<0.1	0.1	38
Bs1	6-13	7.5YR 4/5	10YR 5/5	39.3	54.5	6.2	4.7	10.8	4.2	18.5	96.4	1.3	2.1	24
Bs2	13-29	7.5YR 4/5	10YR 6/5	39.1	55.6	5.4	5.4	10.9	2.7	13.2	95.9	0.7	1.8	28
Bs3	29-62	10YR 4/5	10YR 6/5	45.0	51.0	4.0	5.2	10.8	1.4	8.7	86.6	0.5	1.2	22
2BC	62-83	2.5Y 4/4	2.5Y 7/4	51.7	45.1	3.2	5.3	10.6	0.7	6.2	55.3	0.2	0.6	2
2Cd	83-95+	2.5Y 4/2	2.5Y 5/2	68.0	29.3	2.7	4.9	10.3	0.6	5.1	30.5	0.1	0.3	1
Site 107 ashy over sandy-skeletal, mixed Typic Vitricryand														
Oi, Oe	5.0													
C	0-1	2.5Y 5/2	10YR 7/2 (St. Helens T ash)											
A	1-5	7.5YR 3/4	10YR 4/4	64.8	31.0	4.1	5.0	10.4	2.9	6.5	54.2	0.5	1.2	31
Bw1	5-18	7.5YR 3/4	10YR 4/4	62.0	34.6	3.5	5.2	10.6	2.8	7.2	70.9	0.6	1.5	32
Bw2	18-30	10YR 3/5	10YR 5/5	65.6	31.2	3.2	5.2	10.5	1.8	4.4	64.1	0.4	1.4	32
Bw3	30-38	10YR 3/3	10YR 5/5	69.9	27.8	2.3	5.2	10.3	1.3	4.6	62.8	0.4	1.4	3:
2Bw4	38-64	10YR 4/3	10YR 6/3	83.4	14.9	1.8	5.2	10.0	0.4	1.8	23.8	0.2	0.4	4
2C	64-85+	2.5Y 5/4	2.5Y 6/4	93.6	5.6	0.9	5.1	9.5	0.1	0.9	17.7	0.1	0.1	0
Site 104 sandy-skeletal, mixed, frigid Vitrandic Udorthent														
Oi, Oe	6.0													
C	0-1	2.5Y 3/2	10YR 7/2 (St. Helens T ash)											
A	1-11	7.5YR 3/4	10YR 5/4	80.5	16.3	3.2	5.6	9.8	1.0	4.4	26.4	0.3	0.4	7
Bw1	11-32	7.5YR 4/4	10YR 5/4	82.0	15.5	2.6	6.0	9.7	0.6	3.7	23.9	0.3	0.4	5
Bw2	32-55	7.5YR 4/3	10YR 5/3	84.9	13.6	1.5	6.1	9.9	0.4	3.4	24.4	0.3	0.3	2
2Bw3	55-80	2.5Y 4/3	2.5Y 6/3	90.9	8.1	1.0	6.1	9.4	0.2	2.2	19.1	0.2	0.2	1
2C	80-100+	2.5Y 4/4	2.5Y 6/4	92.5	6.9	0.7	5.9	8.8	0.1	1.4	16.2	0.2	0.1	0
Site 101 loamy-skeletal mixed frigid Typic Xerochrept														
Oi, Oe	4.0													
A	0-10	10YR 3/2	10YR 4/3	64.9	28.3	6.8	6.1	8.4	3.2	4.0	27.0	0.5	0.2	2
Bw1	10-27	10YR 3/4	10YR 5/4	68.4	25.4	6.2	6.2	8.4	0.7	3.0	25.8	0.5	0.1	0
Bw2	27-46	10YR 3/4	10YR 5/4	61.5	32.7	5.8	5.9	8.7	0.8	3.0	26.5	0.3	0.2	0
C	46-64+	10YR 4/3	10YR 6/3	77.5	19.7	2.8	5.7	7.8	0.2	1.4	25.1	0.3	<0.1	0

*very fine sand

Steep slopes and greater susceptibility to fire and subsequent erosion associated with this drier site may have resulted in removal of much of the volcanic ash. There is only moderate ash influence on this coarse-textured soil as evidenced by intermediate NaF pH values, low P retention, and small quantities of glass in the very fine sand fraction, resulting in classification as a Vitrandic Udorthent. This classification indicates the soil has some of the characteristics associated with volcanic ash-derived soils, but they are too weakly expressed for inclusion in the Andisol order (Soil Survey Staff 1992). Development of Bw horizons results in classification as either an Entisol or Inceptisol, depending on soil texture (Soil Survey Staff 1992) and both of these soil orders are well-represented throughout this vegetation zone.

Site 101 is located on a 50% slope at an elevation of 585 m and represents the warmer, drier end of the climatic gradient observed in the Trout Creek drainage. Parent material is glacial drift and vegetation is classified as a *P. menziesii-Physocarpus malvaceus* (ninebark) h.t., *Physocarpus malvaceus* phase. *Pinus ponderosa* (ponderosa pine), absent from the higher-elevation sites, and Douglas-fir are the only tree species. The increased abundance of graminoids has resulted in formation of the darkest A horizon of any of the soils

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examined in this study. There is also sufficient B horizon development to meet the requirements for a cambic horizon, resulting in placement of the soil into the Inceptisol order. There is little or no volcanic ash influence and the soil is therefore classified as a Typic (rather than Andic or Vitrandic) Xerochrept (Soil Survey Staff 1992). Throughout this region, it has been observed that Mazama ash is usually absent in soils associated with Douglas-fir h.t.'s (Barker 1981; Weisel 1982). During the warmer, drier conditions that existed at the time of the cataclysmic eruption of Mt. Mazama, these sites most likely did not have sufficient canopy cover to prevent erosion of the ash that presumably was deposited uniformly throughout the area.

Conclusions

In the Trout Creek drainage of northern Idaho, Spodosols formed in volcanic ash are associated with the A. *lasiocarpa* series at the higher elevations. Classification of these soils is determined by the albic-spodic horizon sequence. These soils are also classified as intergrades to the Andisol order because of the strong volcanic ash influence. Habitat types of the *T. heterophylla* series occupy the middle elevations. Andisols are the dominant soils at the moister and cooler end of this zone. At the warmer, drier end of the western hemlock zone, there has been less influence of volcanic ash on soil properties. Accordingly, soils are classified as Andic (and Vitrandic) intergrades of Inceptisols and Entisols. The *P. menziesii* series occupies the frigid and xeric climatic regime of the lower elevations. Soils have little or no volcanic ash influence and, based on our data, are placed in Typic rather than Andic or Vitrandic subgroups of Inceptisols and Entisols.

This study illustrates some of the changes in soil properties that occur in association with different habitat types along elevational gradients in the Selkirk Mountains. These changes reflect differences in volcanic ash influence, climate, and various soil-vegetation interactions. Because recent changes in Soil Taxonomy better recognize the range of characteristics in soils such as these, we suggest that many quantifiable relationships exist between vegetation and soil classification systems in volcanic ash-influenced regions of the Pacific Northwest. We further suggest these relationships can be utilized by resource managers and field scientists as a means of extrapolating limited amounts of data that exist for these forested ecosystems.

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'ECOSYSTEM MANAGEMENT: PRINCIPLES AND APPLICATIONS

John A. Nesser
Correlator, Northern Region, USDA-Forest Service

Ecosystem management involves the maintenance of sustainable ecosystems while providing for a wider array of uses, values, products, and services from the land to an increasingly diverse public (Overbay, 1992).

Overbay (1992) proposes that the following principles be used to describe the initial components of ecosystem management:

- Multiple-use, sustained-yield management of lands and resources depends on sustaining the diversity and productivity of ecosystems at many geographic scales.
- The natural dynamics and complexity of ecosystems means that conditions are not perfectly predictable and that any ecosystem offers many options for uses, values, products, and services, which can change over time.
- Descriptions of desired conditions for ecosystems at various geographic scales should integrate ecological, economic, and social considerations into practical statements that can guide management activities.
- Ecosystem connections at various scales and across ownerships make coordination of goals and plans for certain resources essential to success.
- Ecological classifications. inventories, data management, and analysis tools should be integrated to support integrated management of lands and resources.
- Monitoring and research should be integrated with management to continually improve the scientific basis of ecosystem management.

Land Evaluation

Ecological land units (ELU's) are based on ecosystem components which do not change readily following management. These components include landform, geology and macro climate. Ecological land units are basic, bio-physical units which delineate similar landscapes with respect to ecosystem function, composition and structure. They may be delineated at different scales dependent on analysis needs. As an example, geology may be important in characterizing landscapes at the Ecoregion scale while soils may be more appropriate at the plot level. Ecological land units also provide the basic bio-physical template for interpretation of ecosystem processes such as fire regimes, historic vegetation patterns and succession, hydrologic function, and habitat relationships. Ecological land units also serve as a template for interpreting change in those ecosystem components that display great temporal variability such as existing vegetation and wildlife populations.

The effects of management practices can be assessed by contrasting the existing condition of a site to other managed or unmanaged sites that occur on the same ecological land unit. The differences observed are then attributable to management, not site variability.

EM Framework

The following steps describe how the land evaluation process may be used to achieve ecosystem management:

- Determine the desires and requirements of people who will be influenced by the planning outcome.
- Describe the ecological potential of the land for meeting stated societal needs. Such descriptions must include a description of the range of conditions required to maintain long-term system sustainability, a description of current condiiions, and a description of desired landscape conditions that achieve societal needs.
- If desired landscape conditions fall outside the range of conditions required for long-term system sustainability, inform the people who will be affected. Public awareness of ecosystem potential is critical In developing achievable 'desired future condition' strategies for land management. Public desires are refined through this process, based on an understanding of sustainable ecosystem criteria.
- Once a socially acceptable, sustainable vision of the landscape is achieved, if is then contrasted against available technology to determine if it can be implemented. For example, in many instances the desired landscape condition may differ from existing conditions. In these situations, factors such as system design and equipment availabilii must be considered to determine if it is technologically feasible to move the existing landscape to some desired set of conditions.
- Determine what parts of the stated human desires can be fulfilled given economic factors. If resources (economic and technological) are not available to construct the desired landscape, the public should be notified and alternative strategies developed. In most situations, short-term economic reasoning and large management impacts contribute to situations that violate land ecological and human values. Accordingly, they should be avoided in the development of strategies for ecosystem management.

These steps refine human desires baaed on land ecology, technology, and economic considerations. Such refinement requires that the public be informed of land evaluation findings and that public opinion be solicited throughout the process. The maintenance of sustainable ecosystems (as a basic tenent of ecosystem management) requires constant public input; however, ecosystems (in and of themselves) do not require management, The ability of our planet to sustain itself through periods of major climate change (glaclatlon), tectonic activity, and other disturbance events (biblical floods) indicates that the earth is quite capable of maintaining itself without our assistance. Instead, we manage ecosystems to ensure that desires and requirements of people are met now and In the future. Managers must understand the ecological potential and interactions of the land if they are to provide sustainable ecosystems for future generations.

Landscape Ecology Principles

Some of the maior landscaoe ecoloav and conservation biology principles applicable to ecosystem management are summarized below:

- Hierarchy theory-the development and organization of landscape patterns (e.g., vegetation communities) is best understood in the context of spatial and temporal hierarchies. Disturbance events that maintain landscape patterns and ecosystem sustainability are also spatial-temporal scale dependent phenomena Acknowledgment of these facts is critical to the development d management strategies for ecosystem sustainability. Applying these principles requires that land evaluation be conducted at multiple scales of ecological description rather than at traditional detailed scales such as stands or stream reaches. The temporal variabilii (e.g., vegetation succession dynamics) of landscapes also needs to be addressed in land evaluation.

Natural variability-all ecosystems vary across time and space, even without human influence. Knowledge of this variability Is extremely useful in determining If the current condition of a landscape is sustainable given historic pattern and process criteria. Descriptions of historic landscape disturbance regimes (e.g., fire magnitude and frequency) and the ecosystem component patterns they maintained (e.g., vegetation composition) provide an initial template for assessing ecosystem health. Such descriptions are useful in broad-level resource analyses of risk as well as in more detailed Identification of watershed restoration treatment needs. These descriptions also provide information for forest plan implemenation and monitoring.

- Coarse-filter conservation strategy--the conservation of diversity (e.g., species, ecosystem pro cesses, and landscape patterns) is the primary method for maintalning the resilience and productivity (health) of ecological systems. Traditional approaches to conserving diversity have relied on a species-by-species approach (i.e.. fine filter) which emphasized maintaining habitat for threatened, endangered, and sensitive species. A more proactive approach to species conservation is the 'coarse-fitter' approach to biodiversity maintenance. This approach assumes that if landscape patterns and process (similar to those that species evolved with) are maintained, then the full complement of species will persist and biodiversity will be maintained. Application of this concept requires an understanding of the natural variability of landscape patterns and processes. Landscape ecology principles provide this understanding and are the foundation for experiments in ecosystem management. Such experiments are effectively implemented through an adaptive management approach to land management.

Summary

Ecosystem management may be implemented through the current planning process and should consider management strategies based on various scales as appropriate to the analysis.

Landscape ecology and conservation biology principles provide a framework for our ecosystem management philosophy which is an experiment and should be implemented based on adaptive management concepts.

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SOIL RELATIONSHIPS TO ECOSYSTEM MANAGEMENT

Robert T. Meurisse[1]

I. INTRODUCTION

A. Our dilemma is one of communicating knowledge and ideas about complex systems. Questions needing answers are: What are ecosystems? What is ecosystem management? what is soil?

B. Objectives:

1. Review concepts of Ecology, Ecosystems and Soil
2. Describe and discuss some Principles of Ecosystem Management
3. Describe a "Model" of Soil Science-Unifying Concepts
4. Issue some challenges to Soil Scientists

II. SOME CONCEPTS ABOUT ECOLOGY, ECOSYSTEMS AND SOIL

A. Concepts of Ecology and Ecosystems:

Ecology: The science that deals with the interrelations of organisms and their environment. (Glossary of Science Terms, Soil Science Soc. Amer. 1975) Term coined by Ernst Haeckel, German biologist, circa 1866.

Ecosystem: Any unit including all of the organisms (i.e., the "community) in a given area interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles within the system. (E.P. Odum, 1971) Term proposed by A.G. Tansley, British Ecologist, 1935.

While ecology is literaly the study of organisms at home, for many people, the focus has been on the organisms themselves. But, it is clear that the emphasis needs to be on the relationship of organisms with their environment, especailly the soil. From the definitions, the concept of ecosystems rest on the following: The importance of spatial and temporal scales; material cycles; energy flows: dynamic interactions and connectivities, and the interaction of organisms with their environment.

B. Concepts of Soil: Humans have a natural affinity to the soil as a result of **the long history of tilling it for growing food and fiber, But soil is more than a medium for plant growth. Soil genesis, hence pedology, gained a prominent place when Jenny (1941) published his** classical work on the factors of soil formation. Where: Soil- f(climate, parent material, organisms, relief, time). This concept can also be expressed as state variables, where, given certain state factors, predictions about soil can be generated as a function of another variable. For example, soil= $f(\text{Climate})_{pm, o, r, t}$

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[1] Regional Soil Scientist, Pacific Northwest **Region, USDA Forest Service**

Soil also is an open system, where energy and material moves into, within and through it. Some examples are: gains and losses of water: biocycling of materials; erosion and deposition; and leaching losses.

C. Ecosystem function is an important concept that inixtricably links soil with the notion of ecosystems. It is exemplified in the concept of bioenergetics and cycles where soil plays a crucial role in regulating ecosystem composition, structure and function. A graphic illustration is provided by Richards (1987).

Soil plays an important role in the regulation of the type and magnitude of producers, the storage of potential energy as organic carbon or inorganic nutrients, and the decomposers that are largely soil organisms. Soil organisms are important not only for their functional roles in carbon and nutrient cycling, but they represent a major portion of the earth's biodiversity. We need to know more about the population of organisms, their functions, fluxes with management, and distribution in soils.

Soil biota exhibit wide diversity. For example, soil meso fauna in a cool temperate grassland have a wide range of population densities. They range from several hundreds of ants to many thousands of mites and springtails to more than millions per meter^2 of nematods (Richards, 1987.)

III. ECOSYSTEM MANAGEMENT PRINCIPLES (Following are six principles developed by the Forest Service and are elaborated on in the proceedings from a national workshop in 1992, "Taking an Ecological Approach to Management." However, the principles are applicable elsewhere)

A. Manage for Sustainability of Ecosystems:
Sustain vitality, productivity and diversity of ecosystems.
Sustainability is a function of bio-physical, economic and social-political interactions.

B. Ecosystems are Dynamic, Complex and Have Multiple Options:
They are shaped by pertubations from fire, wind, floods, insects, pathogens, volcanoes, glaciers, and human activities.
They have various opportunities and limitations based on capabilities and resiliencies.
Some, such as wetlands and riparian systems have disproportionate importance to their size and extent.

C. A Desired Future Condition Expresses Integrated and Pragmatic Ideas about Ecosystems:
Resource plans establish direction.
Management prescriptions must be based on physical and biological capabilities of the land.
DFC's are described in terms of composition, structure and patterns of important ecosystems/components.

D. Ecosystems are Connacted at Various Scaler:
Ecosystems occur at various scales and cross ownership boundaries.
Consider linkages among terrestrial, riparian and aquatic ecosystems.
Analyses must consider spatial and temporal scales for direct, indirect and cumulative effects.

E. Planning and Management Utilizes Integrated Data:
Classify, map, inventory, and analyze both abiotic and biotic components at various scales.
Integrate components for "holistic" view.
Spatial analysis (GIS) and data management systems are essential tools.

F. Integrated Monitoring and Research Provide a Science Base:
Research must be interdisciplinary, long-term and focus on system function/processes.
Adaptive management is based on scientific knowledge and new technologies.
Monitoring must be integrated and assess progress toward the Desired Future Condition.

It is clear that the relationship between soil and ecosystem management is a necessary and dependent one. An understanding of the nature and properties of soils is essential for determining the composition, structure and function of ecossytems. Interpreting capabilities, suitabilities and resiliency of the soil is fundamental to ecosystem management. The National Cooperative Soil Survey is in a unique position because of its extensive, standardized data base that crosses agency and political boundaries throughout the United States. The soil surevy also provides a critical scientific basis for ecosystem management. This interagency data set will be invaluable for implementing ecosystem management.

Soil maps, derived from in-place sampling, are important tools for assessing landscape characteristics in terms of pattern, composition, structure, and function of ecosystems. Natural soil-landform bodies portray characteristic shapes and patterns that allow for analysis of ecosystem processes at a landscape level. We need to ask ourselves how well we characterize these patterns and shapes of natural bodies. Can we improve our analysis of them? I think we can.

IV. AN INTEGRATED MODEL OF SOIL SCIENCE-UNIFYING CONCEPTS

Meurisse and Lammers (1993) described a framework of five models for communication and understanding knowledge of the complexity of the soil system. These models, or viewpoints, are a basis from which we examine a pool of facts, formulate and test hypotheses, and make interpretations. They are not mutually exclusive or independent from each other. An illustration of these models follows.

ECOSYSTEM OR COMPONENT ⟷ WATER-TRANSMITTING MANTLE

ECOSYSTEM OR COMPONENT
- o Dynamic interactions/rates of change
- o Nutrient cycles/transport processes
- o Decomposition/Trophic relations
- o Environmental filter
- o Time scale 10 to 10^{5} yrs.

WATER-TRANSMITTING MANTLE
- o Movement/storage of water/energy
- o Soil physical properties
- o Erosion processes
- o Pedotransfer functions
- o Time scale 10 to 10^{2} yrs.

NATURAL BODIES
- o State factors
- o Weathering processes
- o Geomorphic history
- o Soil individuals
- o Classification
- o Mapping
- o Time scale 10^{2} to 10^{3} yrs.

MEDIUM FOR PLANT GROWTH ⟷ STRUCTURAL MATERIAL

MEDIUM FOR PLANT GROWTH
- o Available moisture/nutrients/heat
- o Aeration/anchorage
- o Plant physiology
- o Response to management
- o Time scale 10 to 10^{3} yrs.

STRUCTURAL MATERIAL
- o Mechanical properties (strength/plasticity)
- o Drainage/porosity
- o Conductivity--heat/water/energy
- o Time scale 10 to 10^{2} yrs.

The model should be viewed as a means of integrating multiple aspects of soil science. It also needs to consider the various technologies and tools for analysis and interpretation for each of the individual models. Soil science teaching, research, extension, and management prescriptions need to be structured to incorporate these or similar models.

V. SUMMARY AND CONCLUDING CHALLENGES FOR NCSS SOIL SCIENTISTS (To implement ecosystem management principles)

It seems clear that the soil is is not only a component of ecosystems, but are ecosystems in themselves. Thus, the role of soil and soil scientists in **ecosystem management is** integral to implementing the basic principles as described above. In order to provide for a sustainable planet, society must have access to timely and accurate soil information in a readily accessible form. I suggest the following challenges as a means to success:

A. Wisely use technology: to enhance data and information analysis, interpretation, and availability at multiple spatial scales.

B. Enhance mapping unit **characterization by strengthening:** multi-factor composition, component variability, and soilscape patterns.

C. Increase understanding of soil organisms--their distribution, populations and functional roles,

D. Improve characterization of: soil processes, and magnitude and rates of change of carbon, and nutrient pools, and hydrologic processes.

E. Develop criteria, test them, and rate soils for their resiliency to specific management impacts.

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Western/Midwestern Regional Cooperative
Soil Survey Conference

Coeur d'Alene, Idaho
June 12-17, 1994
Ecosystem Basis for Soil Survey[1/]

The Steering Team for this joint Western-Midwestern Regional National Cooperative Soil Survey Conference has developed a timely and excellent agenda. I am pleased to address some of the positive issues pertaining to the increased interest and demand to utilize the concepts of ecosystem in our preparation and use of soil surveys.

This morning I would like to share with you some of the guides in the new Soil Survey Manual pertaining to doing business according to ecosystems, review some current activities being driven by the ecosystem approach by the agencies with which we are employed and discuss current trends and activities toward a coordinated ecosystem soil survey.

Ecosystem concepts -- Soil Survey Manual

Collectively, as we look across the United States, Alaska, Hawaii, and Puerto Rico, the members of the National Cooperative Soil Survey have a responsibility to prepare soil surveys for a diversity of landscapes and user demands.

The "Soil Survey Manual', one of our long-awaited documents concerning the preparation of soil surveys, has recently been released. This is the third revision of our guide for making soil surveys. I have taken the opportunity to carefully review several sections in this manual. Even though this manual does not discuss ecosystems as such, many of the principles end techniques included in this manual on how we make and interpret soil maps are based on principles of ecosystems.

The term "Soil Survey" as defined by the Soil Survey Manual, refers to the National Cooperative Soil Survey. Thus, this document provides a common source of information and guidance on how we go about our business of making soil surveys.

A review of a few basic concepts end definitions as stated in the new Soil Survey Manual which have bearing on the ecosystem approach to soil survey are appropriate. Soil is defined as 'all natural bodies that contain living matter and are capable of supporting plants." The knowledge of soils at the end of the nineteenth century was gained from 1) farming, 2) agricultural chemistry, 3) biology, and 4) geology. The first soil surveys in the United States were made in different parts of the country to test the proposed mapping technologies and applicability for use. These surveys, in Pecos Valley, New Mexico; Salt Leke City, Utah; Connecticut Valley, Connecticut; end Cecil County, Maryland, provided our first look at a long line of soil surveys mapped and published by the United States Department of Agriculture.

1/ Jim Culver, Assistant Director of Soil Survey Division, SCS-USDA

In a sense most of the early soil surveys indirectly observed and used many of the current principles of the ecosystem soil survey. An observation made in the 1904 Tama County, Iowa Soil Survey is illustrated in the Soil Survey Manual. It was recorded the soils formed under forest were contrasting different then soils formed under grass even through the parent material was similar.

Hans Jenny's "Factors of Soil Formation,' as applicable to making soil maps, is discussed. The formation of the soils is treated as an aggregate of several interrelated processes, such 8s physical processes, chemical processes, and biological processes. There are several references on the importance of the correlations between vegetation and soils in making quality maps. Vegetation is closely related to the soil and its genesis. The three main relationships discussed are a better understanding of soil genesis, assistance in recognizing soil boundaries, end assistance in predicting from soil maps ebout the kind and amount of vegetation produced.

The Soil Survey Manual contains a number of comments on how we make soil maps, and the skills of the soil scientists, which utilize the ecosystem principles. Soil mapping is 8 technical art! It requires 8 sound training in soil science with 8 familiarity of the earth science principles.

A skilled soil scientist who makes a quality ecosystem soil map is one who

-- is a perceptive observer

-- understands significance of landscapes

-- is able to visualize the pattern of the soils

-- is able to associate sets of landscape features with sets of internal soil properties

-- is able to abstract the essential pattern of the soil

-- is able to express soil patterns and relationships on 8 map

-- strives for accuracy

-- is truthful about reliability of the maps.

Some of the consideration the soil scientist uses in making a ecosystem map are:

-- looks ahead on the projected route or traverse and predicts the kinds of soils on the landscape ahead

-- observes breaks in slope gradient

-- notes change in landscape, i.e. change in convex to concave slope configuration

-- observes any change in kind or vigor of vegetation

-- makes a view of landscape from a new vantage point.

Agency Ecosystem Activity

Tansley, a Botanist in 1935, defined the concept of Ecosystem as en aggregate of plants, animals, microbes, plus the environment in which they live.

Within the past few years several Federal agencies have developed pdicies and have an increased awareness towsrd an ecosystem approach. The Soil Conservation Service integration of soil, water, air, plants and animals (SWAPA) approach has evolved into the current ecosystem-based assistance concept. The Forest Service, in their "National Hierarchical Framework of Ecdogicel Units,' gives priority to the factors of climate, physiography, water, soils, air, hydrdogy, and potential natural communities. The Bureau of Land Management (BLM) has prepared some excellent documents on the importance of identifying and mapping riparian areas.

The principles of these systems have much in common with the discussion given in the 'Factors of Soil Formation' section included in most of our published soil surveys. These factors are parent material, climate, plant end animal life, relief, and time.

Current activity end trends toward ecosystem regional soil surveys

A number of major soil survey activities are directed toward using ecosystem principles in making and maintaining quality soil surveys. Some highlights are:

-- doing a project soil survey based on a major land resource area or physiogrsphic area rather than by strict political boundaries. The concept of soil surveys by Major Land Resource Area (MLRA) is now included in the National Soil Survey Hsndbook. All updates or maintenance soil survey projects now require that work on them be done by MLRA or its equivalent physiographic area. Presently, there is some level of update maintenance for 60 MLRAs, and 12 have been approved by the Director of the Soil Survey Division.

-- proposals have been put forth to fund soil survey projects by physiographic or major land resource areas instead of by traditional state area.

-- techniques have been developed and are being tested to map riparian areas as part of soil survey field operations.

-- develop a national strategy for Soil Conservation Service, Forest Service, and Bureau of Land Management to collectively agree on one common eco-mapping scheme and one given scale -the suggested scale is between 1:2,500,000 end 1:7,500,000. The Environmental Protection Agency and National Biological Survey (NBS)) have also been invited to join in this endeavor.

_ increase interest in temporal soil properties. Bob Grossman. research soil scientist, NSSC, hes developed a number of field techniques to measure and evaluate temporal soil properties.

-- greater concern in soil mapping and soil correlation procedures. Examples include wetlands and hydric soil indicators, emendments in Soil Taxonomy complementing ecosystem soil surveys, broader options to separate map units that are distinctly different for some uses or potential future uses, i.e. similar or the same tsxonomic pedons on uplands and terrace landscapes need to be separate map units.

Several models on how we view soil science have been proposed over the years. An excellent brief summary of five models is included in 'Use of Soil Survey information for Management of Natural Forest and Grasslands" by R. T. Meurisse and D. A. Lammers.[2/] One of the references in these concepts is Cline[3/], who was the original principal author of the Soil Survey Manual. I hold the opinion that en ecosystem-based soil survey is en integration of these five soil science models. A brief overview of each model is es follows:

Soil es a natural area.

-- Pedon

-- Classification

-- Spatial variability

Soil as a medium for plant growth.

-- Agronomy

-- Forage

- Forest

Soil as an ecosystem or ecosystem component.

-- Nutrient cycles

-- Energy flows

-- Organisms

Soil es a vegetated water-transmitting mantle.

-- Hydrologic cycle

Physical properties.

-- Vegetation

Soil as a structural material.

-- Soil strength end plasticity

-- Liquid and plastic limits

-- Porosity

2/ R. T. Meurisse end D. A. Lammers. 1992. Use of Soil Survey Information for Management of National Forests end Grasslands.

3/ Cline, M. G., 1961. The **Changing Model** of Soil Science. Soil Sci. Soc. Amer. Proc. 26: 442-446

The Federal Geographic Data Committee provides national oversight in terms of consistent definitions of data elements, a control base map, etc. for effective use in a Geographic Information System. The Soil Conservation Service for the soil data layer, while the Forest Service has responsibility for the land use data.

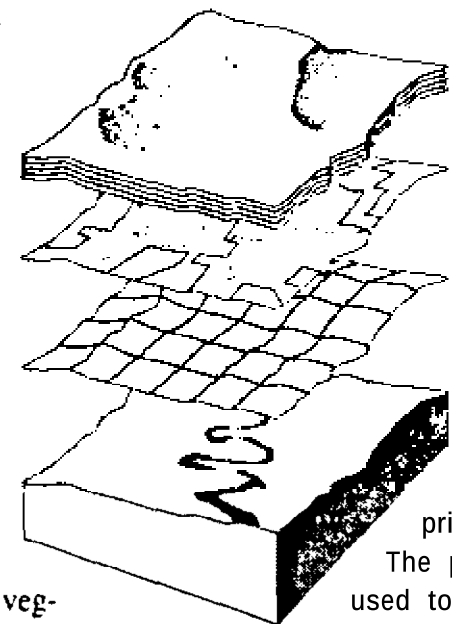
We will collectively plan future strategies for quality ecosystem soil surveys. As one looks et the cover of some recent soil surveys, it is apparent that, outwardly, our products will take on a different look. At the same time, we must ensure that the soil map we prepare adequately documents the special and attribute data that records the actual observed, measured, and inferred properties we know about each soil map unit we design.

I am excited. There is a tremendous interdisciplinary opportunity to improve our capacity to provide our users quality soil information in a wide variety of presentations.

An Integrated Landscape Resource Analysis Approach to Comprehensive Watershed Management

By Alan E. Amen, Jacek Blasczynski, Jim Harte, and Dick Page, Bureau of Land Management

ABSTRACT - The Bureau of Land Management is using Geographic Information System (GIS) analytical techniques to assist with the development of comprehensive watershed management planning on rangeland and wildlands. The Sagers Wash Watershed near Moab. Utah, has been proposed as a prototype watershed for the reduction of salt input into Colorado River. Soil erosion prediction (using the RUSLE/GIS interface), sediment yield, and salt input are being modeled under various erosion control and grazing management practices to provide for best management alternatives. Data used include: digital soil survey information; Digital Elevation Models; remote sensing imagery; vegetation: surface geology; and resource condition information. Geographic information system techniques are used for enhancing resource inventories, generating interpretations and analysis maps with accompanying records data to support resource management decisions. The methodology incorporates a strong landscape - resource analysis approach. Digital soil maps are interpreted for the parameters of precipitation, soil salinity, soil hydrologic groups , and presence or absence of various percentages and sizes of coarse fragments on the surface and other interpretations. Overlays are made for the various data themes and analyzed to produce a treatment opportunities map showing areas appropriate for various erosion control and grazing management practices, that could be utilized on the watershed. The final step in the process involves selection of treatment priority areas for the watershed. The public lands survey theme is used to identify precise locations of streams and channels, proximity to pathways of sediment transport, and to locate archeological sites, where erosion practices might impact the cultural resources. The methodology is also effectively used to display and communicate resource information and comprehensive planning activities.



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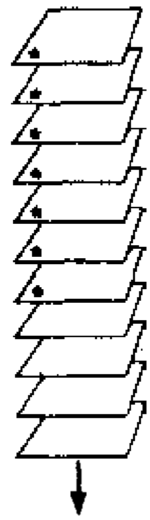
GIS
Terrain/Resource Analysis
(Sagers Wash Walershed Comprehensive Plan)

Climate (Precipitation)
Topography (DEMs)
Geology (Soil Parent Materials)
Soils (Physical & Chemical Properties)
Vegetation (Type, Cover, and T&E Plants)
Surface Hydrology
Land use
Resource Condition (Soils & Range)
Archeological Sites
Existing Treatment & Structures
Research Information



Existing Condition Evaluations
- Soil Erosion Prediction
- Sediment Quantity & Quality
- Salt Transport

Management Opportunities
- Site &Practice Selection
- Practice Effectiveness Prediction

Cost-Benefit Evaluations

* Soil Survey Mapping, Modeling & Enhancement

SOIL SURVEY ENHANCEMENT AND ECOLOGICAL SITE CORRELATION

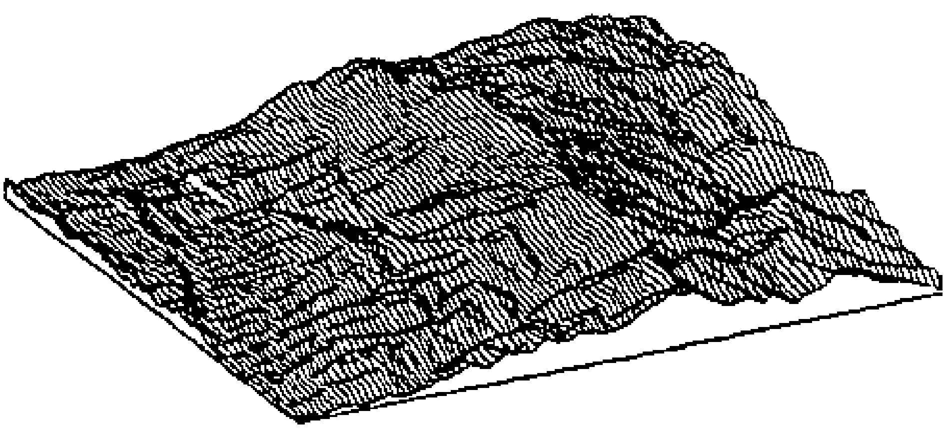
by: Alan E. Amen, *Jacek Blaszczynski, Dick Page, and Jack Sheffy*
Bureau of lond Monogement

The soil survey enhancement ond ecological site correlotion process uses Geogrophic Informotion Systems (GIS) technology to integrote digitol elevation doto, orthophotos, Londsat Thematic Mopper, ond other supporting doto (climote, geology, vegetation, ond adjoining soils doto) for improved definition of toxonomic soil components within mop ping units. This methodology emphosizes o landscope ond geologic onolysis opprooch. Use of GIS londform/hydrologic characterization methods, ond odditionol geologic interpretotion provide m ore detoiled informotion on the spotiol voriobility of soil properties within mopping units. This opproach hos been effective in wildlands ond rongelond oreos in Utoh, Arizona ond Wyoming thot hove lorge oreos of shollow ond medium-depth soils ond occomponying exposures of geologic formotions. The enhanced soil doto provides odditionol interpretotion ond onoly sis capabilities for specific needs, e.g. woter quolity, riporion oreo and grazing monogement on public lands. information and technology provided by this methodology is effectively used to enhonce existing soil surveys ond also for disploying and communicating soil information.

Application •

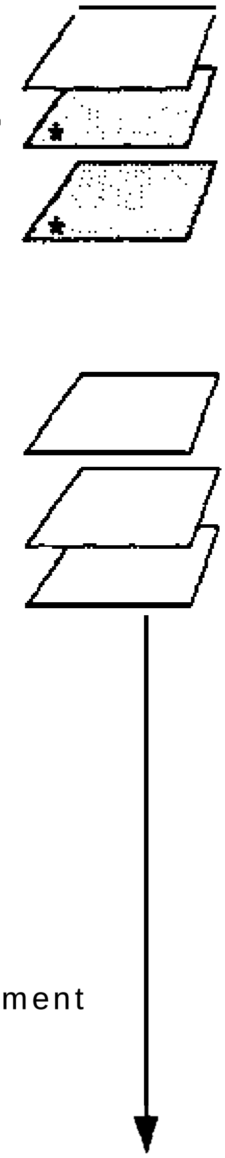
The soil survey enhancement and ecological site correlotion process provides additionol detoil, interpretation ond onolysis copobility for land management such os:

1. Wotershed onolysis . woter quolity
2. Riporion oreo identificotion and monogement
3. Ecologicol site identificotion ond grozing monogement
4. Archeologicol ond culturol
5. Threotened ond endongered species
6. Monitoring site selection



Soil Survey Mapping, Modeling, and Enhancement

Data



Climate Data

Topography (Slope, Aspect, Elevation)

- Digital Elevation Model (DEM) Data

Geology and Soil Parent Materials

- Geologic formation, member. & sediment properties
- Geomorphic processes
- Spectral data (TM)
- Geologic interpretations

Vegetation (Types & Cover)

- Spectral dato (TM)

Existing Soil Information

Land Use

Process

Soil Pro-Map Preparation

- Composite resource and ancillary information by overlay process
- Extropolate soil informotion from selected sampled oreas ond existing soil data
- Mop unit design (bared on needs)
- Delineate soil map units
- Aerial photogtaph (stereo and interpretations)

Field Verification and Pre-Map Refinement

- Field observations ond sampling
- Refine delineations
- Record field notes
- Complete soil map unit descriptions

Final Soil Map & Accompanying Attribute Data

* Soil Survey Enhancement on Rangelands and Wildland Areas—Emphasizes use of geologic and topographic data to supplement soil and landscape interpretations for areas of shallow and medium depth soils, and geologic exposures.

VARIATION OF SURFACE SOIL SALINITY ON STEEP MANCOS SHALE TERRAIN

DENNIS M. MURPHY

ABSTRACT: Rising salinity concentrations in the Colorado River are a threat to municipal, industrial, and agricultural users of the water. Salt loading to the river occurring from nonpoint sources is greatest from diffuse source runoff on erodible saline soils derived from the Mancos shale formation. This study was undertaken to define salinity concentration differences of surface soil derived from Hancos shale, and to define landform descriptors to be used in a GIS system to identify high salinity concentration areas. With millions of acres of Mancos shale terrain in the Colorado River Basin, a process to screen acreage for salinity "hot spots" would benefit ongoing salinity management efforts. Surface soil salinity was evaluated in the Elephant Skin Wash watershed of western Colorado over a wide range of geomorphic environments. It was found that southern aspects in steep Hancos shale terrain exhibited soil salinity at least 2.2 times higher than northern, western, and eastern aspects. This is attributed to southern aspects exhibiting drier soil moisture regimes, less plant cover, and higher erosion and runoff rates. Depositional areas, primarily alluvial valley floors, averaged 9.2 times less salinity than that measured on steep eroding terrain.

(KEY TERMS: Salinity; Hancos shale: geomorphology; nonpoint source pollution; land use planning; water quality.)

INTRODUCTION

The Bureau of Reclamation estimates that rising salinity concentrations in the Colorado River at Imperial Dam could reach 963 mg/l by the year 2010 (USDI - BLH, 1987). Rising salinity concentrations are a threat to the varied water uses (municipal, industrial, and agricultural) both inside and outside the

Colorado River Basin. In a" effort to check expected increases in salinity, Congress, in 1974, passed the Colorado River Basin Salinity Control Act (PL 98-569). Amendments to this act in 1984 direct the Bureau of Land Management (BLM) to develop a comprehensive program for minimizing salt contributions to the Colorado River from BLM-administered lands (public lands).

Salinity yields from public lands occur from both point and nonpoint (diffuse) sources, with the latter being the greatest contributor. The primary salt source is highly erodible saline soils derived from the Mancos Shale formation, a Cretaceous sedimentary marine deposit. It ie estimated that within-the Upper Colorado River Basin states of Colorado, Utah and Wyoming-the salinity yield from diffuse sources on public lands approximates 700,000 tone annually (USDI-BLM, 1978).

Past studies, summarized in Schumm and Gregory, 1986, have conclusively demonstrated that salt production ie greatest from steep Mancos Shale terrain when compared to salt production from other land forms such as pediment surfaces and alluvial valley floors, unless these lens steep landforms are highly dissected or contain visible salt deposits (efflorescence). The high production of salt from steep terrain is mainly attributed to high rates of erosion from soils formed directly from Hancos Shale. Variations of salinity on steep Mancos Shale terrain have been documented (Schumm and Gregory, 1986; Jackson and Julander, 1982; Johnson, 1982; Ponce, 1975; Laronne, 1977; White, 1977; and Thorne et al, 1967), but responsible factors (lithology, topography, microclimate, and biological and physical soil formation processes) have been weakly defined.

Therefore, the objective of this study is to define soil salinity variations on steep Mancos Shale terrain and determine the primary responsible factors. Also, the study was designed to define landform descriptors to be used in a geographical information system (GIS) to assist in identifying high salinity concentration areas. With millions of acres of Mancos Shale terrain in the Colorado River Basin, a process to screen acreage for salinity "HOT SPOTS" would prove valuable for salinity management efforts.

STUDY AREA

The study is based on a saline soil inventory conducted by the Bureau of Land Management Montrose District, Colorado during the 1990 field season. The four management areas that were inventoried have been identified for future salinity reduction (USDI-ELM, 1989). Inventory efforts were concentrated in the Elephant Skin Wash area (figure 1) because previous monitoring showed runoff waters from different subbasins yielded different salinity concentrations, and because of visual observations of variable salt efflorescence on badland terrain (figure 2). Thus, the remainder of this report concentrates on inventory results from the Elephant Skin wash area.

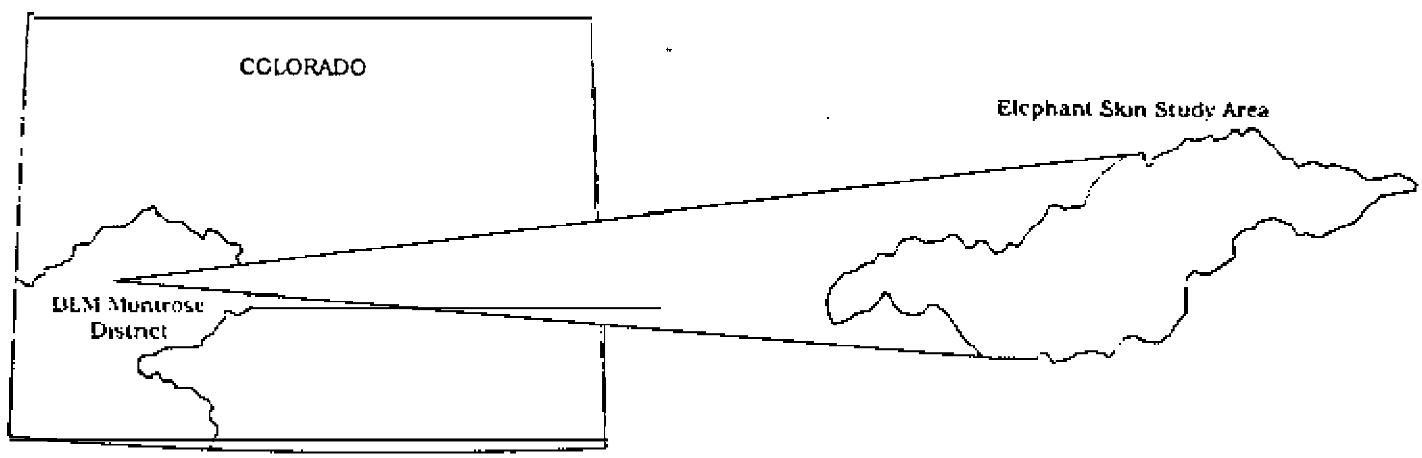
Elephant Skin Wash is located approximately 5 miles northeast of Montrose, Colorado, lying west of the Black Canyon rim. The drainage is 3.70 square miles with the mainstem-ephemeral channel flowing in a westerly direction. Relief varies from 5,720 to 7,076 feet in a distance (basin length) of 4.9 miles. The climate is semi-arid with annual precipitation ranging from 9 to 12 inches. August is the month of heaviest precipitation with most coming from high intensity thunderstorms.

The Elephant Skin Wash Drainage was formed from erosional dissection of a pediment surface into underlying, undivided Mancos Shale. The resultant topography is characterized by steep badlands, occasionally capped with remnants of the pediment surface, and an alluvial valley floor (figures 3).

Steep badland terrain dominates the area. This terrain is unstable as evidenced by mass wasting and the formation of dense rill networks. Instability is especially visible on southern aspects where slopes can exceed 90 percent and watershed cover is often less than 1 percent. Soils are largely undeveloped except for inclusions of shallow, clayey Chipeta and Persayo soils on north slopes (USDA-SCS, 1981). Vegetation is dominated by mat and fourwing saltbush, yucca, and bunchgrasses (Stipa, Elymus and Oryzopsis).

The alluvial valley floor, adjacent to the mainstem channel and larger tributaries, was formed from deposited sediment, eroded from the steep upland terrain. The alluvial valley floor averages 400 feet in width, has an overall down-valley gradient of 2 percent, and is erosionally stable or depositional except for areas of active gullying. Soils are predominantly Billings silty clay loam (USDA-SCS. 1981). Common vegetation consists of shadscale, winterfat and, western wheatgrass.

Land uses include seasonal sheep grazing, off highway vehicle use(OHV) and hunting. surface disturbance from OHV use has resulted in some accelerated



'Figure 1. Study Area Location

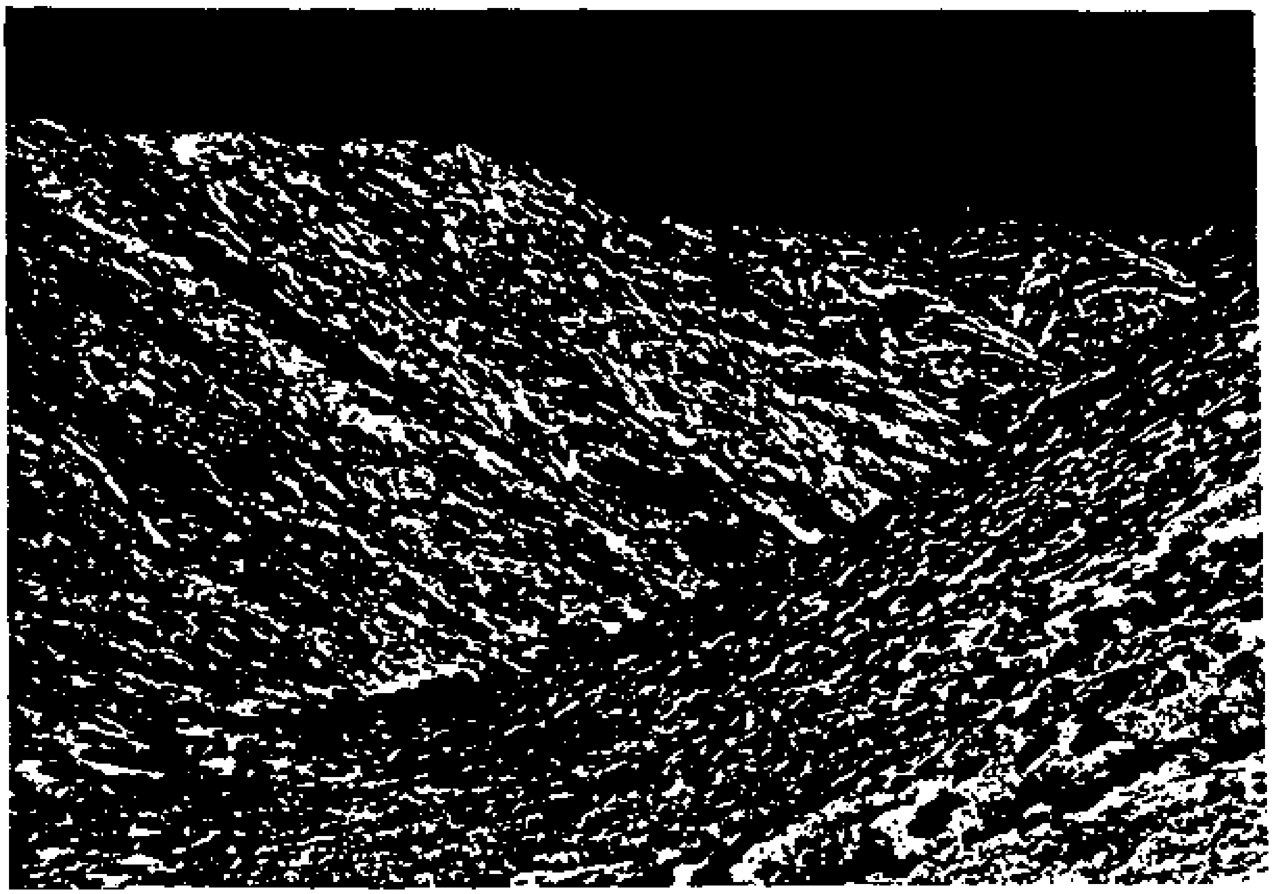


Figure 2. Elephant Skin Wash - Southern (left) and Northern (right) Aspects, Showing Differences in Watershed Cover and Salt Efflorescence.

Figure 3. Elephant Skin Wash - Alluvial Valley Floor with Incised Channel and Steep-eroding Terrain.

erosion. Present management limits OHV use to designated roads and trails (USDI-BLM, 1989).

The Elephant Skin Wash drainage is currently managed under a watershed activity plan, with the goal of determining effectiveness of structural measures for reducing salt yields from steep Mancos Shale terrain. At present, three subbssine have functional salinity reduction structures in place.

METHODS

The salinity inventory included both field and laboratory procedures. Field measurements were made in erosional environments (steep terrain) and depositional environments (alluvial valley floors) at a ratio of about 3:1, respectively. Sampling was thus concentrated on the steep erosional terrain in order to define soil salinity variability. Additionally, the steep terrain was inventoried at mid-slope including as many aspects as possible. Sampling transects were established by extended a 100 foot tape along the contour, and elevation, and topographic location (hillslope freeface, debris slope, alluvial valley floor) were recorded. A visual determination was also made as to whether the local environment was erosional or depositional. The hillslope aspect and slope were determined using a compass and clinometer, respectively.

A composite soil sample was collected by coring and combining 10 evenly spaced soil samples along the tape. The samples were cored to a depth of 4 inches, which was estimated to be representative of soil surface salinity (rill development from large runoff events can approach this depth). Two soil cans were filled with the soil sample to determine electrical conductance (EC) and moisture content. Watershed cover was estimated along the transect using a quadrat frequency frame (USDI-BLM, 1985), recording bare ground, persistent and non-persistent vegetation litter, rock, basal cover, and canopy cover (noting whether the canopy hit had underlying cover), until 500 points were documented.

Laboratory procedures included determinations of soil EC, soil moisture content, and watershed and basal cover. soil EC was measured from liquid, extracted from a saturated soil paste, using a CLA 1433.1 Instant EC Salinity Drop Tester. Variation in soil salinity can be indirectly measured by electrical conductance due to its direct relationship with ionic concentration (salinity). Since only relative differences in salinity were needed, absolute values of salinity concentrations were not deemed necessary. Watershed cover was calculated by summing all "on bare ground hits (litter, rock, and canopy and basal vegetation cover - canopy hits with underlying cover were not included, as this would result in a double count) and dividing this by total recorded points. Total live perennial vegetation basal hits were divided by total recorded points to calculate basal cover.

RESULTS

Extreme drought conditions prevailed prier to and during field data collection. Consequently, soil moisture content "ever exceeded 7 percent. Due to such low and static soil moisture Conditions, this variable was dropped from further analysis.

Analyses of soil EC showed differences between values for steep Mancos Shale terrain (erosional environment) and the alluvial valley floor (depositional environment). Soil EC means (table 1) for erosional and depositional sites were compared using the t-test, and found to be significantly different at the 0.001 significance level. That is to say, there is greater than a 99.999 percent chance that the soil EC means from erosional and depositional sites are from different populations. The soil EC mea" for erosional sites is 5.2 times greater than the soil EC mea" for depositional sites. This supports conclusions reached in other studies, previously cited, that show salinity is not as great on alluvial areas as on steep Mancos Shale terrain.

For the purpose of analysis, hillslope aspect for erosional sites was transformed into four aspect zones. These are shown in table 1 (e.g. aspect zone 1 corresponds to northern aspects from 316 to 45 degrees, etc.). An analysis of variance (table 2) shows soil EC values differ between aspects. As shown in the graphical display in table 2 and the soil EC mea" values in table 1, soil EC for aspect zone 3 is significantly greater than all other aspect zones, being 2.2 times higher than the next highest mea", aspect zone 4.

The data obtained in this study do not reflect direct measurements Of hydrologic processes, but the relevant hydrologic processes can be deduced from the indirect observations. Figure 4 (C and D) shows that both watershed and basal cover are weak predictors of soil EC. Values of soil EC are low and relatively constant over a wide range of the higher cover values. Soil EC is

Table 1. STATISTICAL SUMMARY OF INVENTORY DATA

ELEPHANT SKIN WASH

	MEAN VALUES				
	SLOPE %	SOIL EC mmhos/cm	WATERSHED COVER %	BASAL COVER %	SAMPLE NUMBER
EROSIONAL SITES (ASPECT ZONES)					
1 NORTH (316 TO 45 DEG.)	52	3.6	49	12	9
2 EAST (46 TO 135 DEG.)	58	4.5	33	7	8
3 SOUTH (136 TO 225 DEG.)	72	12.2	2	0	20
4 WEST (226 TO 315 DEG.)	51	5.5	35	9	11
COMBINED EROS. SITES	61	7.8	23	6	48
DEPOSITIONAL SITES	5	1.5	51	6	19

Table 2. ANALYSIS OF VARIANCE BETWEEN ASPECT ZONES FOR SOIL EC

Source	DF	SS	US	F	P
aspect zone	3	700.85	233.62	25.79	0.000
ERROR	44	398.63	9.06		
TOTAL	47	1,099.47			

```
                                                INDIVIDUAL 95 PCT CONFIDENCE
                                                INTERVALS FOR SOIL EC MEANS

ASPECT ZONE  N    MEAN     ST.DEV.  ------+---------+---------+---------+
      1      9   3.556     1.373    (-----*-----)
      2      8   4.500     3.231       (-----*-----)
      3     20  12.225     3.764                            (---*---)
      4     11   5.464     2.034          (-----*----)
                                     -----+---------+---------+---------+
         POOLED ST. DEV.= 3.010          3.5       7.0      10.5      14.0
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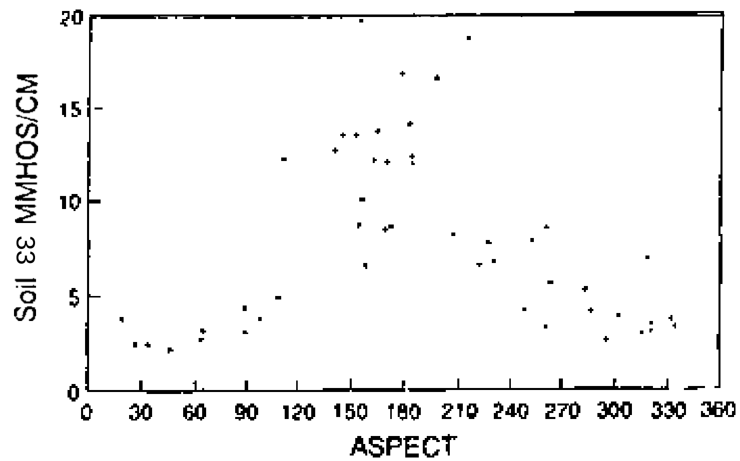

Figure 4A. Aspect vs. Soil Salinity
Erosional Environment

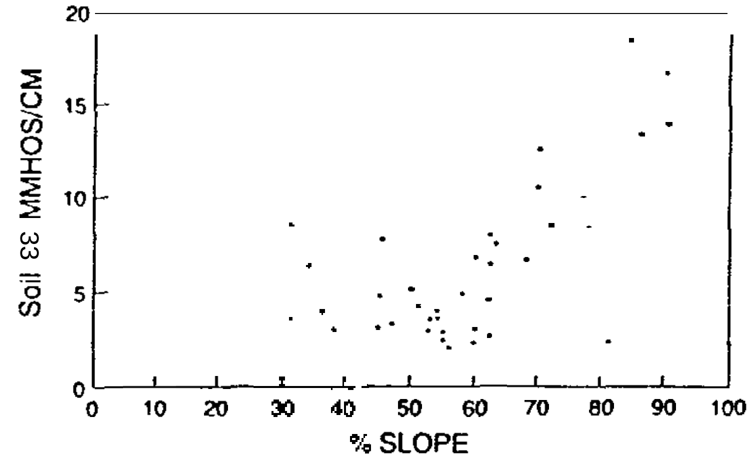

Figure 4B. Slope vs. Soil Salinity
Erosional Environment

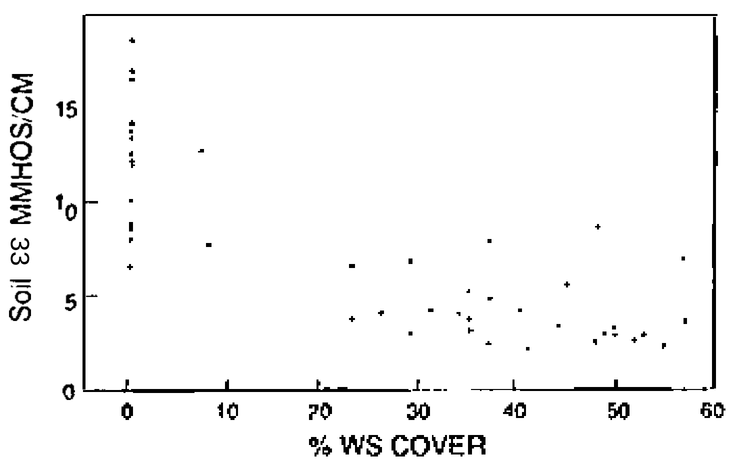

Figure 4C. Watershed Cover vs. Soil Salinity
Erosional Environment

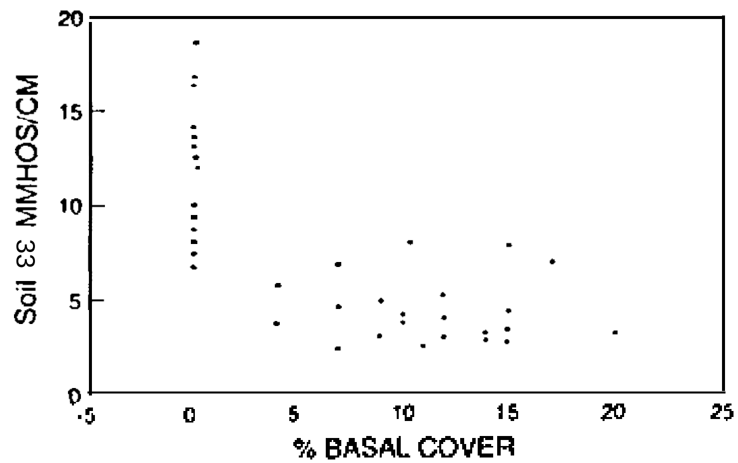

Figure 4D. Basal Cover vs. Soil Salinity
Erosional Environment

highest when cover values are zero, but a wide range of soil EC is possible near zero cover. Slope steepness has an apparent positive relationship with soil EC throughout the measured range; however, the measured range does not extend below 30 percent. Soil EC not only shows a distinct pattern with hillslope aspect, but measured values exist over the full range of aspects. Hydrologic processes vary with aspect due largely to variation in exposure to solar radiation.

The exposure of a hillslope to solar radiation has a marked affect on microclimate and the rate at which geomorphic processes operate (Branson et al, 1981). Northern aspects receive the least solar radiation, and direct solar radiation is lost altogether when the slope exceeds the angle of incident solar radiation (Smith, 1966). This occurs on the average measured northern aspect (52 percent) from August through April, and at no time from Hay through July is incident solar radiation at an angle greater than 12 degrees. An a result northern aspects experience the lowest evapotranspiration, and have the highest soil moisture and vegetation cover of any aspect. Conversely, southern aspects receive the most solar radiation, which is maximal when the hillslope is perpendicular to incident solar radiation. On the average measured southern aspect (72 percent), maximum solar radiation occurs when the sun is 3.5 degrees north latitude, about two weeks after the spring equinox. Incident solar radiation never deviates more than 27 degrees off perpendicular from the average southern aspect. Southern aspects, therefore, experience higher temperatures and evapotranspiration, and the least vegetation cover of any aspect.

The average slope for southern aspects tends to be less than the average steepness for northern aspects, because of erosional debris that accumulates at the bane of southern aspects (Branson et al, 1981). This study, however, measured gradient at mid-slope and clearly shows (table 1) that the active mid-slope area is steeper for southern aspects than all others.

On southern aspects, the combination of steeper slopes and less plant cover results in higher runoff and erosion rates (Branson and Owen, 1970; Rife, 1991). Consequently, soil development is poor and surface salinity concentrations approach that of the underlying Mancos shale. Runoff and erosion are less and infiltration is greater on northern aspects, due to better soil development and increased vegetation cover. On northern aspects, lower soil erosion and higher infiltration rates result in lower surface soil salinity. Surface salinity variations with aspect should be interpreted as a decrease in salinity on northern aspects from the natural or background salinity concentration of southern aspects. This decrease is due to natural hydrologic and geomorphic processes and can be observed indirectly through soil EC measurements.

Based on the previous discussion, a predictive equation (eq. 1) was developed from regression analysis, using aspect as the independent variable and soil EC as the dependent variable: For this analysis the true aspect values as shown in figure 4A were transformed so that aspect only varies between 0 and 180 degrees from due north. The ANOVA Test justifies the use of the transformed values since no significant difference exists between soil EC on eastern and western aspects.

SEC = 1/(0.000008347*(ASP-242.4)^2+0.0354 (eq.1)

R-SQ=0.8134

where,

SEC = soil EC mmhos/cm

ASP = hillslope aspect in degrees (0-180)

Soil salinity on Mancos Shale terrain can be influenced by lithology, Climate, pediment soils, etc. Therefore, the applicability of equation 1 should be restricted to the study area until additional field validations are conducted. However, the relationships between aspect, slope, vegetation cover, and soil EC, as previously discussed and graphically displayed in figure 4 (A-D), should hold true for steep Mancos Shale terrain in similar environments. This is evidenced by data collected in a salinity management area north of Delta, Colorado, which showed similar finding6 to those in Elephant Skin Wash.

DISCUSSION

Previously cited research shows soil erosion and salinity yields from Mancos shale derived soils are greatest on steep badland terrain. However, as this atudy shows, significant variability in soil salinity exists within thie landform. Using the results of this study and a digital elevation model (DEH)

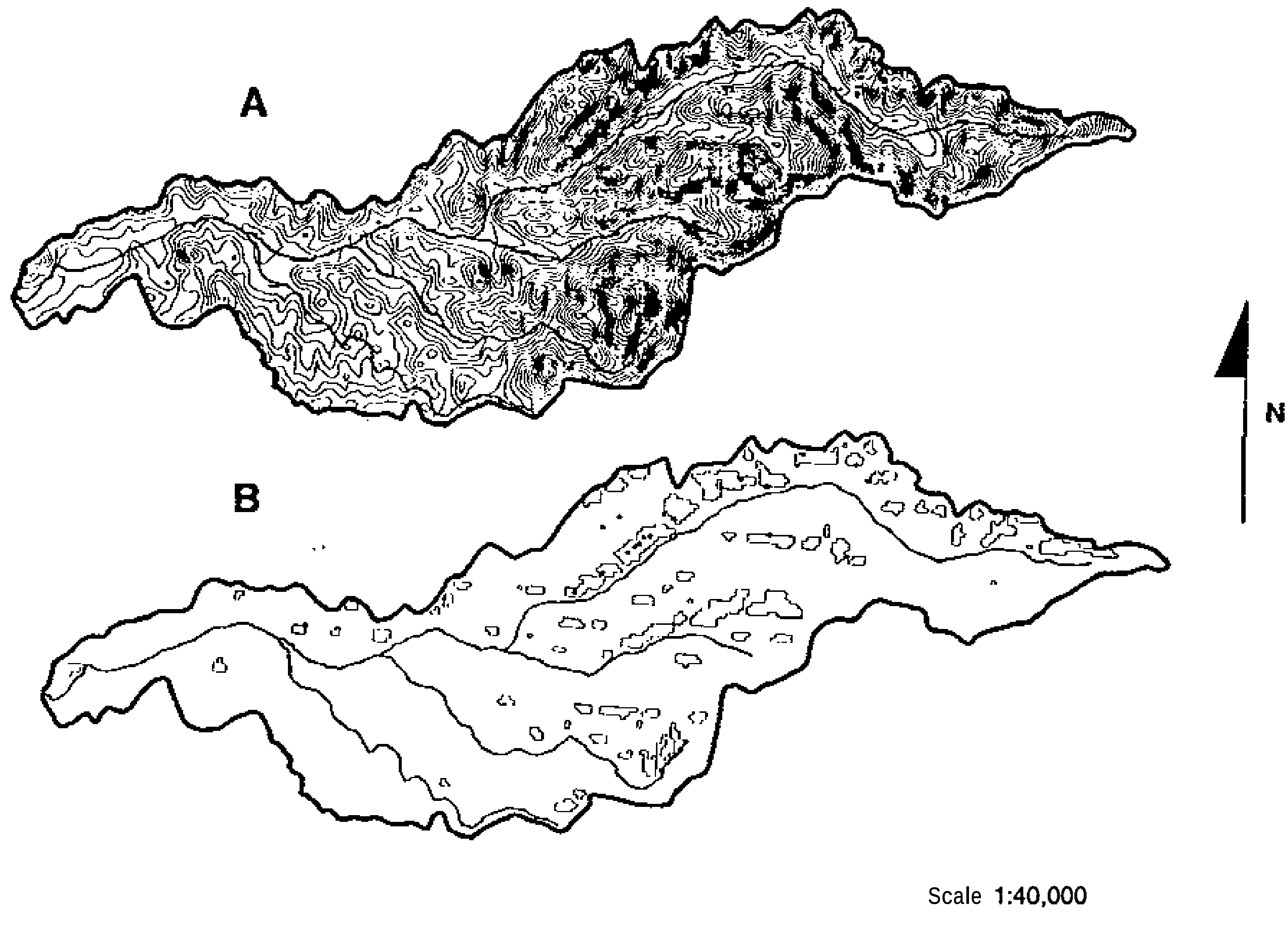

Figure 5. Elephant Skin Wash

A. 7-meter Contour Intervals and Major Drainages

B. DEM-generated Southern Aspect Parcels (slopes 30% or greater), and Inventory Transect Locations on Southern Aspects (+)

of Elephant Skin Wash, an attempt was made to delineate the most saline areas, i.e., steep southern aspects. Hap B of Elephant Skin Wash (figure 5) shows parcels where slope is greater than 30 percent (approximately the lower limit of slopes measured on southern aspects in erosional environments) and hillslope aspect is between 136 and 225 degrees (southern aspect). To determine if transects conducted on southern aspects were representative of the parcels identified by the DEM. transect location6 were added to Hap B. All but one of the inventory transects fall within or immediately adjacent to the defined parcels. The outlying transect results from a GIS limitation on pixel size of 30 x 30 meters. Small segments of steep southern aspect that fall short of these dimensions can not be defined by the DEM.

Past salinity reduction efforts by the BLM have included restricting surface disturbing activities to improve watershed condition and structural controls to retain saline runoff and/or sediment. Applying these techniques directly to steep Mancos shale terrain has limitations. Due to the harsh environments1 conditions on steep southern aspects., the potential for improving the hydrologic condition on these areas is low. However, salinity reduction benefits could be realized by optimizing watershed condition on debris elopes and alluvial areas receiving runoff from steep southern aspects. Additionally, it is important to maintain good watershed condition on the remaining aspects (east, west, and north). Since surface soil salinity on steep terrain has an inverse relationship with watershed cover, reducing cover would increase erosion and salinity.

Due to the high cost of constructing and maintaining structures in Mancos Shale-derived soils, these should only be considered where other management options are not feasible or when other resource benefits (e.g. riparisn, wildlife, livestock, etc.) can be achieved simultaneously. To optimize salinity reduction benefits from structural controls on steep Mancos shale terrain, they should be located where the largest percentage of the drainage area is comprised of steep southern aspects.

For deeign of structures and management of surface disturbing activities considered effective in reducing salt yields, see USDI BLH, 1978; 1980; end 1984.

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1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

The National Long-Term Soil Productivity Study and Site Installations on Volcanic Ash soils

presented by

Deborah Page-Dumroese

U.S. Forest Service

Moscow. ID

What is it?

The long-term soil productivity (LTSP) trials are a joint effort of the research and administrative timber and soil arms of the USDA Forest Service. It is a long-term, designed stress experiment which will answer some basic questions about process science and land management practices. It will try to define what the inherent potential of the land for net primary productivity is, how this potential is altered by changes in organic matter content and soil porosity, and how we can change the current monitoring standards at the National Forest level.

The idea is not to mimic operational practices, or our best guess at what may be operations in the future, but to manipulate the fundamental properties of a site that are always affected to some degree by timber management. This will help make the results usable by other investigators across the country.

Sustaining the wood-growing capacity of commercial forests is a fundamental goal of forest management in North America. The Multiple Use Sustained Yield Act of 1960 binds the Forest Service to achieve and maintain outputs of various renewable resources in perpetuity without permanent impairment of the productivity of the land. Section 6 of the National Forest Act of 1976 (NFMA) charges the Secretary of Agriculture with ensuring research and continuous monitoring of each management system to safeguard the land's productivity.

Objectives

The principal objectives of the LTSP installations are to (1) define the potential productivity of forest sites along a soil and climatological continuum, (2) understand how modifications in site organic matter and soil porosity affect the fundamental processes controlling site productivity, (3) develop and validate soil quality monitoring standards for assessing changes in potential productivity, and (4) develop models for generalizing our results over broad geographic areas.

Treatments

This study utilizes a 3*3 factorial design with the following compaction and organic matter treatments.

Compaction level	Organic Matter level
No compaction	Bole only removal
No compaction	Bole and crown removal
No compaction	Bole, crown, and forest floor removal
Moderate compaction	Bole only removal
Moderate compaction	Bole and crown removal
Moderate compaction	Bole, crown, and forest floor removal
Maximum compaction	Bole only removal
Maximum compaction	Bole and crown removal
Maximum compaction	Bole, crown, and forest floor removal

No compaction is the "natural" bulk density of the site, medium compaction is a intermediate level of compaction, and maximum compaction results in a soil bulk density of about 20% less than the root-growth limiting bulk density of the specific soil. Each location is also encouraged to install ameliorative treatments such as fertilization or soil ripping.

The Intermountain/Pacific Northwest Study Sites

In the Inter-mountain Region there is one replication that has the pre-harvest data collected, timber harvested, trees planted, and first year post-harvest measurement taken. This study site is located on a bench adjoining the Priest River at the Priest River Experimental Forest, Priest River, ID. The study area habitat type is classified as *Tsuga heterophylla/Clintonia uniflora*. The soil has a silt loam surface layer 28 to 38 cm thick derived from Mount Mazama volcanic ash. The subsoil is 50 to 75 cm thick. The soil is a medial, frigid Ochreptic Fragixeralf (Mission series).

Treatments were applied as described above. Moderate compaction was achieved by driving a Grappler log carrier over the plots twice. Maximum compaction was obtained with four passes by a D-6 Caterpillar tractor. Bulk densities were increased from 0.65 g/cc (no compaction) to 0.81 g/cc (maximum compaction). Overall, after the first growing season, rooting depth was significantly less in the moderate and maximum compaction plots that had total organic matter removed as compared to the no compaction plot with no organic matter removed. Ectomycorrhizal short root counts were greatest in the high compaction, total organic matter removal plots. This corresponds to other research in this region that correlates high ectomycorrhizal counts with stressful or harsh environments.

Another set of three replications will have the pre-harvest data collected in the summer of 1994. Harvesting will begin in the fall of 1994. These plots are located on the Payette National Forest near Council, ID.

In the Pacific Northwest Region, one replication near Troy, OR on the Walla Walla National Forest has the pre-harvest data collected. Three replicates on the Umpqua National Forest, Toketee Ranger Station will have the pre-harvest data collected in the summer of 1994 with harvesting to take place soon after that.

All of the sites in these two regions are on volcanic ash cap soils (principally the Mount Mazama eruption). Volcanic ash soils are susceptible to compaction and given the slow rate of natural recovery, long-term site degradation is an important concern for land managers. Long-term productivity is of particular concern when uneven-aged management and multiple stand entries are becoming emphasized. This study, and the other sites around the country, will help identify the levels of compaction and organic matter that will still maintain productivity.

Ecosystem Inventory and Analysis
in the Northern Region

C. Lee Maynard
Soil Scientist/Ecologist Region 1

'If we are serious about sustainability we must raise our focus in management and planning to large landscapes and beyond' (Odum, 1904).

The Northern Region of the U.S. Forest Service has recently been in the process of implementing the directions for ecosystem inventory and analysis detailed by the National Ecosystem Mapping Hierarchy (USDA, 1004). In general. the purpose of ecological unit inventories is to provide information about biological capabilities, limitations to land use, and management opportunities at both the broad (landscape level) and refined (project level) scales. Using methods outlined in the Ecological Classification and Inventory Handbook, a soil resource inventory usually forms the basis for the development of ecological unit inventory (Region 1 USDA, 1903). Within the Northern Region consistent soil resource map units have been delineated at 1:24,000 for dominant soil subgroups in conformity with the Land System Inventory (NCSS survey) mapping procedures and are referred to as 'landtypes'.

Using differentia inherent to the landtype delineations a systematic stratification of a landscape or ecosystem can be generated to provide a Qeoclimatic template upon which other physical and biological properties can be interpreted. This template is based on predictable. inherent landscape features which are intimately related to ecosystem composition, structure and function. It is also nested within the section and subsection levels of the National Ecosystem Mapping hierarchy. Using this template it is possible to conduct and ecosystem inventory efficiently and accurately so that consistent, statistically valid analysis can be performed. By displaying the range of existing information in the context of this consistent environmental template it is than possible to identify data gaps and additional inventory needs.

To facilitate broad scale ecosystem analysis in the Columbia and Missouri river systems, soil scientists within the Northern Region are in the process of map ping associations of existing landtype delineations, These associations stratify environmental site data by variables having the greatest predictive power with regard to the phenomenon being evaluated. To address both upland and riparian land use questions such as susceptibility and response to disturbance, two sets of 'Landtype Associatons' are being mapped and characterized. The first, with an emphasis on characterizing watershed, stream and riparian properties (aquatic landtype associations-ALTA's); and a second, the (terrestrial landtype associations-TLTA's), with an emphasis toward characterizing the inherent site properties of upland environments.

Aquatic landtype associations are being mapped at a scale of 1:100,000 with delineations based on grouping landtypes with similar landform and geologic properties, The use of these differentia is based on the assumption that landiorm and geology are the two variables which can be mapped consistently at the landscape level, that mosl closely predict significant changes in inherent watershed, stream and riparian properties. Stratification of the landscape based on these criteria provides for the development of map units with predictable ranges in drainage density, erosion properties. valley-bottom and stream width and gradient attributes, dominanl riparian soil and vegetation types, and streambed structural features (i.e. pool/riffle ratios) and panicle size distribution.

Terestrial land type associations, also mapped at the 1:100,000 scale will provide map units capable of predicting general landscape patterns in the distribution of dominant soil and vegetation groups, and natural disturbance regimes. they are being developed based on the predictive value of landform, geology, soils, local climatic regimes and potential vegetation.

Due to the extensive volume of spatial and attribute data associated with ecological analysis units, a geographic information system is a highly valuable. if not essential tool. Depending upon the size and complexity of the analysis area, the iterative number of structural and biological combinations can be extensive. Computerized mapping tools are essential for the efficient storage, retrieval and manipulation of the information necessary for accurate ecosystem characterization and interpretation. In a GIS, landtype associations can be assigned to landtype polygons and spatially displayed, allowing the extent and distribution of each unique delineation be evaluated and the ecosystem to be characterized by the attributes of its componenls. In addition, tabular data summaries of LTA properties such as erosion rates and sediment delivery features can be complied and statistically analyzed. When stream and watershed delineations are intersected with LTA's and evaluated in the context of their LTA components, landtype association attribute data can be used to describe the range of habitat paramelers for aquatic, riparian, and upland species of both plants and animals. The use of a GIS allows for a simultaneous analysis of multiple scales using the same analytical framework throughout the process.

Following the environmental characterization provided by the landtype association template, disturbance history is then introduced into the analysis, With the introduction of disturbance history (bolh natural and management induced), and other existing condition informalion it is possible to conduct valid comparisons between potential and exisling conditions for any selected site within a delineation. The ecological impacts of current management activities can then be monitored and evaluated by the same measurable parameters used to inventory and charanerize the overall landscape, and the components of its ecosystems. Management guidelines may also be developed based on those same measureable parameters of site and soil properties that accurately reflect change over lime. Likewise, rehabilitation for componenls of highly disturbed ecosystems (i.e riparian areas, stream segments or watersheds) can then be proposed with an ecological framework as their foundation.

Denizens of the Soil: Small, but Critical

by Andy Moldenke, Research Entomologist, Oregon State University. Corvallis, Oregon

Very few people really understand how soils work. I'd like to give three illustrative examples of how soil arthropods, soil microbes and roots work together as a combined system in the real world. The first example is of onion production. Basically, the plant is incapable of taking up any phosphorus at all from the soil unless it has mycorrhizae on the roots. With mycorrhizae, the roots pick up lots of phosphorous. The growth of the onion plant depends upon the number of arthropods called springtails living in the soil. Springtails function by eating the tips of the mycorrhizae which stimulates the mycorrhizae to grow, dissolve more of the soil around it and feed it lo the plant. As you increase the number of springtails in the soil, the plan1 grows faster until there arc so many springtails that they eat all the mycorrhizae. Then growth drops to zero again.

The second example is from oak forests in Europe. When oak trees live on sandy soil they grow very slowly. They don't make many leaves so there's not much liner at the end of the year. But the liner that does come down year after year piles up very thick. Most of the nutrients are in the liner layer. unused. not pan of the biological growth of that ecosystem. On the other hand. oak trees that grow on clay soil grow very fast and have lots of leaves. But when the leaves hit the ground they decompose very rapidly and make a very thin litter layer. In fact, all of those nutrients in that ecosystem are bound up into the tree growth itself.

Penxoufje oribatid mite

An oak tree puts lots of chemicals in its leaves called phenols that prevent caterpillars from destroying the trees. When the leaves die and enter the litter on the ground, all those chemicals are still in the leaf. When a millipede or an earthworm comes along and starts to eat that leaf, the pH changes and the phenols polymerize and form a great big plastic rubbery mass killing the millipede. However, on clay soil, a little springtail lives in the soil. At night, before it comes up to feed on the litter, it fills its belly with inorganic clay particles. Then it comes up to eat fungi and leaves and litter. The inorganic clay particles in the gut prevent the polymerization from taking place and the springtail lives and grows happily. As a result, the nutrients in that ecosystem cycle; they don't pile up on the ground. The moral of the story is that the productivity of that entire forest ecosystem is basically the result of one little arthropod in that soil.

The last example is another one from oak forests in England. Joe Anderson went out in oak forests in England and brought all the different soils back to the lab. He sterilized those soils killing the bacteria, fungi, arthropods, worms, etc. Then he added back to the soil all of the bacteria and fungi that normally lived in that soil. The only thing missing were all the little arthropods. Those fungi and bacteria release a certain amount of nitrogen, (x). Now, in another pot he put the same litter with the fungi and bacteria that normally are there and put in an oak seedling. What did he find? He found exactly the same amount of nutrients (x) because the oak tree seedling didn't do anything. Then, he took another pot and added a millipede. What happened? The amount of nutrient recycling went up ninefold. Then he ran the experiment a fourth time, with both a millipede and an oak seedling. There was no extra nutrient building (x), but the growth of the seedling oak tree was four times what it was when there weren't any arthropods present. The activity of those arthropods affected the rates of decomposition. and all of that extra nitrogen went directly into the growth of the plant.

Anderson has taken many many soil types and many different kinds of vertebrates in that experiment. What he's found is that the rate of nutrient turnover is dependent upon the roil type, but within any given kind of soil type, it's really independent of how many bacteria and fungi you have in that system. It's actually independent of the kind of arthropod or invertebrate you put in there. It's only dependent on how many of them are there. They can be tiny little oribadd mites or great big oribatid mites, it doesn't make any difference.

Soil invertebrates are system catalysts. They don't do much of anything chemically in the processing that takes place in the soil but they regulate the rate of decomposition and the rate of nutrient recycling. They do that by crushing up the resources and the living microbes that are in the soil, by mixing the organic and the inorganic components of the soil, and by driving the complex processes of microbial succession. They feed on the current microbial crop, and by their own feces they provide for a new and different type of microbial succession to take place.

Now what's the punch line of the story here? The punch line is that dirt isn't dirty, soil isn't soiled, litter isn't garbage. There's something missing in the way we use those words; it's the living component that's missing. The upper layers of soil, which are the only ones that are important in growing plants and trees and everything else, are alive. Litter and topsoil are, in fact, biologically the most diverse part of any terrestrial ecosystem. They are also the most chemically diverse part of any ecosystem. In our forest soils in the Blue Mountains there are literally hundreds of

Continued on page 4

Denizens cont.

Continued from page 3

species of arthropods in every square meter of soil. There are literally hundreds of thousands of individual arthropods per square meter of soil. These are all things you can see walking around in your hand; they've got eyes they've got legs, they get hungry, they get tired, they lust after their mates, they do little mating dances, they have behavior. These arc not bacteria, they are not amoebae, these are rather highly complicated organisms.

You can find a variety of these critters any time you go out and take a shovelful of dirt. The most common things in the soil arc oribatid mites, and the variation among mites is amazing. The biggest one is the size of a period on a printed page; the smallest one is 1/250th of an inch in length. There is a long-legged otibatid mite. There is a flat-backed. aircraft-carrier oribatid mite. There are oribatid mites that have great big ostrich plume feathers all over their bodies.

There are about 250,000 onbatid mites in every square meter of soil. One is called a pen-knife oribatid mite. When it's at-tack@ it folds up like a turtle. One is what I call a stegasaurus onbatid mite. The mite itself is very small and has big move-able flat plates covering the body. Some of them have basically bombay doors: flex-ible wings that they can retract their legs into. One even has a special trap door that comes up and protects the at-tire bottom of the face, all the little appendages for eating. There is another oribatid mite that has a cannon on the side of the body. It shoots a sticky goo when ● aackul. There is one that hides by covering the whole top of the body with mud that it cements on top.

Oribatid mites are fungal feed-ers. They eat fungal hypha with great lobster-like claws. A fun-gal hypha is like a piece of spaghetti with a skeleton on the outside. so the mire has to crush it and crack it open with shears and then jab them into its mouth like you would spaghetti. Another species feeds by insert-ing the whole feeding aparatus into the breathing pores on the pine needles. When they feel a fungal hypha, they grab it. As they pull one chelicera, the other one goes in and it all works hydrostatically. There are also some oribatids that suck bacteria through straws. Huge muscles that work the suction cup inside the mouth attach to the back of its head.

The other major group of soil dwellers are springtails. There are about 100.000 per square meter out in the forest. They're called springtails because they have this tail at the end of the body that normally is held underneath under very high blood pressure. When attacked, they have a little clamp which releases and catapults the springtail way up into the air. A springtail that may be 1112th of an inch long can jump maybe a yard away. A very effective device. Another springtail is all covered with scales like the wings of a butterfly.

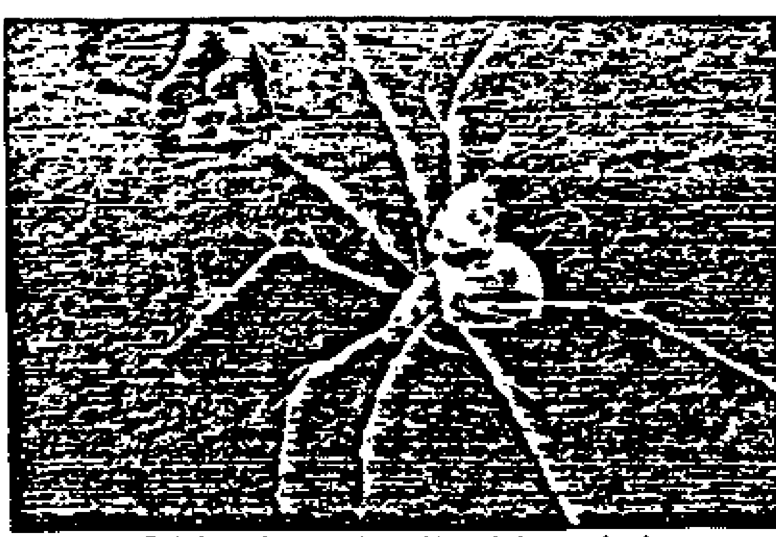
Now springtails and oribatid mites are just two things in the soil. Any meter of soil has lots and lots of things that live in it. Bright, red bdellid mites are not only in the soil. Thy are used in biological control in many parts of the world. In Oregon we use them heavily in the pear industry down in Ashland and Medford. There are pseudoscorpions, skunk spiders. centi-pedes, aod snail-feeding beetle.

The point that I want to make is that all the upper layers of the soil are biogenic. microstructure of the soil is fashioned arthropods and worms, and therefore the major chemical and physical properties a directly under biocontrol. Every chemic and physical property of soils is basica driven by the surface:volume ratio of the particles that make it up. The upper lay of soil are composed of the living bodi countless invertebrates, fungi, and bacte-ria, and the skeletons of all the dead ones well.

Oregon State University is actually the fi place in the U.S. where researchers h actually made slides of soil and looked them. We found that even deep down in the soil all of it is made up of invertebrate fec Most things eat the manure or feces of other things. The total nutrient content oi the soil is actually of secondary imp tance. Also of secondary importance whether the nutrients are immobilized in the organic debris or whether they're im-mobilized in the inorganic phase down the mineral soil. The critical paramete how dynamic soil-converting processes are. In other words. how many dung beetles you have in the system. and how ma species do you have in that system? Now. when I occasionally teach a lecture to for groups in ecology at osu. the first thin do when 1 come in to the board is I write 'BPGT." I write those on the board at the beginning of a lecture and I tell everyone the beginning that they arc supposed to able to tell me what that means. I'll tell you what it is and make a lo story short: "Bug Po Grows Trees."

I want to finish up by g ing you three facts for your consideration, because you've probably nev thought like a root befo I want you to think like a root. The first fact is th plant roots are only p sive sponges. They can do nothing themselves. Th can do no decompositio

Continued on page 5



Stilt-legged mite with shed larval skins on back

Denizens, cont.

continued from page 4

...ey can effect no process of nutrient solubility; they can make no chemical change ... the soil. The second point is that soil chemical transformations—the decomposition, the mineralization, and the recycling—are actually caused by the extracellular digestion of the secreted enzymes of bacteria and fungi in the soil. There are some abiotic changes that take place in the soil: freezing and thawing and drying, but those generally take place at times when they're not terribly useful to the plants. The third point is that absorption of nutrients is directly dependent upon the cell's surface area. In all soils, anywhere you are in the world, the surface area of soil microbes is millions, billions, zillions times that of plant roots. Plant roots are at a competitive handicap to get those nutrients.

So in the real world, how does it work? How do plants grow? On the one hand in the real world, you have a plant that's got a lot of energy from photosynthesis but it needs nutrients to grow. On the other hand you have a soil microbe that's got lots of nutrients but it needs energy to grow.

Now there're two solutions to the problem. The first solution is soil critters—anything from protozoa to the two-foot long Oregon earthworm. Nutrients are either pooled in dead plant cells in the soil or in the tissue of the living microbes themselves. Each time one of those invertebrates feeds, it ... the physical state of those nutrients ... by munching it up with its jaw. It exposes those nutrients to new kinds of microbes in its own gut. It extracts its own ... percentage as tax. The invertebrate moves and then it defecates, and for a few seconds or at most a few minutes there are ... the nutrients available to the community at large. As soon as they're grabbed up they are immobilized again. Now remember everybody in the soil is eating everybody else's pre-packaged resources. This process is going on all the time. Sooner or later some of those nutrients are going to be ... close enough to a root that the root can grab it.

The second solution to that problem is an incomplete solution: a mycorrhizae. A mycorrhizae is a symbiosis between a fungus and a plant root. The fungus makes an attachment to the plant root and grows out into the soil. As it grows out into the soil, the plant pumps fuel into the mychorrhiza (sugars fixed in photosynthesis), the mycorrhiza dissolves its surroundings, and what it doesn't want it sends to the plant root.

There are several living species that live in the soil, each one responding to its own set of environmental variables, its own unique web. We can use that information as indicator species. If you bring me back a vial full of soil from an area I've studied, I can tell you the time of year you took that sample. I can tell you the stage of forest succession. I can tell you the altitude you took it from. I can tell you the overstory canopy. I can probably tell you something about the understory canopy. I can tell you whether it was from a north-facing slope, east-facing slope, ac. If you took it from Sisters and the Ponderosa Pine forest there, I could tell you how far it was from the nearest tree trunk, whether that tree trunk was alive or dead, or whether it was a juniper or a Ponderosa Pine. I can tell you that because of the species composition of that soil community.

So the structure of the actual community an give useful information if you take the time to decipher. For instance, if you ask what happens if we fumigate stumps to control the root rot? What does it do to the whole ecosystem? How far does it go out away from that stump and does it last for weeks, months, years, or for decades? What about broadcast burning? Do the effects last for two or three years, five or ten years, twenty years, fifty years, one hundred years? You can answer those questions with this kind of information.

The second useful thing I think we can do is to look at the notion of a keystone species. Of all the hundreds of species out there, are there some that play a crucial role in an important ecological pathway? One species that can't be substituted for by any other?

Nitrogen-fixing bacteria, do something unique, something that can't be substituted for. Another example of that is the cyanide-producing millipede that is so common in western Oregon. All the nutrient transfers take place in the soil itself, from one fecal particle to another fecal particle and pass it down that chain of succession. But how do you get from a dead leaf on the ground to a fecal particle? Well, that's the role of tk cyanide-feeding millipede in our forest. There's really only one common millipede in that whole forest system from southern Alaska all the way to northern California. Basically every single leaf, both deciduous and coniferous, that falls on the ground, actually goes through the gut of that one species of millipede before it even enters the soil ecosystem. So there you have one species that does something that can't really be substituted for by anything else. It's a keystone.

There are a few morals I'd like you to get.

First, soils are alive. They are biogenic. All the upper layers are in fact nothing but living critters or the feces of living critters.

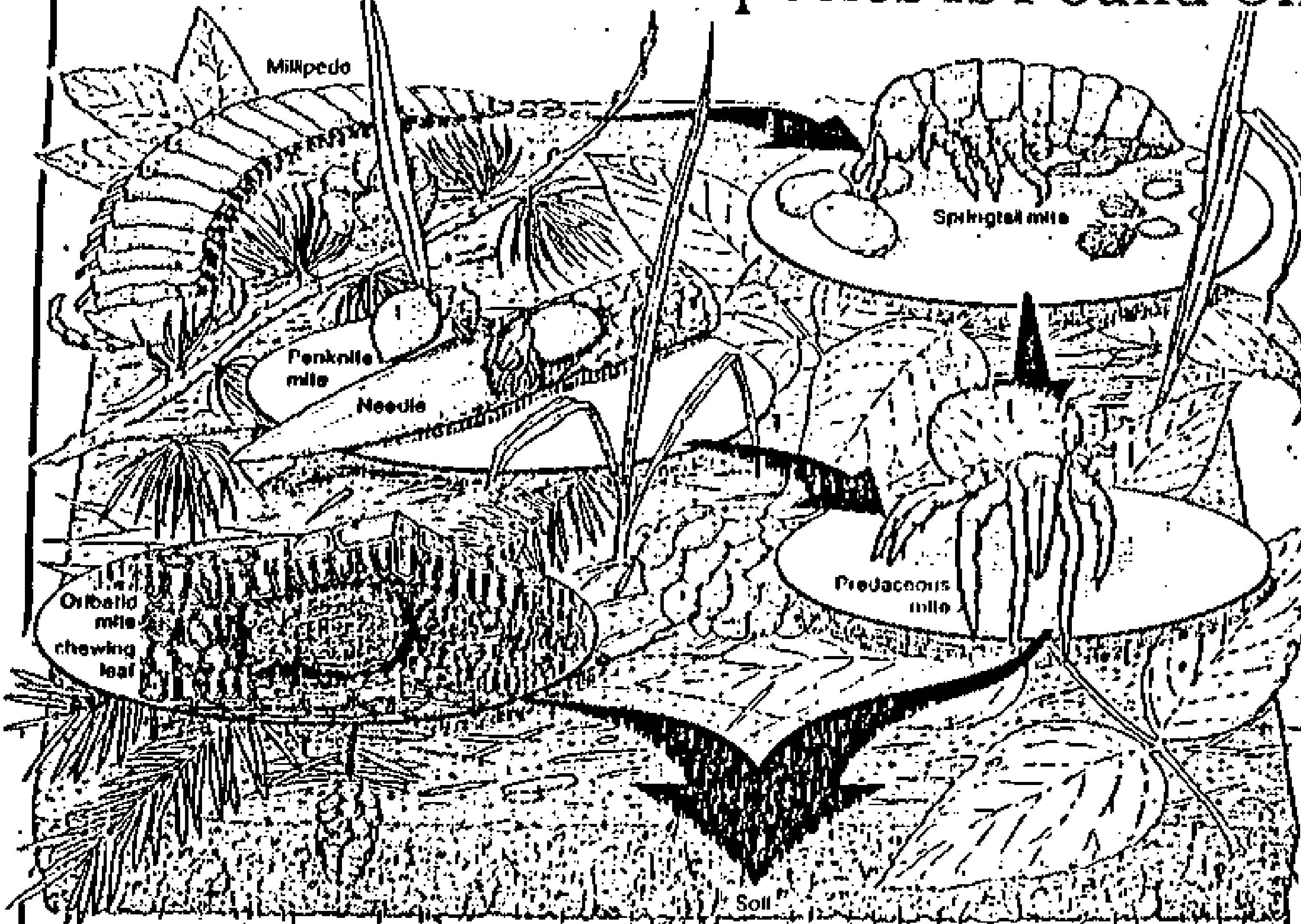
Second, soil arthropods am the regulators in most soil p-. They are the system catalysts that drive the microbial processes of chemical excitement. All of those p- would stop if we didn't have the critters here feeding upon than

Third, soils are by far the most biologically diverse part of any terrestrial ecosystem.

Fourth, by monitoring the types of diversity that are there you can learn how an ecosystem is functioning. we can generate useful information on different time scales and spatial scales that is different from what you can learn by looking at soil cores or tree rings.

Last, we need to start to use our eyes and examine the world we live in. We will see what a really neat world we live in and just maybe we will stop treating soil as if it were dirt.

A Wealth of Forest Species Is Found Underfoot



Source: Andrew Moldenke, Ph.D.

The New York Times; Illustration by Thomas C. Moore

Manufacturing Fertility for the Forest's Soil

Tiny creatures eat forest debris, and each other, in a process that breaks plant matter into smaller and smaller pieces and exposes it to decomposer bacteria. A millipede devours a pine needle; its feces feed a springtail mite. A penknife mite also eats pine needles. A predaceous mite feeds on other mites. An oribatid mite eats leaves.

Army of unseen animals recycles forest detritus.

By JON R. LUOMA

ENVIRONMENTALISTS have focused great attention on spotted owls and ancient trees in the forests of the Pacific Northwest. But a small cadre of researchers who have been studying insects and other invertebrates of the forest soil now say that the old-growth forest has been hiding underfoot perhaps its most astonishing biological secret.

Detailed studies of arthropods including insects, spiders, mites and centipedes in the soil of the old-growth forest suggest that the soil under the region's forest floor is the site of some of the most explosive biological diversity found on earth. Some experts believe that these temperate forests harbor a diversity of species that approaches the much-touted biological diversity of tropical rainforests.

As part of one of the most detailed analyses of arthropod diversity ever conducted, scientists now estimate that about 8,000 distinct species inhabit a single study site in an Oregon old growth forest, most of them in the soil. The findings are "especially surprising because we think of that kind of diversity as being related to the tropics, not the temperate forests," said Melody Allen, executive director of the Xerces Society, an invertebrate conservation group.

But scientists say that those num-

Continued on Page C9

In Old-Growth Forests, a Wealth of

Continued From Page C1

bers are far less significant than still-sketchy hints of the role insects and other arthropods apparently play in the temperate forest ecosystem. "We've come to suspect that these invertebrates of the forest soil are probably the most critical factor in determining the long term productivity of the forest," said Dr. Andrew Moldenke, an entomologist Oregon State University in Corvallis.

In tropical rainforests, twigs, fallen leaves and dead organisms are decomposed rapidly by bacteria and fungi that thrive in the warm, wet ecosystem. But in the temperate forests of the Pacific Northwest, arthropods appear to be linchpins in the decomposition process.

Billions of extremely tiny insects, mites, "microspiders" and other invertebrates serve as biological recycling engines that reduce tons of organic litter and debris, from logs to bits of moss that fall to the forest floor, into finer and finer bits. Bacteria and fungi living in the digestive tracts of the arthropods and in the soil then progressively reprocess the finely crushed, once living tissue into basic nutrient chemicals to feed roots and, hence, the above-ground ecosystem.

New techniques for identifying and examining soil samples offer great promise in increasing understanding of the rich ecosystems in the forest soil. Researchers caution that they still know "almost nothing" about precisely how all the thousands of arthropods interact and survive.

Taxonomists working in the region have been able to identify about 3,400 arthropod species at a single research site, the H. J. Andrews Experimental Forest in Oregon, a sort of living forest laboratory operated by the United States Forest Service. Many of those species have never before been named and described. In comparison, the count of all species of reptiles, birds, and mammals com- [illegible]

Catalogue Is Only Begun

Yet, according to Dr. John Lattin, director of the Systematic Entomology Laboratory at Oregon State University, the number of species catalogued so far probably represents less than half of the estimated species present on just the Andrews Forest site.

Simply to describe and name the yet-unnamed species will take years, in part, because the sheer numbers of arthropods in even a small area, according to Dr. Lattin. Most of the soil arthropods are exceedingly small, as tiny as 1 or 2 one-hundredths of an inch long. That is as small as or smaller than the period at the end of this sentence. And surveys have shown that the soil under a single square yard of forest can hold as many as 200,000 mites from a single sub-order of mites, the oribatids, not to mention tens of thousands of other mites, beetles, centipedes, pseudoscorpions, springtails, "microspiders" and other creatures.

Dr. Moldenke and his students have in recent years begun studying soil and arthropod ecosystems using a technique called thin-section microscopy, originally developed by oil-exploration geologists. That approach has revealed that the very structure of temperate forest soils, and hence much of their biological and chemical activity, is determined by the dietary habits of the soil arthropods.

Thin-section microscopy is accomplished by infusing, in a pressure chamber, epoxy into a carefully removed core of soil. Once the epoxy hardens, the now rock-like soil sample can be sliced into exceedingly thin wafers and polished smooth for examination under a microscope.

The technique preserves the soil with its parts in place, from larger bits of partly decayed plant matter to microscopic soil particles. On one such slide, Dr. Moldenke showed a visitor the image of what was clearly a needle from a coniferous tree, partly decayed, but still mostly intact.

Magnified, however, the small needle in the soil turns out to be an assemblage of thousands of infinitesimal fecal pellets arranged in almost precisely the shape of the needle. Not long after a bit of vegetation falls, millipedes descend on it, grinding it up. Chewed up bits of vegetation pass through the insects' digestive tracts in a matter of seconds and are redeposited virtually in place as a pellet.

A closer microscopic look at each pellet reveals that each is nothing more than chopped up bits of plant cells, reassembled into a sort of jigsaw puzzle of plant matter. These tiny clumps of cell tissue will, in turn, be eaten by other arthropods.

Deeper in the soil, the jigsaw-like cell tissues become progressively less recognizable, as successive waves of "microshredder" arthropods crush and partly digest these fecal pellets, like a series of minute millstones grinding food down to finer and finer bits.

Working in turn, tiny creatures gradually turn insoluble cells into nutrients.

Cell tissue cannot dissolve in water. Yet for a living ecosystem to perpetuate itself, nutrient chemicals that are locked into insoluble organic molecules in tissues of dead organisms must somehow be made soluble to be taken up by the roots of plants.

Each arthropod extracts only the whisper of nutrition from food that was once living cell matter. But in the process, each arthropod exposes more surface area to decomposer bacteria. The bacteria, in turn, biochemically process trace more cell matter on the pellet's surface into soluble compounds, making more nutrition available to the next arthropod until, eventually, insoluble cell matter becomes soluble nutrients.

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In the old growth forest, the process is sometimes excruciatingly slow. Soil organisms are just now completing the decomposition of some giant trees that crashed to earth about the time Columbus sighted land.

Precisely how all these biological and chemical interactions occur, and which of the thousands of species' survival is key to the survival of others, are matters that remain poorly understood. "We've reached the point where we know just . little bit more about the fauna of the forest soil at the end of the the 20th century than was known at the beginning of the 19th," Dr. Moldenke said.

Mysterious Diversity

And researchers still don't know why there are so many invertebrate species in the forest soil first place. "There are still . lot of questions about why there's so much diversity," said Dr Lattin. "But the fact that they are out there in such great numbers suggests that they play . very, very important role in the ecosystem."

Dr. Moldenke agreed "I don't know what the implications of all that diversity are," h. said. "Neither does anybody else. And that's the scary part. I guess what concerns us is that the kinds of above-ground ecosystems that most ecologists have studied in the par, is a very small part of what's really mu there.

"When you have an awful lot of species, it means almost by definition a great number of processes: thousands of different functions taking place. If we instead continue to manage forests on the basis that the ecosystem is much more simple than it really IS. we may be setting ourselves up for . big surprise, and it may not be a nice surprise"

One potential practical benefit of all that diversity lies on the research horizon; the arthropod communities may be able to serve as an exquisitely tuned gauge of changes in the forest ecosystem.

In 1986, Dr. Moldenke began plugging data about the tens of thousands of arthropods collected from dozens of sites into a computer for statistical analysis. The results were so surprisingly consistent that he worried that the computer had been misprogrammed. Computer analysis proved that by analyzing the thousands of arthropods in . tin can full of soil from . site, a researcher could predict with accuracy the condition of the site itself.

"AS . result of knowing that pattern, anyone could take . sample in the Andrews Forest find out what time of year it was taken, whether it came from a north or south slope, what the moisture content of the soil was," Dr. Moldenke said. "In some areas, ff could fell you what kind of tree was nearby and how far away."

Mighty Mites

AS ● simplified ● rrmpk. he says, an abundance d tiny mites called Eulohmannia, whkh are "bright orange-yellow and look like a gasoline truck," indicate that a site IS relatively dry and in a young forest. On the other hand, an abundance of Eremaeus mites, which "look like turtles with . pattern of red dots," indicates . moist site in old growth forest.

By analyzing such characteristics among thousands of arthropod data-points, a researcher may be able to monitor changes at a site brought on by, say, global warming or herbicide use.

"A tree doesn't tell you too much about what's happening," said Dr. Moldenke. "If you want to monitor change in the environment, the worst thing to look at is an organism that's centuries old. But the arthropod community allows to look at what's happened over a different time frame, as little as a few months. And you can only do that because you have all that diversity."

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One Hundred Twenty Thousand Little Legs

*Andrew **Moldenke***

Nowhere are the critical roles of insects and other invertebrates easier to understand, yet more poorly investigated, than in forest soil. Proper growth of forest trees depends on receiving appropriate nutrient levels and water from the roots. The metabolic activity of fungi and bacteria liberate nutrients through litter decomposition and chemical transformations of the soil. Experiments have shown that insects and other microarthropods control these rates.

No one has ever counted the number of kinds of bacteria and fungi under **a single tree in** the forest; no ecologist knows just how many chemical transformation processes are necessary for the full recycling of nutrients. We do know, however, that in undisturbed forests there are 200 to 250 species of invertebrates per square meter of forest soil in the Pacific Northwest – probably literally thousands of kinds in all the microhabitats of a square mile of forest. There are 100,000 to

Dead logs are crucial for forest health. The final step in nutrient recycling is uptake of nutrients by mycorrhizal fungi, which pass nutrients to the trees in exchange for phobsynthetic sugar pumped to the roots. Here the mycorrhizal fungus Russula emetica *is attached to the roots of western hemlock Photograph 0 1990 by Gary Braasch.*

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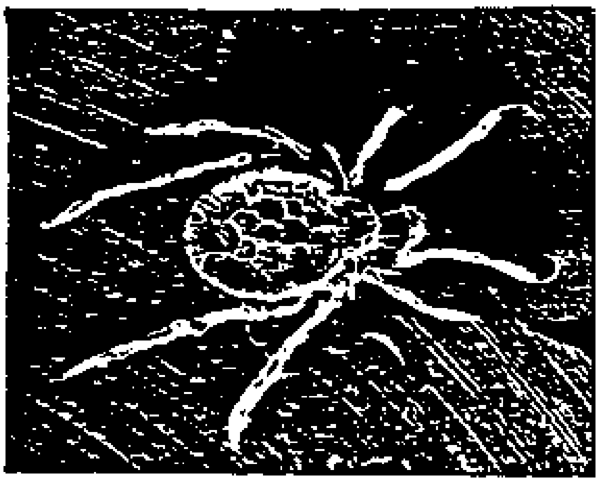


-**Odontodamaeus** veriomatus is *one of the larger (750 microns or about .03 inch) fungiwrous oribatid mites There are 100,000* **to** 200,000 *oribatid mites per square meter of undisturbed* ***Pacific*** *Northwest forest* ***Scanning*** electron ***mi-crograph*** *by A. H. Soeldner.*

200,000 oribatid mites per square meter of undisturbed forest, including perhaps as many as 75 species. Forest ecosystems *cannot* afford to lose species such as these, which are involved in critical nutrient recycling.

In our conifer forests, the pioneering work of Forest Service mycologist Jim Trappe has shown that most essential nutrients are passed to trees through a network of symbiotic fungi known as mycorrhizae. **Mycorrhizae** may be microscopic fungi deep within the tree roots, dense sheaths offungal tissue wrapped around the root tips, or even meter-wide mats of woven **fun**gal hyphae permeating the soil while attached to the tree root. There might be as many as 150 different kinds of mycorrhizae on the roots of a single Douglas-fir tree. Different kinds **of** my corrhizae provide different services to the tree, such as nutrient uptake and resistance to drought and disease.

The mycorrhizae don't act alone. Many different types of soil bacteria and fungi are required to perform the many transformations necessary to break down the complex organic chemicals in litter, wood, and carcasses. The role of soil invertebrates is to facilitate these processes by stimulating the growth of microbes, mixing the substrates, aerating the soil, and transporting spores and living **fungal** hyphae to a place where they can grow, thereby driving the succession of the myriad different microbial species living in the soil.

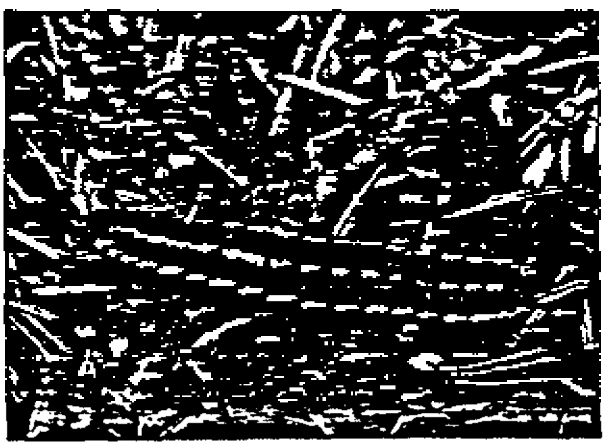
The strikinglycolored millipede *Harpaphe haydeniana* is a crucial ecosystem link. It grazes on fallen conifer needles, and by crunching up many plant ceils, mixes their contents with the bacteria in its gut. Then it deposits a fecal pellet, which is attacked by a different set of bacteria which further the decomposition process. The fecal pellet is invaded by fungi, eaten by a smaller arthropod like the **chocolate-**brown oribatid mite *Odontodamaeus veriornatus,* exposed to yet a different set of enzymes and gut bacteria, and transformed into smaller fecal pellets. Then, perhaps, an immature ***Har-paphe*** engulfs many tiny fecal pellets, mixes them with the mineral soil, and starts the whole cascading fragmentation process over again.

The numbers and kinds of soil fauna are so large that forest managers and soil scientists mistakenly take them for granted. U.S. Forest Service **silviculturalists** have **learned** that examination of the diverse forest understory can reveal critical aspects of soil type and moisture availability more efficiently than chemical tests.

Likewise, soil invertebrates can be used as "biological probes- of soil processes that operate over time scales and spatial scales that are difficult to monitor in the field.

Chemical tests measure chemical concentrations at a moment in time, and seldom distinguish between what is there and what is available for tree growth. Tree growth integrates all the numerous factors affecting a tree over decades; it is difficult to distinguish soil-related factors from all the other types. Most soil creatures have surprisingly long life cycles: (*Odontodamaeus* probably one year; *Harpaphe* probably several years). Their growth rates integrate over several months in small areas of forest soil many of the properties important for tree growth.

Soil arthropods respond clearly to soil properties relevant to their ways of life: soil temperature, moisture, fungal abundance, limiting nutrients, soil structure. Individual speciesshow strong preferences in the stages of forest succession and their populations respond numerically to abundance of resources. Because most of them have very limited mobility, they highlight localized distributions of nutrients. Using a statistical program that allows comparison of the relative abundance of large numbers of species, it is possible for me to examine a sample of arthropods extracted from the soil and to deduce not only what sort of forest they *came* from, but how far the soil was from the nearest tree and even sometimes the species of that tree.



The cyanide-producing 3- to 3½-inch millipede, Harpaphe haydeniana, is a conspicuous part of Northwest conifer forests. By feeding on fallen needles, it starts the lengthy decomposition process necessary for nutrient recycling. Photographed in the H. J. Andrews Experimental Forest by Trygve Steen

My colleagues and I are using microarthropods to examine questions of "biological legacy": how long does the biochemical signature of an individual tree remain imprinted on the local soil ecosystem once it blows down or is cut? Does this legacy influence the pattern of vegetational change that occurs, perhaps even determining the species of tree that takes its place? Do management practices such as slash-burning and the use of herbicides have longlasting effects on the soil that can be detected years or even decades later? If we are managing forests for posterity, and not for short-term gain, we need to know the answers to these sorts of questions.

Biodivenity will always be of interest to museum scientists like me, but public support for insect diversity is concentrated on showy species. It is the **maintenance of the total diversity that** keeps ecosystems running effectively. *More* scientists need to develop techniques that show managersof federal lands the utility of using biodiversity as a practical tool.

It is likely, based on Petersen and Luxton's review of world soil fauna, that temperate soil diversity equals or exceeds that of tropic soil. South-d estimates that about 80 percent of the temperate **forest** insect fauna spend a significant portion of their life cycles in the soil. In absolute terms, then, it is quite probable that the highest levels of terrestrial diversity anywhere on earth occur in the soils of our temperate forests.

Every time you take a step in a mature Oregon forest, your foot is being supported on the backs of 16,000 invertebrates held up by an average total of 120,000 legs. Just think how many creatures it takes to support a single tree.

Dr. Andrew Moldenke is a research biologist and teacher in the Department of Entomology at Oregon State University His interest lies in the interactions *of invertebrates and their environment, particularly the subjects of pollination ecology and* soil *fauna*

NEWS BRIEFS

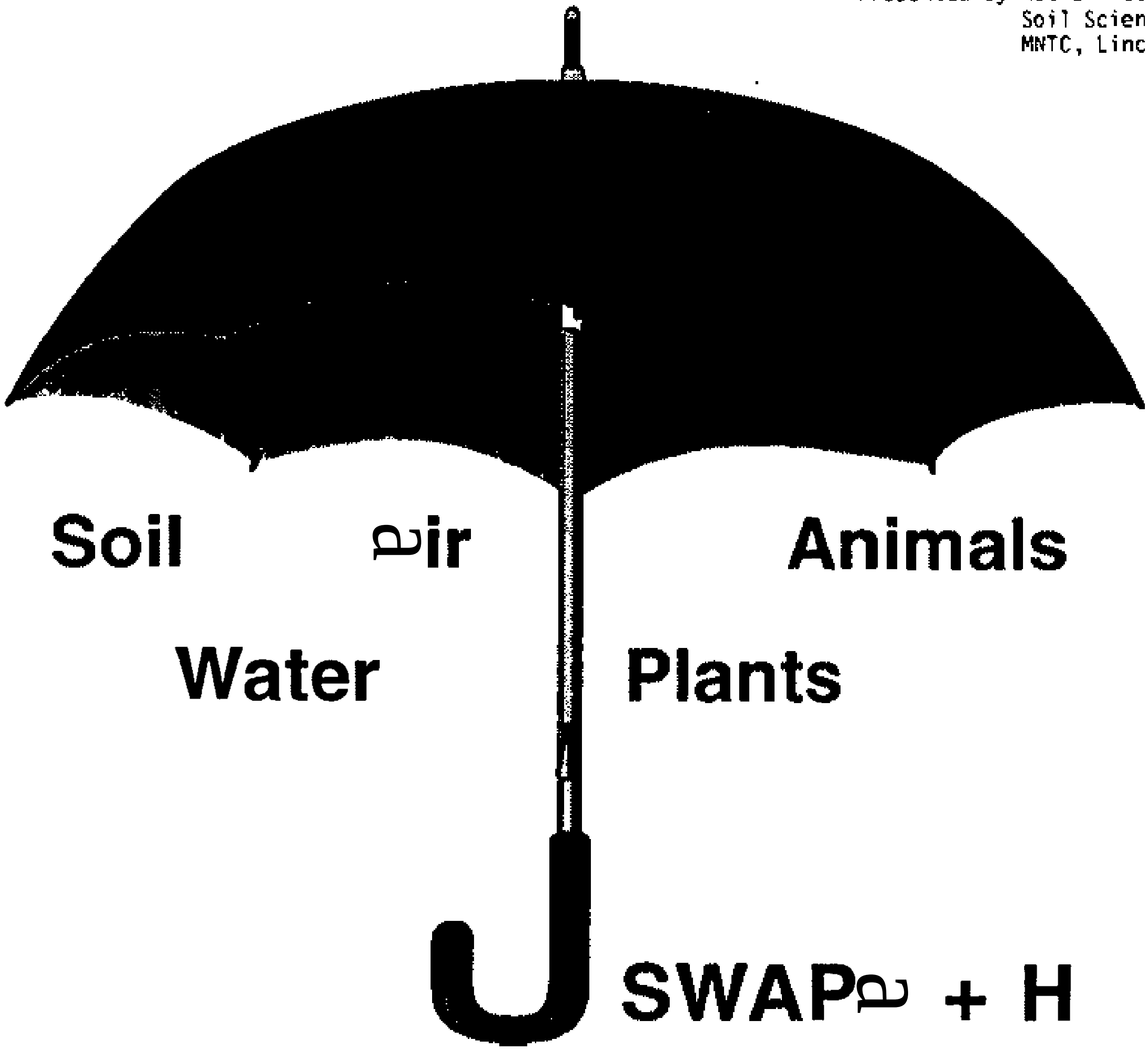
This fall, Sierra Club Books will publish ***Butterfly** Gardening: Creating **Summer Magic in Your Garden,*** **by** the Xerces Society and the Smithsonian Institution. Advance orders will be filled at that time.

The book features ***more than*** 100 close-up color photographs of butterflies and flowers, garden design diagrams, a master plant list, and essays by leading **butterfly,** gardening, and conservation experts. The book, which will sell for $18.95 retail, is available to Xerces Society members for $14.95 plus $2.50 shipping **and handling. If you are not a member, you may join Xerces now and order the book at the discounted price. To order, send a $17.45 check or money** order to: The Xerces Society, **10 S.W. Ash Street,** Portland, OR 97204.

An Oregon **Silver-spot** Butterfly Recovery Team has been reconstituted and is actively working on conservation *measures* **for the** species and its habitat. ***Speyeria** serene hippolyta* is a **threatened butterfly that lives along the Pacific coast from southern Washington to northern California. Its habitat is endangered by development and forest succession.**

The team includes Xerces Society **members Paul Hammond, Cathy Macdonald, Dennis Murphy, Paul Opler, and Katrin Snow. For** *mole* **information:** Paul **Opler,** United States Fish and Wildlife **Service (USFWS)** Office of Information Transfer, **1025 Pennock Place, Suite 212,** Fort Collins, CO 80524, **(303)** 493.8401.

Presented by Nathan McCaleb
Soil Scientist
MNTC, Lincoln, NE



Integrate Soils Interpretations for the Five Resource Concerns Into the Planning Process as They Relate To:

– Conservation Practice Physical Effects

– Quality Criteria

▶ Practice Standards

PROCEDURE FOR DEVELOPING SOIL INTERPRETATIONS FOR THE CPPE PROCESS

Step 1

Develop list of soil properties/data elements that effect the resource concern.

Step 2

Ask - Would this practice normally be selected to solve this problem or concern? (Yes or No)

If YES, then go to Step 3, if NO then go to the next question.

Ask - Would the implementation of this practice affect the concern?

If YES, then go to Step 3, if NO then go to the next concern on the CPPE.

Step 3

List soil properties that influence the design and/or applicability (+ or -) of the practice to solve the concern.

The test statement for significance, positive or negative, of each property of soil map units for the CPPE process:

> Does the (soil property) influence the design and applicability of the (practice) to solve the (resource concern)?

Step 4

Develop interpretive criteria for soil properties/data elements listed in Step 3.

Step 5

Create planning consideration statements for the soil interpretive criteria.

Process

- – Identify. Critical Practices
- – Form Interdisciplinary Team
- – Identify Critical Soil Properties
- ▶ Develop Criteria Tables

LIST OF SOIL PROPERTIES / DATA ELEMENTS

AWC (Aridic, Udic, & Ustic)

$CaCO_3$ EQUIVALENT AND/OR $CaSO_4$ EQUIVALENT

CAPABILITY UNIT

CEC

COARSE FRAGMENTS

DEPTH TO ROCK OR CEMENTED PAN

FLOODING

K FACTOR

ORGANIC MATTER %

PERMEABILIT

pH

PLASTICITY INDEX

SALINITY (Commodity Crops or Adapted Pasture)

SAR/ESP

SLOPE (% and/or Aspect)

SOIL ALBEDO

T FACTOR

TEXTURE

VADOSE ZONE

WATER TABLE - PONDING

WIND EROSION GROUP

WIND EROSION I VALUE

Soil Interpretations for CPPE Process
Conservation Practice: Conservation Tillage - Mulch Till
S WAPA Resource: Water
Resource Concern: Quality - Ground Water Contaminants - Pesticides

Soil Property	Portion Pedon	Rating	Property Limits	Resource Concern Statements
Permeability	<40"	slight moderate severe	< 0.2 in/hr 0.2 - 6.0 > 6.0 in/hr	deep perc deep perc deep perc
Texture	layer1	slight moderate severe	clays loams sands	high trans. high trans., low sorp. poten.
Water table	whole soil	slight moderate severe	> 5' + to 5'	shallow wtr. tbl. shallow wtr. tbl.

- Algorithms
- Field Office Computer System
- Soils Database
- Soil Interpretations
- ▶ Eco-Based Conservation Plan

Spatial Land Treatment Practice Tracking for Water Quality Conservation Planning

T. M. Sobecki* and R. L. Hummel

T. M. Sobecki, USDA-SCS, West National Technical Center, 511 N. W. Broadway, Rm. 248, Portland, OR 97209-3489; and R. L. Hununel, USDA-SCS, Oregon State Office, 1220 S. W. 3rd Avenue, Portland, OR 97204-2881.

ABSTRACT

Knowledge of the spatial distribution of land treatment practices within a watershed is needed to assess the impact of conservation planning and practice application on water bodies impacted by agricultural nonpoint source (AgNPS) pollution. The U. S. Geological Survey's River Reach database was utilized for lov precision georeferencing of land treatment and management practices in the Dairy-McKay Hydrologic Unit Area (HUA) Project in Oregon. The Graphical Resource Analysis Support System (GRASS) geographic information system (GIS) was used to produce maps allowing spatial tabulation of conservation practice application with the River Reach Number (RRN) as a tag. The RRN proved an effective way to aggregate conservation practices within the HUA in a hydrologically-meaningful way. Vadose and phreatic zone attributes important in determining the movement of AgNPS pollutants within the HUA were able to be associated with subasins drained by specific RRN-designated stream segments. This allowed transparent access to vadose zone information needed for water quality conservation planning.

INTRODUCTION

The fundamental data carrier of physical land attributes used by the Soil Conservation Service **(SCS)** in planning to conserve the soil resource is the soil map unit (Soil Survey Staff, 1991). The term **"data carrier"** in this context implies: a) a spatially-delineated, georeferenced portion **of** the the earth's surface, with which b) a number of physical and chemical attributes are associated. The first characteritsic is represented either **by** hand-compiled soil map unit delineations, or by digitized delineations in a geographic *information system* **(GIS).** The second **chracteristic** is exemplified **by the** practice of naming soil map units for soil series, which are physically represented by a type pedon (Soil Survey Staff, 1975). Soil interpretations for the map unit or a phase **of** *a series* (Soil Survey Staff, *1991) are* conveyed in narrative or tabular form, or as attribute data in a GIS. The conservation planner uses the principle of cartographic generalization **(Buol,** et al., 1973) to group map *unit* delineations in a given geographic area into various interpretive groups, manually or electronically, to *meet* his planning needs.

The SCS also has the responsibility **of** planning for four additionnl resources: water, air, plants, and animals (Soil Conservation Service, **1990a).** It is now necessary to 'determine the physical **effects** relevant to each *resource* during the planning **process"** so that the planner can **"select** combinations of practices that solve the identified or predictable problems without creating new problems." (Soil Conservation Service, 1990b).

The Conservation Practice Physical Effects (CPPE) matrix of the Field Office Technical Guide (Table 1) lists two aspects of the water resource, quantity and quality, that must be considered in conservation planning (Soil Conservation Service, 1990b). The CPPE matrix, in its present state, presents the conservation planner general, qualitative effects ratings. There is often a range in the rating for a given effect. The planner, however, must make a site-specific assessment of conservation practices physical effects in order to design her conservation management system (CMS) for a field or other conservation treatment unit (CTU) (Soil Conservation Service, 1992).

To adequately assess practice effects on water quality, the planner must know where she is in relation to potentially impacted surface or groundwater bodies. This requires geographic data, but not of extreme absolute precision. Some knowledge about location in relation to the surface drainage network in a watershed and relative to groundwater recharge areas is usually sufficient. She must also know the physical characteristics of the root, vadose, and phreatic zones in order to assess pathways of pollutants to the potentially impacted waterbodies (Soil Conservation Service, 1988). This suggests some knowledge of attributes about the geographic area of concern. This information is available for the root zone in the soil survey. For the vadose zone, however, there is no comparable, easily retrievable information. It must often be generalized from sources intended for another purposes, or is of less detail than needed.

The objective of this paper is to present: a) a system for the low-precision geo-referencing required in water quality conservation planning, and b) suggest a way to make vadose zone information more readily available to the planner. This system does not require an electronic GIS at the field office level. Because it has a geographhic component, it facilitate6 CPPE determinations for conservation practices effectiveness monitoring, and is useful in implementation and project monitoring (E&TA Committee, 1990; MacDonald, et al., 1991; Soil Conservation Service, 1991).

METHODS AND MATERIALS

Geo-referencing

River Reach files were obtained from U. S. Geological Survey (USGS) for the Dairy-McKay Hydrologic Unit Area (HUA) in Western Oregon (Fig. 1). In this geographic database each stream segment, at 1:100,000 scale, is assigned a unique numerical designation, the River Reach Number (RRN). The system was originally constructed from map scales of 1:250,000 by EPA, and USGS has extended it to 1:100,000 scale to pick up smaller tributaries (Mike Darling, personnal communication, USGS, Portland, OR) (Fig. 2).

A series of maps coincident with standard USGS 7.5 min. topographic quadrangle6 (Fig. 1) were generated, using the Graphical Resource Analysis Support System (GRASS), that depict the RRN associated with a particular stream segment (Fig. 3). Practices applied to fields in tracts of land within subbasins of the HUA were spatially "tagged" at the field office level by assigning field6 to the appropriate stream segment as identified by the RRN. The 7.5 min. topographic quadrangles were used to assist placing farm (operating unit) fields in the appropriate basin of a RRN-designated stream segment.

Vadoze/Phreatic Zone Attribute Data

A list of vadose and phreatic zone attributes (V/P attributes) that were deemed important in assessing subsurface pathway6 of pollutant6 to groundwater and surface, water bodies (Caine and Swanson, 1999; Driscoll, 1986; Freeze and Cherry, 1979; C. E. Stearns, personnel communication, USDA-Soil Conservation Service, Portland, Oregon) was established (Table 2). Readily available geologic reports were canvassed (Allison, 1953; Hart and Newcomb, 1965; Schliker and Deacon, 1967) and expert opinion used to specify unique sets of V/P attributes for subbasins drained by selected RRN-designated stream segments within the HUA. The unique set of V/P attributes was then assigned to the respective RRN, similar to the assignment of representative pedon laboratory characterization data to soil survey nap units (R. B. Grossman, personnel communication, USDA-Soil Conservation Service, Lincoln, NE). Data quality is indicated as high (actual well data and studies in a m-designated subbasin use to estimate attribute values), medium (geologic reports and maps of the basin or region evaluated and extrapolated to a RRN-designated subbasin), and low (educated guesses based on general knowledge about the geologic character of the basin or region used to make general statements about a RRN-designated subbasin).

RESULTS AND DISCUSSION

Georeferencing

Table 3 is a sample of farm (operating unit) fields from the Dairy-McKay HUA which have been tagged with their respective RRN. The general location of selected operating units in Table 3 is shown in Fig. 3. The fields were assigned to a particular RRN based on that field falling within a subbasin of the watershed that the RRN-designated stream segment drains. Therefore, it is possible to spatially track the application of conservation and managment practices that have the potential to impact water quality of a particular water body by sorting fields by RRN. Note how some fields within a given tract often have the same RRN, while others within that sane tract have different RRNs (Table 3).

River Reach Numbers, once assigned to a field, can be stored in the current SCS data managment system for the field office, CAMPS (Computer Assisted Hanagment and Planning System). They can then provide a spatial dimension to the field office electronic data base that is meaningful to water quality conservation planning, without having a GIS onsite.

The River Reach database contains a number of attributes in addition to the RRN. For instance, there are pointers indicating the adjacent upstream and downstream RRNs for each RRN-designated stream segment. This makes it possible to consider general routing of agricultural nonpoint source pollutants within or through a watershed if a local GIS database or watershed hydrologic model is unavailable. Also included is a stream level identifier (LEVEL), which in essence is a reverse Strahler stream order (Ruhe, 1975).

Vadose and Phreatic Zone Attributes

Once a low precision, relative georeferencing system is available, it can be used to convey attribute information. Table 4 gives the assignment of V/P attributes to selected RRNs found in the Forest Grove, OR USGS 7.5min. quadrangle. The attribute information can be general or detailed, based on the availability of resource references and subject matter expertise.

There are no specific depth or lateral limits implied in the above assignments. It is suggested that, as a minimum, V/P attributes realized from the bottom of the root zone to the top of a *regional* water table (Driscoll,1986), and vithin a hillslope segment from a first- or second-order divide to the respective first- or second-order drainageway should be considered. This represents a basic *segment of* almost all landscapes (Ruhe, 1975), and corresponds to the conceptual models frequently proposed to convey subsurface water flow to surface and groundwater (Freeze and Cherry, 1979; Hall and Olson, 1991). Low-order hillslopes are also important elements in sediment delivery to surface waters (Caine and Swanson, 1989). The collection of V/P attributes assigned to RRNs in a watershed should give a sense of the depositional system or three-dimensional facies relationships (Galloway and Hobday, 1983) that characterize the geology underlying the main watershed and that are important to determining the direction of vadose-zone water flow.

The assignment of V/P attributes to a particular RRN can be considered a ‘propositional pedon" in Holmgren's sense: observational propositions are associated with a locus (space inclusive of the feature under study, in this case physical parameters of near-surface earth materials important in dictating water movement) geographically referenced to a focus (a particular location, in this case identified by the RRN) (Holmgren, 1998). It represents an application of Holmgren's pedon concept to e geographic point location at a scale smaller than typically used in detailed soil survey work, however. The RRN might also serve as the focus for referencing additional stable-static and temporal-dynamic geologic, soil, or surface feature5 (Arnold, 1990; Grossman, et al., 1990).

Benefits to the Conservation Planner

The planner is forced to make daily decisions about specific tracts of land in the conservation planning a;:d implementation process. Yet he is often faced with a paucity of easily obtainable information about the specific location vhere he is planning. It is best that she make informed decisions, and to do that she must have up to date resource information available in a transparent, easy to obtain manner.

The ideas of Holmgren (1988) are again appropriate: "In the modern informational sense, we are concerned with propositions about location rather than with the properties of polypedons.". He is referring to the information age6 liberation from artificial constructs, such a6 the soil scientists polypedon, that in the past were needed to convey spatially referenced attribute6 of volumes of the earths surface. We no longer require such constructs. All our planner needs are borne proposition6 about location: propostions about water and agrichemical movement in a specific volume of the the upper portion of the earths crust.

CONCLUSION

This study indicate6 that the River Reach database provide6 a rather simple means of spatially tracking conservation practice6 using currently available technology. After, initial importation of the database and creation of quadrangle-sized map6 depicting RRNs, a GIS system is not needed to spatially track practice application at the field level.

Coupled with an electronic data managmement system, as complex a6 CARPS or as Simple a6 a Spreadsheet, practices can be aggregated by hydrologically meaningful units within watersheds, using a system recognized by other Federal and State agencies. This aides in attempting to estimate the potential impact of conservation practices on AgNPS pollution and water quality in project areas.

The potential for use of the River Reach database to organize and convey vadose and phreatic zone information to the planner should be further investigated.

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LIST OF FIGURES

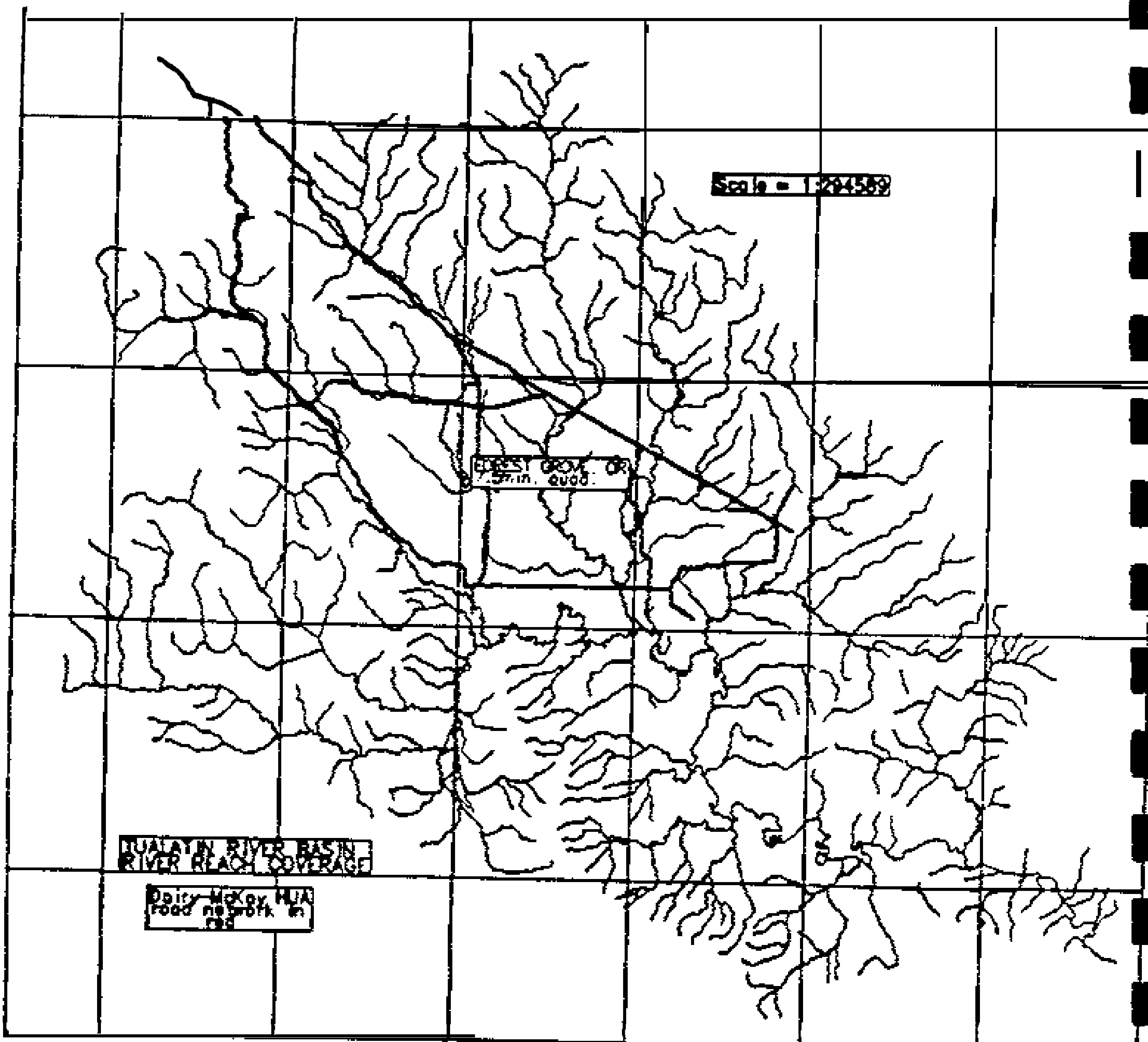


Fig. 1--River Reach database **coverage that** includes the Dairy-McKay Hydrologic Unit Area **(HUA)** Project.

RRN = HUC_SEG_RMI

RRN = River Reach Number

HUC = USGS 8-digit Hydrologic Unit Code (Example: 17090010)

SEG = Arbitrarily assigned stream Segment Number:
1-500 for EPA-assigned numbers from 1:250,000 scale hydrography
>500 for USGS-assigned numbers from 1 :100,000 scale hydrography

RMI = Reach Number - the distance (in river miles) of a stream segment (SEG) upstream from the juncture with a higher order stream. Base reach numbers start at 0.00

Example RRNs:

17090010_012_5.04

170900 10_648_0.00

Fig. 2--Definition of component pans of the River Reach Number.

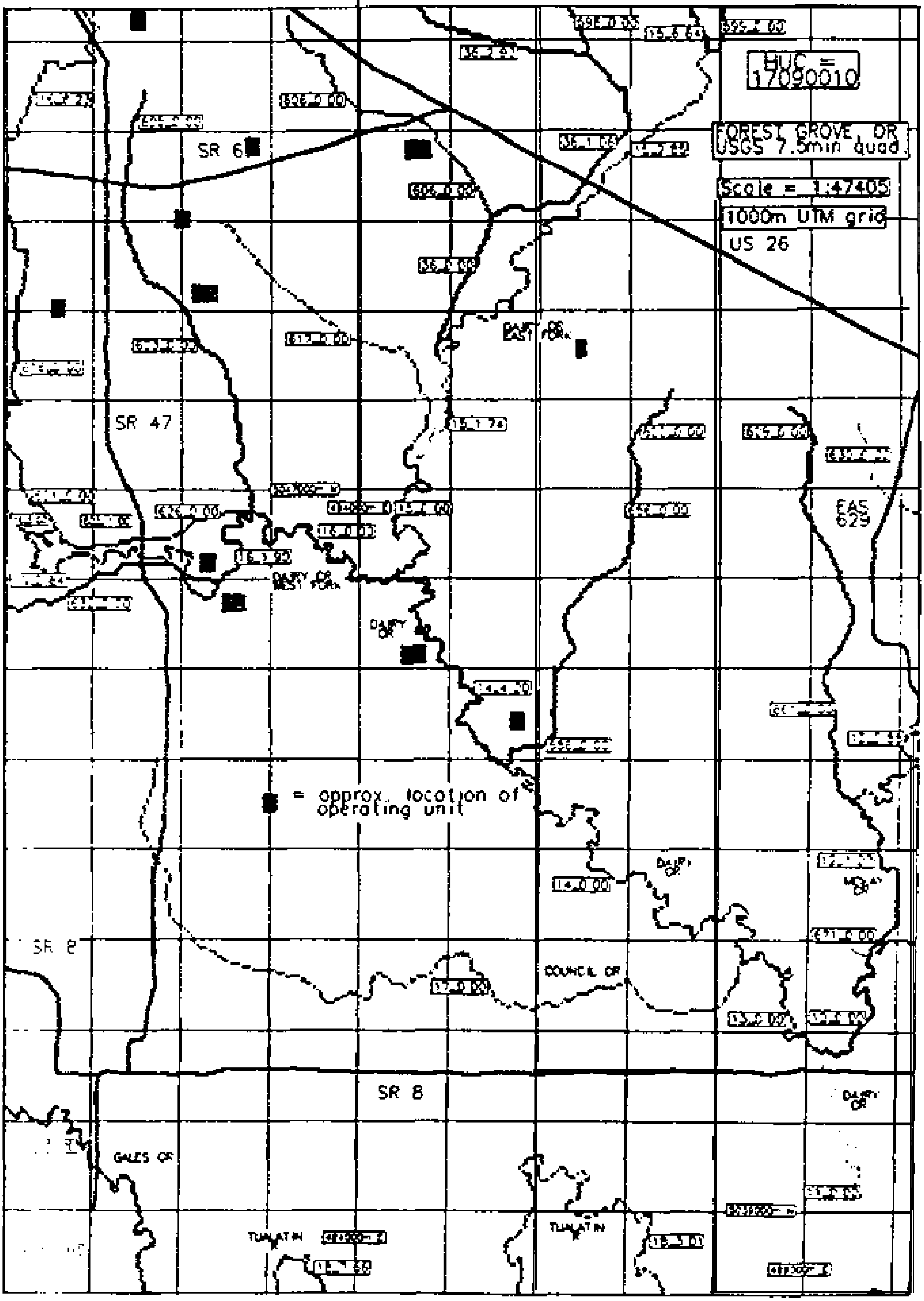


Fig 3--Identification of SEG_RMI portion (in red) of River Reach Numbers (RRN) in a portion of the Dairy-McKay Hydrologic Unit Area (HUA) Project.

Table I--Selected Conservation Practices Physical Effects (CPPE) for water quality

		Aspects/Problems			
		Groundwater Contaminants		Surface Water Contaminants	
Practice	Other Explanations	Nutrients and Organics (Groundwater quality is degraded because of contamination by natural or human-induced nutrients, or from animal and other wastes.)	Heavy Metals (Groundwater quality is degraded because of the introduction of natural or human-induced metals.)	Nutrients and Organics (Surface water quality is degraded because of contamination by natural or human-induced nutrients, or from animal and other wastes.)	Low Dissolved Oxygen (Surface water quality is degraded because of inadequate supplies of dissolved oxygen.)
680b - Nutrient Management; Excess	Applies to organic waste, commercial fertilizer, legume crops, crop residues, all agricultural land.	Significant decrease because excess nutrient applications are reduced. Effects variable because of climate, nutrient, soil, and vadose zone factors.	Slight to moderate decrease because of increased flexibility in selecting areas for waste application.	Significant decrease because excess nutrient applications are reduced. Effects variable because of climate, nutrient, soil, and vadose zone factors.	Significant decrease in dissolved oxygen because excess organic waste applications are reduced. Effects variable because of climate, organics, soil, and vadose zone factors.

Table 2--Set of attributes for the vadose and phreatic zones

A. Groundwater region (Heath, 1984)

B. Recharge area of domestic/public groundwater supply? (yes or no)

C. Regolith stratigraphy

Regolith thickness
Regolith origin
Regolith stratigraphy (grain size, bedding, rock unit names)
Depositional system (Galloway and Hobday, 1983)

D. Bedrock stratigraphy

Igneous or metamorphic? (yes or no)
Sedimentary? (yes or no)
Regional structural features (type)
Localized structural features (faults, deformation)
Rock type(s) (include rock stratigraphic unit name)
Bedding (orientation, thickness, type)
Strike and dip of beds
Soluble constituents (gypsum, soluble salts)
Fractures/Voids (type)
Depositional system (sedimentary only)
Structural basin (name)

E. Phreatic zone (saturated zone)

Perched water table? (yes or no): If yes, then:
Number
Depth
Elevation relative to confluence with downstream MN-designated stream segment (above or below)

Regional water table? (yes or no): If yes, then:
Number
Confined or Unconfined
Water table depth if unconfined
Water table elevation relative to basin baselevel if unconfined (above or below)
Aquifer depth if confined
Aquifer thickness if confined
Potentiometric surface relative to ground surface (above or below)
Aquifer (rock stratigraphic unit name)
Regional water table discharges to streams in rubbasin? (yes or no)

Table 3--Assignment of fields within selected tracts of land to stream segments identified by their River Reach Number.

Operating Unit	Tract	Field	Size	Practices+ 411	680	328	633	RRN‡
			ha					
A	to0121	1				x		605_0.00
		6	140.9'1			x		605_0.00
		7	2.5			x		605_0.00
B	t00158	1	1.1	x	x	x		16 0.00
		2b	3.2	x	x	x		16-0.00
		3	52.6	x	x	x		16~0.00
B2	too23 1	1	7.2	x	x	x		623 0.00
		2	0.5	x	x	x		623-0.00
	t00256	1	7.4	x	x	x		623_0.00
C	to002 1	4	8.1				x	617_0.00
D	too529	1	15.1		x			36_0.00
D2	too559	1	13.6	x		x		606_0.00
		2	6.9		x	x		606_0.00
		5a	10.1	x	x	x		606_0.00
		5c	221.45		x	x		606_0.00
								36_0.00
E	too252	1	26.3	x	x	x		656 0.00
		3	12.3	x	x	x		164.20
		6	15.97.5	x	x	x		656-0.00
				x	x	x		14_0.00
E2	to051 7	1	10.8	x	x	x		14 4.20
		2	2.9,	x	x	x		1414.20
G	to0202	1	2.5		x	x		16_2.84
		2	2.8		x	x		16_1.90
G1	100202		7.0	x	x	x		632_0.00
		4	14.0	x	x	x		632_0.00
	100203	1	6.5	x	x	x		632_0.00
		2	8.3	x	x	x		632_0.00
I	to1119	1		x	x	x		15_1.74
		2	29.8 ...		x	x		15_1.74
		3	1.213.1	x	x	x		15_1.74

+Subset of conservation practices applied to respective fields: 411 = grasses and legumes in rotation, 680 = nutrient managment, 328 = conservation cropping sequence, 633 = waste utilization.

‡SEG_RMI portion of RRN (River Reach Number) for HUC = 17090010.

Table 4--Selected vadose/phreatic zone attributes for some River Reach Numbers (RRN) in the Forest Grove, Oregon 7.5 minute quadrangle.

RRN†	Ground-water Region‡	Recharge Area	Perched Water Table	Regional Water Table	No.	Conf.§ or Unconf.	Water Table Depth (Unconf.)	Water Table Elevation rel. to Baselevel (Unconf.)	Aquifer Depth (Conf.)	Discharges to Streams
							m	m	m	
19_0.00	Alluvial Basins	yes	no	yes	1	Unconf.	1.5-3.5	above	NA	yes
17_0.00	Alluvial Basins	yes	no	yes	2	Unconf.	1-3	above		ye
						Conf.	NA	NA	z-35	?
617_0.00	Alluvial Basins	yes	no	yes	2	Unconf.	2-6	above	NA	yes
						Conf.	NA	NA	122-170	no

†HUC portion of RRN = 17090010.
‡According to Heath (1964).
§Conf. = Confined aquifer, Unconf. = Unconfined aquifer.

Practice Total by River Reach Number

(Acres)

RRN	Nutrient Mgt. (590)	Conservation Tillage (329)	Irrig. Water Mgt. (449)	Subbasin Area
15_1.74	11.3	11.3	11.3	1502
15_2.85	436.8	251.8	300.9	1031
17_0.00	402.3	228.0	264.8	6000
36_0.00	64.8	14.7	64.8	1333
629_0.00	92.4	0.0	50.0	533
630_0.00	87.0	0.0	49.5	222

RRN = River Reach Number

A GUIDE TO RECLAIMING HEAVY-METALS CONTAMINATED SOILS IN THE COELJR D'ALENE RIVER VALLEY

F. B. Frutchey
Kootensi County Natural Resources Department
spring, 199-l

SYNOPSIS

Much of the soil in the 10,000-acre Coeur d'Alene River valley has become contaminated with heavy metals over the past 100 years. Mine tailings in the alluvium from yearly overflow has deposited a foot or more of medium-textured materials over the original fertile silt loam and peat muck soils. The lead content in this material generally tests between 4,000 to 6,000 ppm; the pH is 4.5 to 5.4. The U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS) Soil Survey Manual has dubbed these contaminated soils "Slickens."

Data collected from remediation/restoration efforts in other parts of the United States and Canada corroborates the results of local efforts to rehabilitate heavy metals contaminated soils. Over the past 20 years, it has been demonstrated that slickens soils can be managed to stabilize the heavy metals in place by absorption as well as revitalize the health of this soil to support a myriad of wildlife. In the process, the vegetation in reclaimed areas is sufficient to withstand soil erosion from highwater events, and act as sediment filter and as a phosphate absorber. thereby protecting Lake Coeur d'Alene.

INTRODUCTION

The Coeur d'Alene Basin Restoration Project (CBRP) is now entering the implementation phase, and various agencies and, consequently, landowners, including several governmental agencies, have been struggling to rehabilitate of heavy metals contaminated soils. In this area, few have had much experience in this regard; thus, vegetative capping has largely met with poor results on public lands.

Some of the private landowners along the floodplain of the Coeur d'Alene River have been researching and SUCCESSFULLY implementing stabilization on their soils during the past twenty years in order to: 1) control (heavy metals contaminated soil) erosion caused by the annual flooding; 2) rehabilitate the health of the soil by stabilizing the heavy metals in place (tieing up these metals, making them bio-unavailable); 3) provide nutrients essential for life (nitrogen, phosphorus. and potassium); and 4) provide feasible seed crops of heavy metals adapted reclamation grasses, as well as safe, suitable grazing for both domestic animals and wildlife.

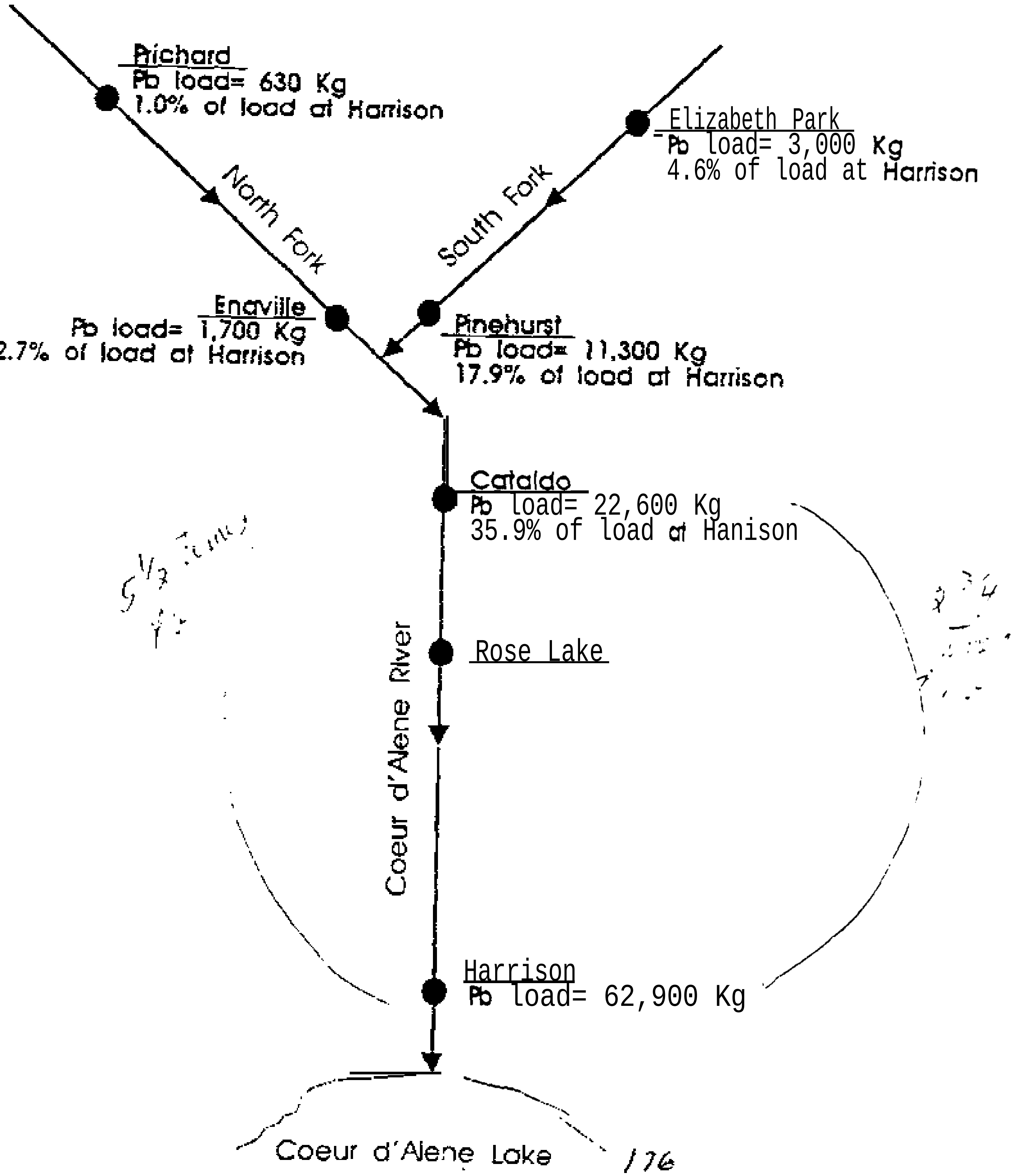
At the prompting of the U.S. Geological Survey and the USDA-SCS, the author has compiled this data plus experience gathered over the past 21 years in this guide so that others may have quicker success in this reclamation effort.

Chemical research reports seem to explain some of the reactions to soil amendments which were observed here in the Coeur d'Alene River valley. Quote from Trace Elements in the Terrestrial Environment by Adriano, Chapter on Lead:

> *The extractability of Pb in soils is influenced by several soil properties. Soils limed to a high pH yielded less extractable Pb (Misra and Pandey, 1976; John, 1972, MacLean et al, 1969). Also, soils with high phosphate (MacLean et al, 1969), organic matter, or clay contents (Karamanos et al, 1976; Scialdone et al, 1980) tend to reduce the extractability of Pb from soils....Under certain conditions, Pb can be transformed by microorganisms....*
>
> *...As with other trace elements, the chemistry of Pb in soils can be qualitatively described as affected by: (1) The specific adsorption or exchange adsorption at a given mineral matrix; (2) The precipitation of sparingly soluble compounds of which it is a constituent; and (3) the formation of relatively stable complex ions or chelates that result from the interaction with organic matter.*
>
> *Using equilibrium batch studies and deducing forms from equilibrium solubility diagrams, Santillan-Medrano and Jurinak (1975) presented data suggesting that, in non-calcareous soils, the solubility of Pb appears to be regulated by* $Pb(OH)_2$, $Pb_3(PO_4)_2$, $Pb_4O(PO_4)_2$, or $Pb_5(PO_4)_3OH$, *depending on the pH ...*

This kind of rehabilitation has been accomplished in other places, in the western United States also. It has been done on some lands in the Coeur d'Alene River valley as well.

LEAD (Pb) LOADINGS
Coeur d'Alene River



MEMORANDUM OF AGREEMENT
(MOA)

Presented by:

Arlene J. Tugel
Soil Scientist
West National Technical Center
SCS, Portland, Oregon

at

Western/Midwestern Regional Cooperative
Soil Survey Conference
June 12-17, 1994
Coeur d'Alene, Idaho

Memorandum of Agreement (MOA)

Memo of *Agreement (MOA)*

- **Four federal agencies with wetlands protection responsibilities, in a new memorandum of agreement, recognize the U.S. Department of Agriculture s Soil Conservation Service as the lead federal agency for delineating wetlands on agricultural lands. This action will provide more certainty for farmers and provide more effective coordination among federal agencies with wetlands protection responsibilities.**

Memo of Agreement (MOA)
Delineation of Wetlands

Interagency agreement

- **USDA**
- **USDI**
- **EPA**
- **US Department of the Army**

Memo of Agreement (MOA)
Delineation of Wetlands

Soil Conservation Service (SCS)

Corps of Engineers (COE)

Environmental Protection Agency (EPA)

Fish and Wildlife Service (FWS)

Memo of Agreement (MOA)

- **Under this agreement, farmers will be able to rely on Soil Conservation Service wetland maps for determining the extent of wetlands under both the Farm Bill (also known as the Swampbuster program) and Section 404 of the Clean Water Act.**

MOA Delineation of Wetlands

Purpose

- **To specify the manner in which wetland delineations and certain other determinations of water of the United States made by USDA under the FSA will be relied upon for purposes of CWA Section 404.**

Memo of Agreement (MOA)
Delineation of Wetlands

- **Subtitle B of Food Security Act (FSA)**
- **Section 404 of Clean Water Act (CWA)**

Memo of Agreement (MOA)

Eliminate duplication

- **SCS makes delineations on all agricultural lands.**
- **SCS identifies "other waters", in coordination with the COE, when they are in the field identifying wetlands after appropriate guidance has been given.**

Memo of Agreement (MOA)

Eliminate duplication

- **COE makes determinations on non-agricultural lands where SCS is not involved.** 981.

- **SCS identifies wetlands on non-agricultural lands, in coordination with the COE, for USDA participants.**

Memo of Agreement (MOA)

Consistency

- **NFSAM procedures will be used in making wetland determinations on agricultural lands.**

- **87 Corps of Engineers Manual procedures will be used to make determinations on non-agricultural lands.**

- **Cross-training between agencies on both manuals before delineations are made.**

187

RESPONSIBILITIES

Mapping Conventions

- **COE, EPA, FWS, SCS written concurrence on mapping conventions**

- **Offsite methods to make wetlands determinations**

183

RESPONSIBILITIES

Delineation Process Review and Oversight

- To achieve consistency
- Continuous improvement in delineation process
- EPA has leadership in establishing interagency oversight teams at state level

RESPONSIBILITIES

Reliance on Previous SCS Wetland Delineations for CWA Purposes

---

- **Certification procedures**
- **Coordination with COE/EPA**
- **Recertified every 5 years**

RESPONSIBILITIES
Appeals

- FSA appeals process for SCS wetland determinations (FSA or CWA)
- COE/EPA will have opportunity to review delineation changes based on an appeal
- FWS consulted

RESPONSIBILITIES
Training

- Interagency training
- 1987 Corps Wetlands Delineation Manual (CWA)
- National Food and Security Act Manual

MOA Delineation of Wetlands

Definitions

- "Agricultural lands" means those lands intensively used and managed for the production of food or fiber to the extent that the natural vegetation has been removed and cannot be used to determine whether the area meets applicable hydrophytic vegetation criteria in making a wetland delineation.

MOA Delineation of Wetlands

Definitions

- Areas that meet the "agricultural lands" definition may include intensively used and managed cropland, hayland, pasture land, orchards, vineyards, and areas which support wetland crops (e.g., cranberries, taro, watercress, rice).

MOA Delineation of Wetlands

Definitions

- **For example, lands intensively used and managed for pasture or hayland where the natural vegetation has been removed and replaced with planted grasses or legumes such as ryegrass, bluegrass, or alfalfa, are considered agricultural lands for the purposes of this MOA.**

MOA Delineation of Wetlands

Definitions

- **"Non-agricultural lands" - "agricultural lands" do not include range lands, forest lands, wood lots, or tree farms. Further, lands where the natural vegetation has not been removed, even though that vegetation may be regularly grazed or mowed and collected as forage or fodder (e.g., uncultivated meadows and prairies, salt hay), are not considered agricultural lands for the purposes of this MOA.**

1994 Western/Midwestern Regional Cooperative

Soil Survey Conference

June 12-17, 1994

Water Quality Issues and Related Soil Information Needs in the Clark Fork-Pend Oreille Watershed

presented by

Ruth Watkins

Project Coordinator for the
Tri-State Implementation Council

Sandpoint, Idaho

The Clark Fork-Pend Oreille watershed encompasses about 25,000 sq. miles in an area spanning western Montana, northern Idaho and eastern Washington. The Clark Fork River, Pend Oreille Lake and the Pend Oreille River are the main bodies of water in the basin, and are the focus of a three-state water quality management effort now underway.

As a result of citizen concerns about increased aquatic weeds and algae in the Clark Fork River and Pend Oreille Lake, language was added to the 1987 Clean Water Act directing EPA to study the sources of pollution in the basin. Focusing on nutrients, the three-year study led to the development of a watershed-wide management plan. The first priority of the management plan was to establish, in October 1993, the Tri-State Implementation Council to oversee the implementation of the plan. Since that time, the Council has been working to carry out pollution control measures through a series of local community-based subcommittees who are dealing with such issues as wasteload allocation, wastewater treatment discharge alternatives, nonpoint source contributions, monitoring, and education.

In the work of these committees, the need often arises for accurate data on soils, ranging from: types of soils and their feasibility for land application of discharge wastes; capacity of soils to handle development and other human activities; and delineation of areas of high erosion risk. This information is not only necessary in the design stages, but prior to the design in the feasibility and planning stages of pollution control measures. Planners and policy makers alike needs good soils information and an understanding of the issues in order to make sound decisions in the watershed.

Soil experts can help by getting involved in local watershed issues, and by making soil information readily available to managers and decision makers.

The Idaho Cumulative Effects Process and it's use of Landtype Associations

Brian D. Sugden, Forest Hydrologist
Plum Creek Timber Company, L.P.

Soil Survey Conference -- June 16, 1991
Coeur d'Alene, Idaho

As some of you are aware. an interdisciplinary task force consisting of representatives of industry. state and federal agencies, and the environmental community have been working for the past three years on developing a cumulative effects assessment and control process for forest practices in Idaho. This task force was formed to address legislation passed in 1991 which directed the Idaho Department of Lands to develop methods for controlling watershed impacts resulting from the cumulative effects of forest practices. For the past two years I have participated as a member of this task force. Earlier this spring, the draft process underwent a final technical review and now is in the last stages of completion. The process will be presented IO Idaho's Forest Practices Advisory Committee this fall and could be adopted by the years end. This afternoon I will provide an overview of the draft process developed by the task force: and more specifically, I will explain how this process uniquely utilizes landtype associations,

This flowchart describes the steps involved in the assessment process (See Figure 1). Without getting into too much detail about how the process may be administered, the initial boxes describe the initiation of the watershed analysis, formation of the watershed committee, and the selection of analyst(s). The first major step to be done by the analyst is an evaluation of mass failure (landslide) and surface erosion hazards in the watershed. These are determined from Forest Service 1:100,000 landtype association maps for which mass failure and surface erosion hazards have been assigned. As most of you are aware, landtype associations are based on the concept that the underlying parent material and the erodibility of that parent material interact to form a particular landscape. Landtype association maps divide the landscape into areas based on landform. terrain shape. and parent material. By having an understanding of the inherent hazards in a drainage, you can better design harvest and transportation systems and the with site specific evaluation, determine the necessary erosion control measures.

The next major step in the flowchart directs the analyst to evaluate the current instream conditions with respect to channel stability and the presence of fine sediment. This will provide the information necessary to determine if forest management activities such as road construction and timber harvest have affected the stream channel. One difficulty in conducting the instream assessment is knowing what portion of impacts are caused by forest practices versus other land uses such as mining and livestock grazing. The process will only regulate forest practice impacts. To help solve this issue, when conducting stream evaluations in watersheds with multiple land uses, the analyst will do their best to try to measure locations where forest practices activities can be separated out. For example. if there is a definite boundary between upstream forest lands and downstream agricultural lands, sample points should be located at the forestlag boundary.

The third major step in the process is an evaluation of the current watershed conditions. The assessments in this section include evaluations of riparian canopy condition as it influences stream temperature, forest canopy condition as it affects the watershed hydrology. a nutrient evaluation, and an evaluation of sediment delivery to streams from roads, skid trails and mass failures.

Once the watershed hazards, instream conditions, and hillslope conditions have been evaluated. the next step is to ask the question “do adverse instream conditions exist?” With Idaho‘s principle cumulative effects concern being fine sediment in streams, it is imperative that we have a basic understanding of what the expected levels of fine sediment should be for a particular stream. This is the second way which the process incorporates landtype associations.

Right now, the Idaho Department of Lands and the Forest Service are compiling fine sediment data collected on streams in pristine watersheds in Idaho. The are also collecting information on adjacent landtype association, stream gradient, channel confinement, and average annual flow at the same location sediment was measured. Once we have this information, a correlation analysis between observed levels of instream fine sediment and the other stream attributes will be conducted. For example. the process will hopefully give us predictive capabilities such as "for a 3% gradient unconfined stream in a 2-5 Landtype (old surface in alluvium) we would expect natural fine sediment levels between 30% and 50%: whereas, in a 3% gradient confined stream in a 3-1 Landtype association (colluvial landform in belt parent material) we would expect 5%-10% fine sediment.

The data collection and correlation analysis is still underway. Initial reports indicate that this approach is promising. If it works. we will have accomplished a monumental feat: Knowing how much fine sediment should be in streams in managed watersheds.

For hydrology, channel condition, nutrients, and stream temperature, we have other criteria by which we determine if adverse instream conditions exist. If. in fact, it is determined that there are adverse instream conditions and they can be reasonably linked to upslope forest management. the landowners are required to develop "Cumulative Watershed Effects Management Prescriptions (CWEMPs)." These CWEMPs must address the problems identified in the analysis and are enforceable in future forest practices.

One example of this is as follows:

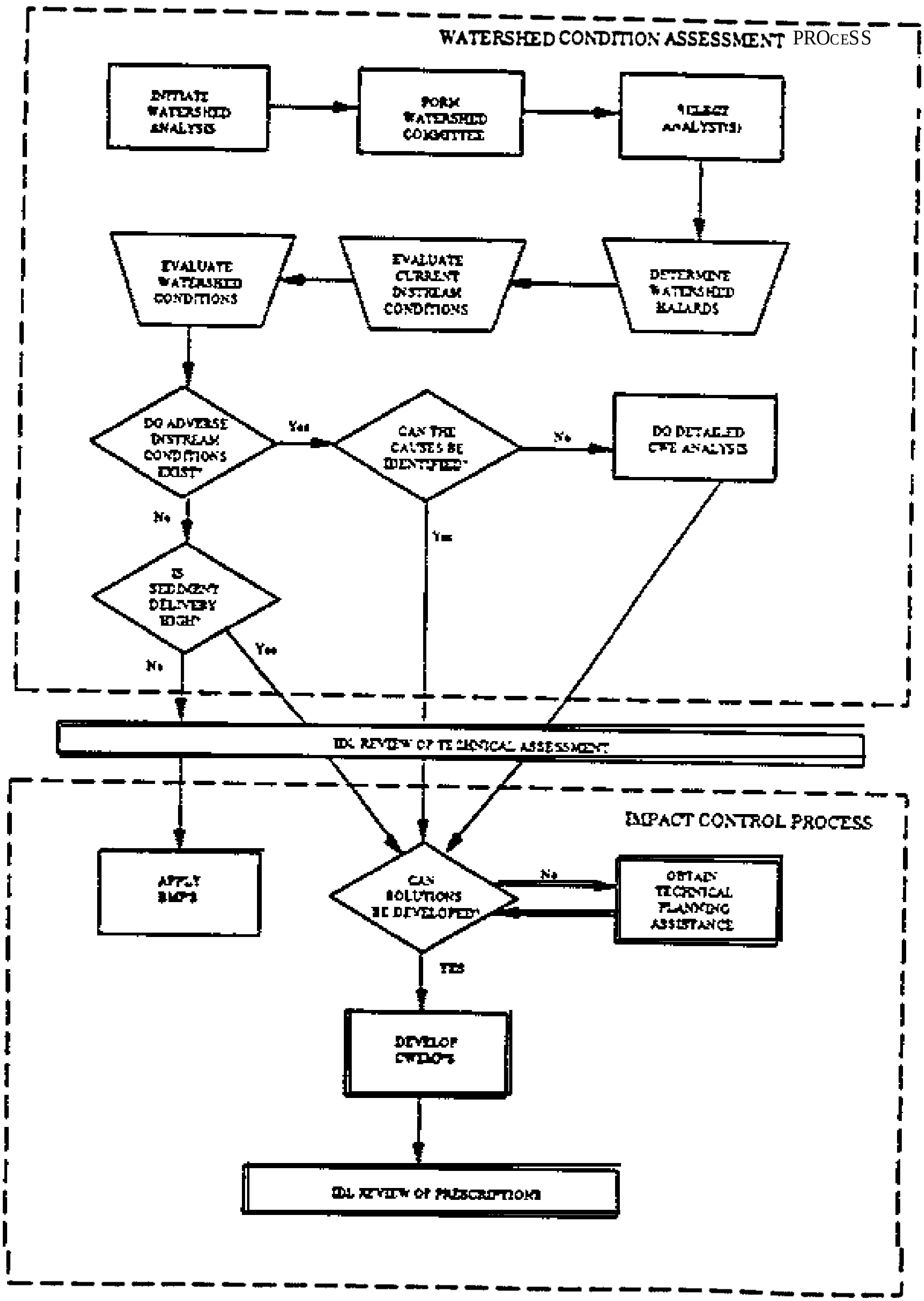
> The instream evaluation reveals 60% surface fines. Based on our data correlation. a pristine stream in that landtype association with the same stream characteristics should have fine sediment levels between 20-30%. Also observed were frequent points of

sediment delivery to streams and an existing road and skid trail system which is poorly maintained and actively eroding. Given the instream evidence and hillslope observations. the stream is found to be in an unacceptable condition and future forest management must find a solution to these problems. The CWEMPs developed may include plans for road improvement, stabilization of fill slopes, etc.

The Idaho Cumulative Effects Process is an exciting new approach to forest management. Managing for specific watershed hazards and instream conditions will over time will create management practices specifically tuned to the unique characteristics and condition of each watershed. Landtype associations are the foundation for this effort and will require continued research and mapping.

-END -

FIGURE 1. CUMULATIVE WATERSHED EFFECTS
PROCESS FLOWCHART
6/94



Presented by Harold Maxwell, State Soil Scientist, SCS, Boise, Idaho

NASIS for NCSS
West Midwest Joint Meeting 1994
Coeur de Alene, IDAHO

ODTLINE:

OVERVIEW

A. Data Flow Diagram

1. NASIS begins with the collection and storing of point data including Soil Characterization Records (SCR).
2. Data aggregation and correlation is used to create the map unit record (MUR).
3. MUR includes spatial data and is linked to other databases such as crop yield, rangeland or woodland tables.
4. Interpretations can be made for MUR or Point data.
5. The National Standard will be used to compare and correlate MUR or Point data.
6. MUR at the field level will be aggregated from the field level to create state and national databases.
7. A National Data Access Facility will be established.
8. MUR will not have limits on number of components that can occur in each map unit.
9. Components will not be restricted to taxonomic limits. The representative values for the component must fall with in the taxonomic limits of the name for that component.
10. NASIS will store the component pedon information by horizons not layers. The numbers of horizons will not be limited.

B. NASIS STRUCTURE

1. NASIS is structured around the DATA DICTIONARY..
2. The backbone allows data access by various paths without duplicating storage. Each map unit will have a unique identifier nation wide
3. NASIS will include both spatial and attribute data.
4. Security systems allow multiple users to share data but provides the owner the ability to control and maintain integrity.
5. Modular Generic design allows unique access capability.
6. Data elements can be added without affecting the existing information or its use.
7. The component data will be stored by high, low and representative values. Representative

values will be controlled by the field soil scientist.

8. Pedon information will be stored by horizon with no limit to the number of layers that can be stored

C. Three Types of Data

1. Point data from field notes to SCR will be stored and available for interpretation. Much of the point data will be collected using the Pedon Software.
2. MUR or map unite and components of map units will be stored and interpreted. Components will be a result of aggregation of the point data.
3. The National Standard will contain Soil Series and other conceptual standards used to correlate soil point data or components.

SPECIFICS:

A. Timing

1. NASIS 1.0 has been tested and will be released October 1994. There will likely be at least one interim release prior to 2.0
2. NASIS 2.0 is in the analysis stage and scheduled for release October 1995.
3. Additional releases are planned for each October as needed. The selection of team members to conduct analysis for NASIS 3.0 will begin later this year.

B. Functionality

1. NASIS 1.0 will be used at the State Office level to accommodate the changeover from the existing system to NASIS.
2. NASIS 2.0 will be designed to replace the existing with functionality as good as or better than existing systems. This version will be fully functional at the field level and will replace the form 5 and form 6.
3. Future releases of NASIS will include spatial interfaces, new modules and interpretations.

C. Platform

1. NASIS is designed on a Sun Work Station and will be ported to a 486 or Pentium platform.

2. UNIX, INFORMIX is the operating software.

3. Pedon will be written in DOS to accommodate field data recorders.

WHY CHANGE:

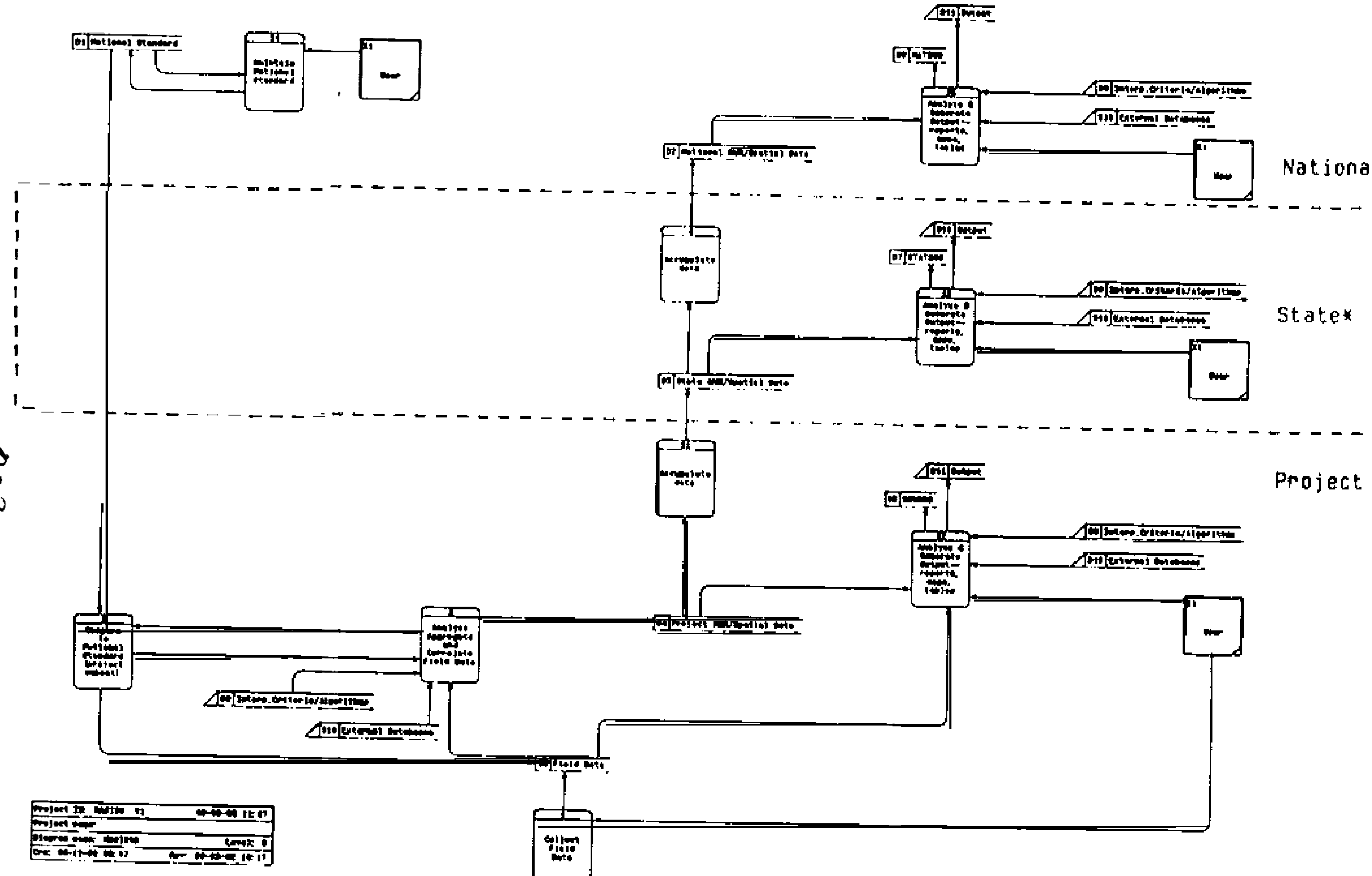
A. Advantage6

1. Allow unlimited component6 in map units and allow all components to be interpreted.
2. Eliminate political or manmade boundaries from the database.
3. The table structure is more flexible at all levels. Adding of data element6 or increasing the length of a data table does not affect operation of the software.
4. The data is managed at the field level. The field staff will have all the capabilities of NASIS.
5. Spatial data is integrated at the mapping level and can used for testing tool as well a6 a delivery tool.
6. Interpretation6 can be tested at the developmental stages of a soil survey as map units are designed.
7. Will allow for field data recorders 60 that information needs to be recorded only once (developmental).
8. Representative value6 developed at the field level will allow software designers to use the data more accurately.
9. Tempo.al data can be stored and retrieved as needed.
10. Removed restraints imposed on the old system such as storing layer6 instead of storing soil horizons. The system currently used by SCS was greatly restricted by field length6 and number of fields.

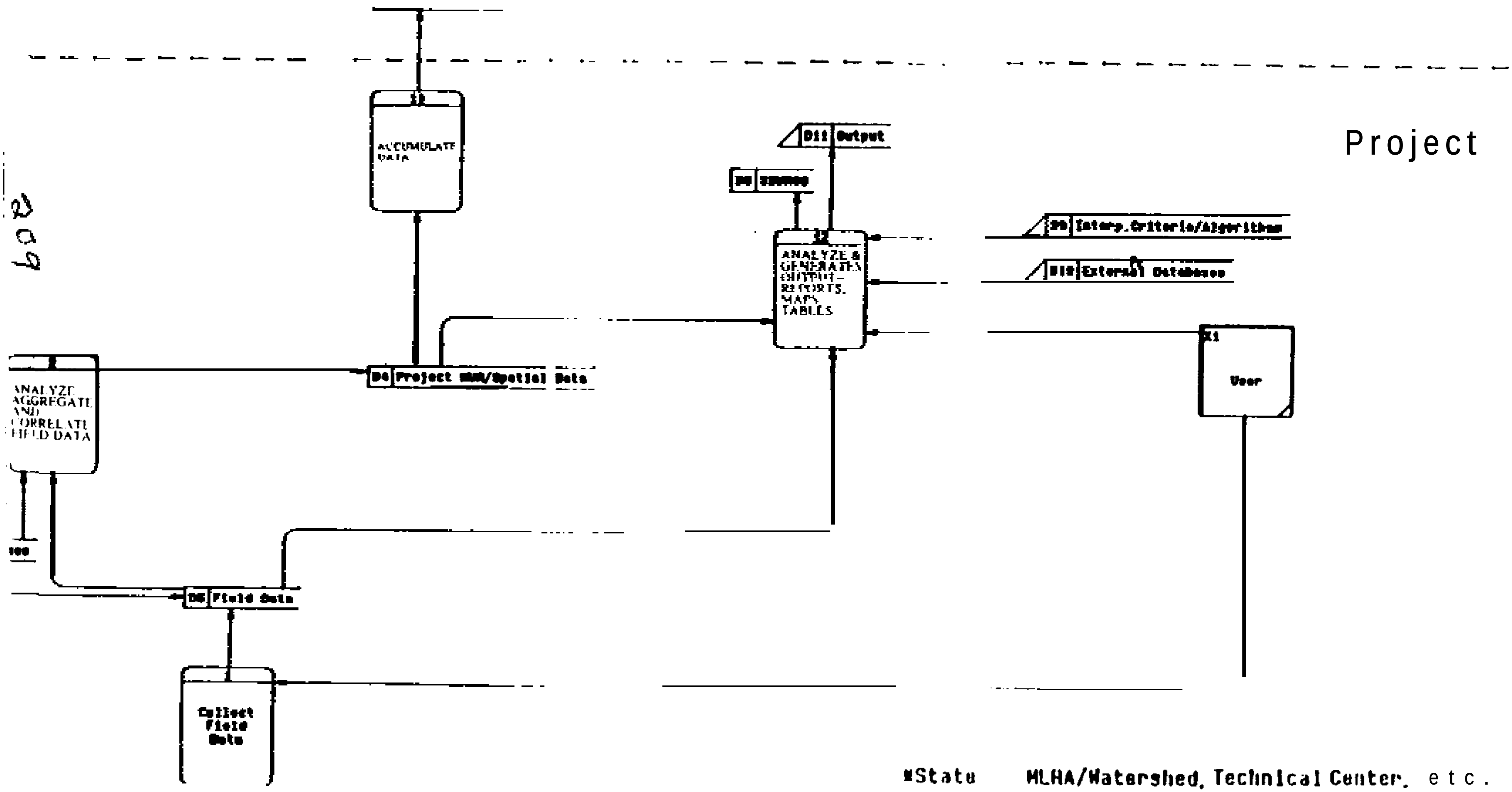
B. Why now

1. The present system Was beginning to show weakness and had served many years.
2. The data base management system for SC5 was being changed from Prelude to Informix.
3. The advent of new uses of soil survey required the addition of new data elements to the data store.
4. Info-share and data sharing between government agencies showed a need for new ways to access data and to be able to Share data rapidly.

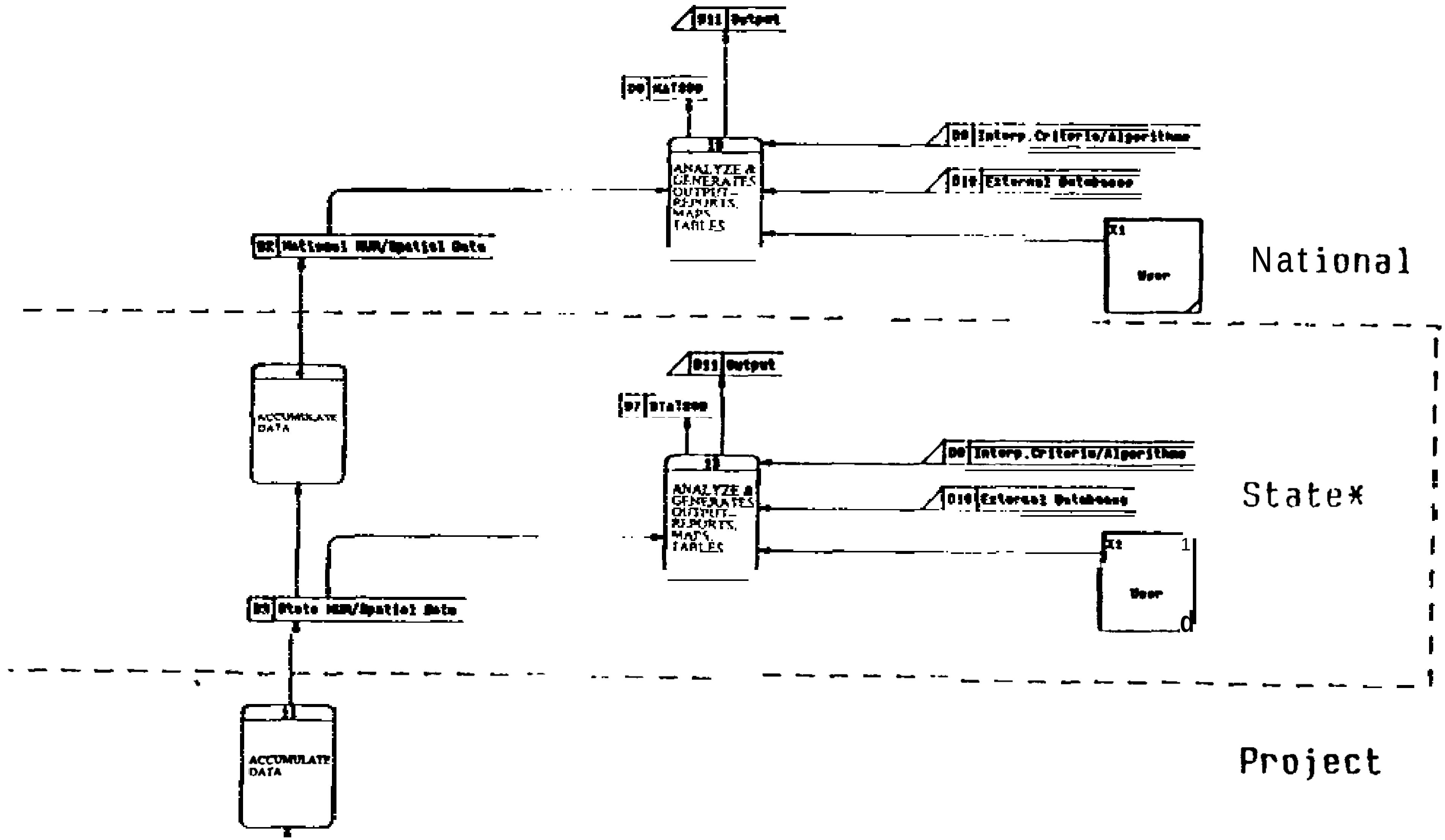
GENERALIZED NASIS DIAGRAM

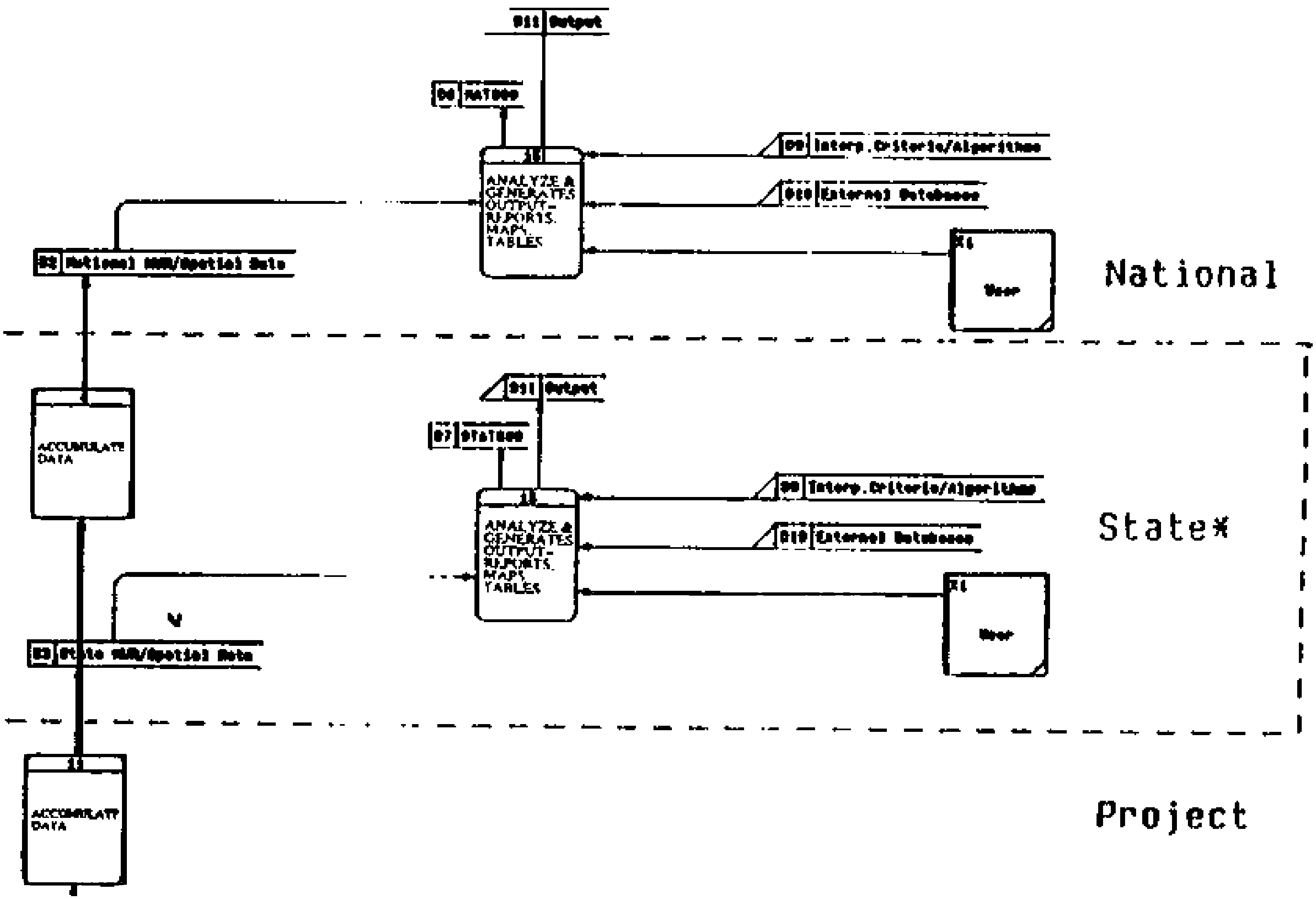


*State or MLRA/Watershed, Technical Center, etc



*State MLHA/Watershed, Technical Center, etc.


D11 Output
D8 Interp.Criteria/Algorithms
D10 External Databases
ANALYZE & GENERATES OUTPUT – REPORTS, MAPS, TABLES
X1 User
National
ACCUMULATE DATA
State*
Project

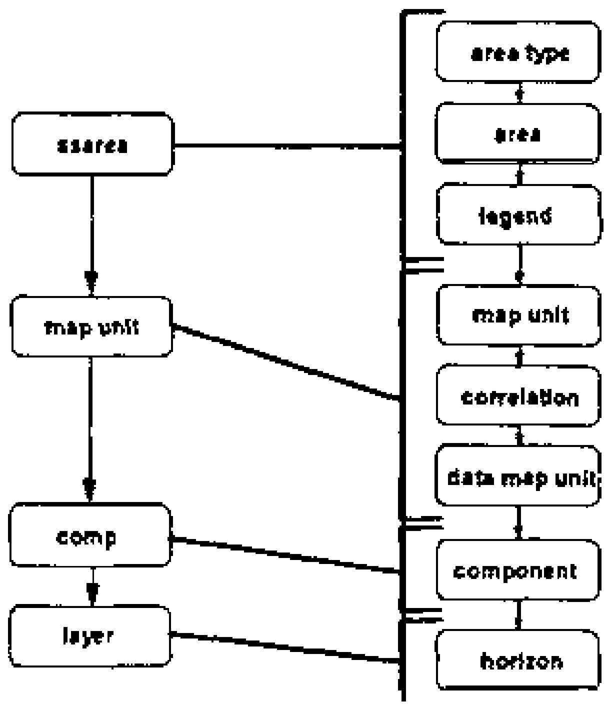

National
State*
Project
ANALYZE & GENERATES OUTPUT- REPORTS, MAPS, TABLES
ANALYZE & GENERATES OUTPUT- REPORTS, MAPS, TABLES
ACCUMULATE DATA
ACCUMULATE DATA

National *Soil Information* System

NASIS Overview

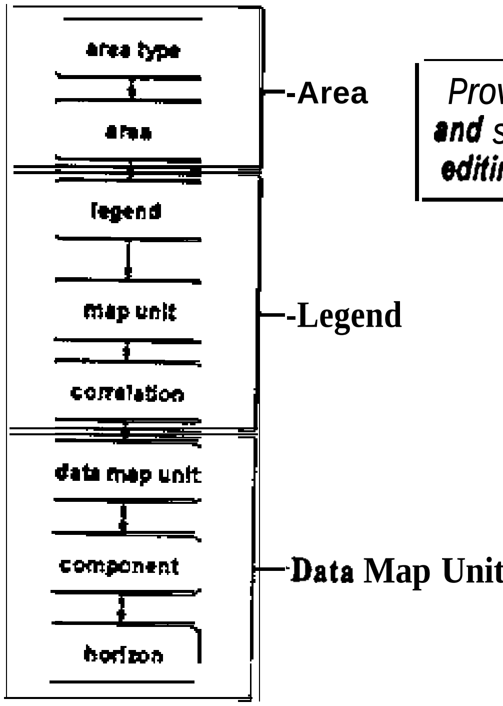
SSSD vs. NASIS
Implementation Timeline
Release 1.0 to 3.0 Features

SSSD | **NASIS**



1

NASIS Security & Owned Objects



*Provides **capability** to read **and** share **data** while limiting **editing** to authorized users.*

Security Classes

- Databases
- Groups
- Users

Owned Objects

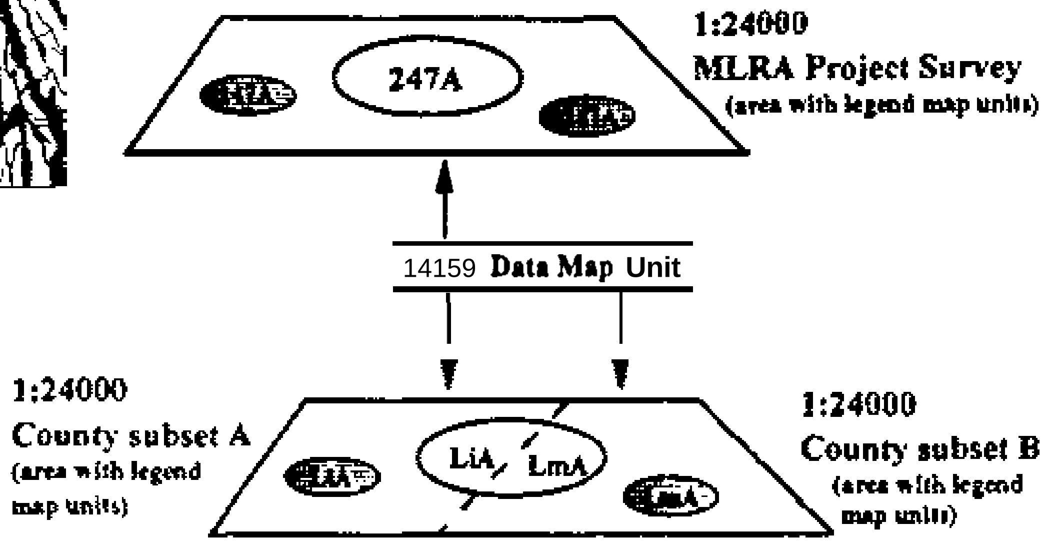
- **Areas**
- Legends
- Data Map Units

SOIL-S's & SOIL-6's vs. NASIS

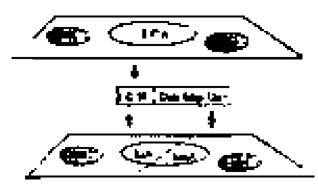
SOILS Functions:	NASIS:
• Repository for downloading SDR tables	• All of tbe data associated with a SOILS will be managed within **NASIS locally**
• Repository for populating MUIR components	• **Map units are populated by copying data within NASIS**
• **Complement to the OSED for specifying RIC**	• **Map unit data may be compared with a recognized standard**

[SOIL-6 Functions	NASIS:
• Retrieve up to tbree **SOIL-5(s) for** a map **unit, adjust** layer **depths and/or** delete **specific layers**	• Map **units** are linked to **multinle** compooeots (unlimited) locally
• Create conversion legend **for** additional symbols	• All correlation rod conversion records are maintained **within th** NASIS correlation table
• Record acres in multi-county surveys	• NASIS stores acreages by area for multiple-area surveys

NASIS Legend Map Unit & Data Map Unit Relationships



NASIS Correlation Table



survey area	map symbol	status
MLRA	247A	approved
subset A	LiA	approved
subset B	LmA	approved
subset B	AvA	inactive

Legend Map Unit Table

legend map unit	data map unit	representative
247A	14159	yes
LiA	14159	yes
LmA	14159	yes
LmA	54321	no
AvA	54321	yes

Correlation Table

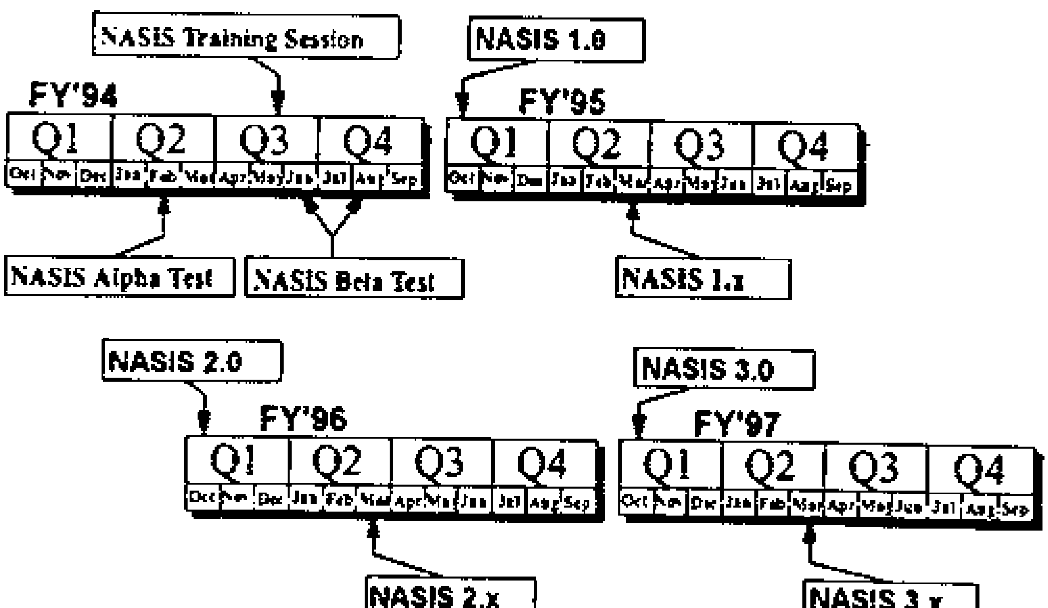
Data Map Unit Table

data map unit ID	map unit data	owner
14159	data tables	MLRA correlator
54321	data tables	subset B project leader

Implementation Timeline

- **Alpha** Test of Conversion & NASIS Editors ➡ Feb **14-25, 1994:** Colorado State Office
- Training for Beta Test ➡ May **23-27, 1994:** Ft. Collins
- NASIS 1.0 Beta Test ➡ **Jun-Aug 1994**
  Phase 1 — Jun: KS, OR, TX, VA
  Phase 2 — Aug: add AR. CO. FL, IA. MI. MT, NM, TN
- Release NASIS 1.0 ➡ **Oct 1994**
- Release NASIS 1.x ➡ **Mar/Apr 1995**
- Release NASIS 2.0 ➡ **Oct 1995**
- Release NASIS 2.x ➡ **Mar/Apr 1996**
- Release NASIS 3.0 ➡ **Oct 1996**

Implementation Timeline



Release 1.0 Features

- Conversion of SSSD to **NASIS**
  - Selective by Soil Survey Area
  - Insures clean data loaded Into NASIS
- Security System & Controls
  - Database ID
  - Group ID
  - **User ID**
- Operational Data Dictionary
  - Tables & Attributes
  - Dynamic
- NASIS Editors (Area, Legend, **& Mapunit)**
  - Table oriented
  - Context oriented

1

Release 1.0 Features

- Q & A Functions
  - Automated internal testing
  - Code reviews
  - Standards enforcement
- Database Interactions
  - Retrieve & translate data
  - Manage edit buffer
  - Post changes back to database
- NASIS Information System
  - Online user guide, tutorial, and definitions
  - Hypertext linking of topics
  - Print individual topics

Release 1.x Features

- Cut/Copy and Paste Function
  - . Select object to cut or copy
  - . Paste into new or existing object
- Configurable Edit Screen Setup
  - . Choose columns (attributes) to edit
  - . Specify order for columns
  - Name & save edit setups
- Query Generator (Select)
  - Select by legend or data **mapunits**
  - Select by attribute criteria
  - . Name 8 save queries
- Global edit function
  - ▸ Changes work on entire selected set

Release 1.x Features

- Communication Support
  - ▸ **SoilNet** capabilities
  - ▸ Facilitate Data Exchange with Security Features
- Calculation & Validation
  - Provides for derivation of data elements
  - ▸ **Facilitates** interpretation generation
- interpretation Generation
- Reports (primarily for DSM)
  - ▸ Where Used Data **Mapunits**
  - . Unlinked Data **Mapunits**
  - . Data dump

Release 2.0 Features

- Export to FOCS, external users
- Interpretation Criteria Maintenance
- Enter/Edit PEDON Data
- Exchange Data between NASIS Sites
- Soil Survey Schedule

@Additional Reports

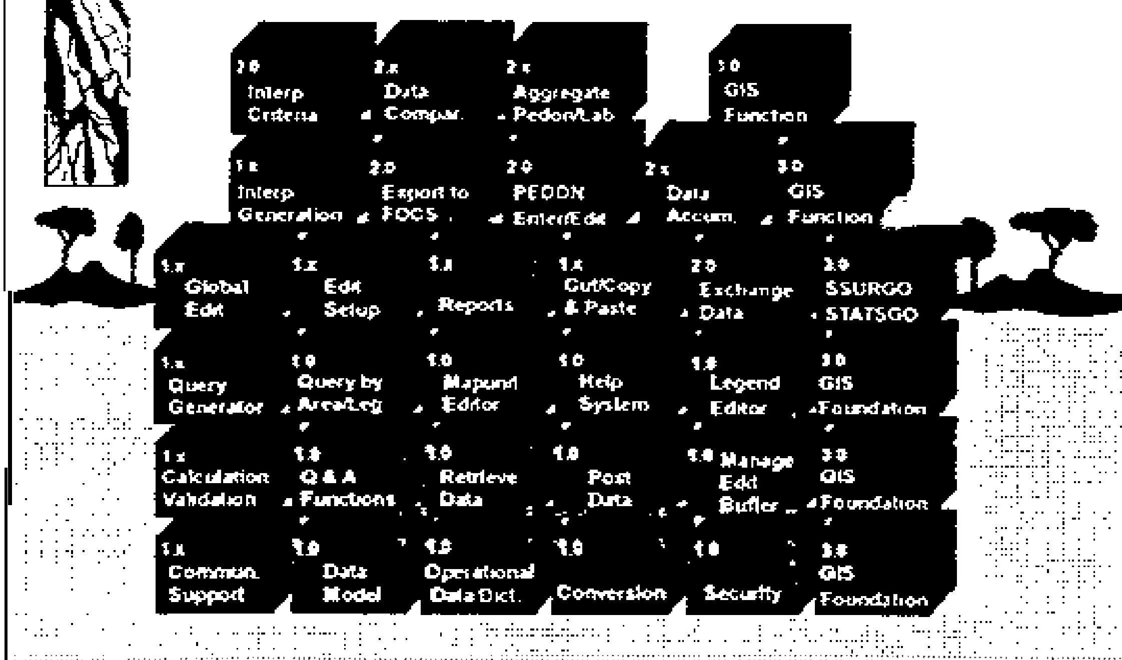
Release 2.x Features

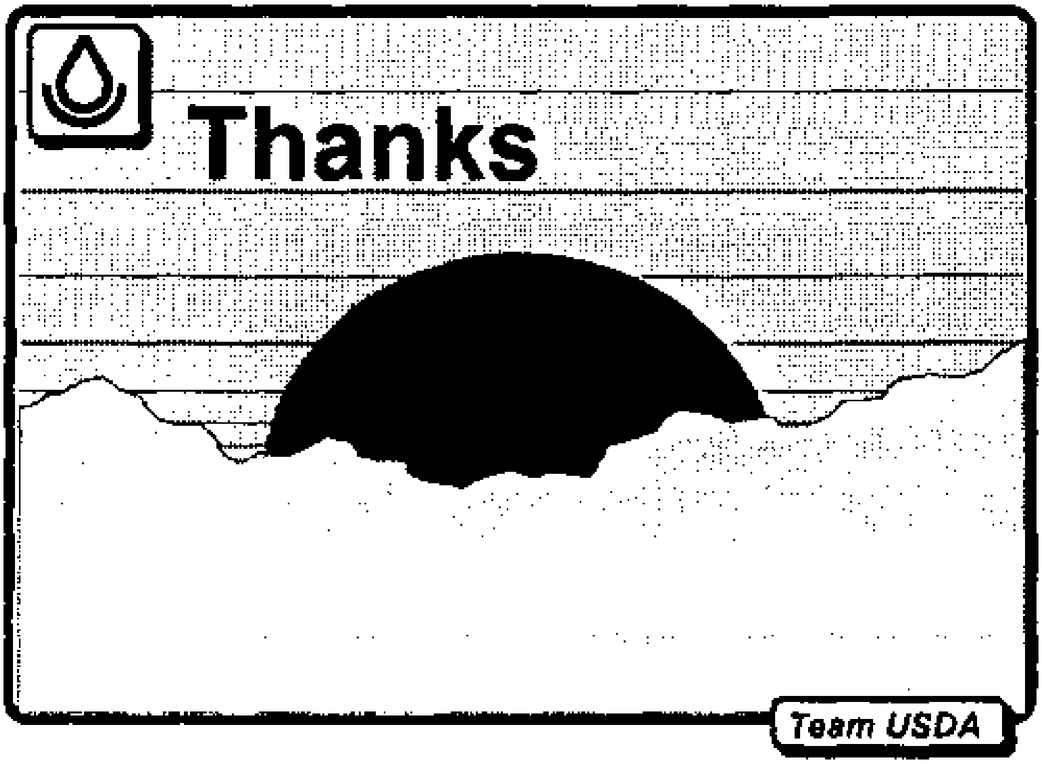
- Data Accumulation
  - Site Characterization Data (SCR)
  - Map Unit Data (MUR)
  - Taxonomic Unit Data (TUR)
- Generalized Data Comparison
  - Pedon or Component RV vs. RIC for Series (National Standard)
  - Pedon vs. Component, Series vs. Series, . . .
- Aggregate PEDON & Lab Data
  - Help create **mapunits**
  - Statistically determine RIC

Release 3.0 Features

- Add GIS capabilities to **NASIS**
- Manage SSURGO, **STATSGO,** NATSGO
- True Survey Area Editor
  - Coincident areas
  - Acreage tabulation
- Enter/Edit PEDON Data
- Incorporate “Fuzzy” Logic

Release 3.0




Thanks
Team USDA

THE NATIONAL SOIL INFORMATION SYSTEM

BACKGROUND

The SCS and its National Cooperative Soil Survey (NCSS) partners have maintained a soil survey database at Iowa State University (ISU) mince about 1975. Starting in about 1985 the SCS began an effort to reevaluate the soil data base. That effort has lad to the development of a National Soil Information System (NASIS).

WHAT IS NASIS?

NASIS is a ● yrtom that provider for the collection, storage, manipulation and dissemination of soil survey information within the National Cooperative Soil survey.

NASIS is also the umbrella project name under which the SCS Soil Survey Division is developing automated ● y8tomr, and much of the talk lately has been about NASIS in this context, but the overall NASIS will continua to have both manual and automated processes.

An information system such ● # NASIS is not simply ● collection of computer programs that operate on data filer. It is a means to ● chiovm organizational objectives by coordinating computer hardware, software, data, process logic, policy and operating procedures to implement organizational objectives.

Much of the work that ham been done to date has involved mapping out the current ● y*tem and then ● ettlinp on the organizational objectives mentioned earlier. A Soil Business Area Analysis Group (SBAAG) and other teams from the field, state and national staffs are continuing this effort. We will form many new teams as we continually strive to ● nhanca and improve our NASIS into the year 2000 and beyond.

The first software to be released under the NASIS umbrella, was the Pedon Dercriptlon Program. It provides the foundation on which we will build. The next release will deal with the storage, manipulation, and dissemination of soil ● urvay information. We plan to make this release in October 1994. It will address many of the inadequacies we have with the current ● yst8m and it is designed based on a new logic for soil ● urwy data that was developed in the ● nalyeia mentioned earlier

Projected release dates for NASIS and a brief ● xplanatlon of the functionality that will be included in each release ● re listed below:

<u>NASIS 1.0 Components - October 1994</u>

- Conversion SSSD to NASIS
- security system & Controls
- Operational Data Dictionary
- Data Editors
- On-line Help System

<u>NASIS 1.x Components - March 1995</u>

- cut, copy and Paste Functions

Configurable Edit Screen Setup
Query Generator (select)
Global Edit
Communication Support
Calculation L Validation
Interpretation Generation
Additional Reports (Duplicate Data Map Units, Unlinked Data Map Units)

NASIS 2.0 Components - October 1995
Export to FOCS, External Users (SDTS)
Exchange Data between NASIS Sites
Soil Survey Schedule
Additional Reports (manuscript reports)
Interpretation Criteria Maintenance
Edit PEDON data

NASIS 2.x Components - March 1996
Data Accumulation
Generalized Data Comparison
Aggregate PEDON L Lab Data (Determine Range in Characteristics)

NASIS 3.0 Components - October 1996
GIS Capabilities
Manage SSURGO, STATSGO, NATSGO
True Survey Area Editor
Enter/Edit PEDON Data
Incorporate "Furry' Logic

NASIS 3.x Components - March 1997
Additional GIS Capabilities
Additional Reports

WHAT WILL HAPPEN TO THE SOIL FORM 5?

The Soil Form 5, Form 6 and the data base structure that it created will be replaced by the NASIS data base. NASIS software will provide the new means to input data into the data base. The projected date for the phase out of the Form 5 and Form 6 is October, 1995.

WHAT WILL HAPPEN TO THE OFFICIAL SERIES DESCRIPTION (OSBD)?

The OSED will remain at ISU for now. There is • National Soil Survey Center team involved in the design of what has been called the "National Standard". This team is looking at the possible combination of the OSED or parts of it and the Soil Interpretations Record (Soil Form 5) or parts of it into a relational data base that might be used for correlation or comparing roil described in the field to existing series.

WHAT WILL HAPPEN TO THE DATA MSB AT ISU?

We will continue to house the NCSS soil data bases at ISU for now. The SCS is evaluating the options for storage of all of its data bases. The results of that ● valuation will indicate whether the data base will ● tay at ISU or be moved to another location.

WHAT ABOUT ALLOWING NON-SCPCRS TO ACCCSS AND CONTRIBUTE DATA TO THE SOIL DATA BASE AT ISU?

We have recently begun a project to put all of the map unit data or the data that LB created from the Soil Form 5 and 6 data. up in an ORACLE relational data base on Project Vincent, a UNIX workstation network at ISU. We are creating A capability to access this data over INTERNET. We also have . National Cooperative Soil Survey Data Management Team that is designing a c-n soil data dictionary and data structure that will ● vontwlly ● l10u non-SCSers to contribute soil data to the ISU data base. These ● ffortr will feed a federal government interdepartmental ● ffort being lead by the Federal Geographic Data Committee to provide easy access to all natural resource and other data. The soil data may eventually become available over ● lactronic networks with software that tells what's available, where it's at, what it costs, and maybe eventually a means for on-line ordering and retrieval.

WHAT ABOUT ACCCSS TO THE DIOITIZCD COUNTY LEVEL (SSURGO) SOIL MAPS AND STATSGO DATA?

These data will continue to be available from the SCS National Cartographic and CIS Center at Fort Worth Texas. They may ● ventully be made available over the same network previously mentioned.

WHAT ABOUT THE AVAILABILITY OF NASIS SOFTWARE TO NON-SCSERS?

The NASIS software will be available to any non-SCSer. It will be distributed from the National Soil survey Center at Lincoln Nebraska.

WHAT KIND OF COMPUTER HARDWARE AND SOFTWARE WILL NASIS REQUIRE?

Except for a DOS personal computer version of the Pedon Description Program which is being developed, all of the NASIS ● oftuare will require a 486 or workstation computer and UNIX and INFORMIX software. Specifics can be obtained from the National Soil Survey Center.

FOR MORE INFORMATION CONTACT:

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Presented by Jim Carley, State Soil Scientist, SCS, Spokane, Washington

WIND EROSION and PM < 10

Today I will be discussing wind erosion and Particulate Matter < 10 (PM < 10). It's an issue many of you are involved with, and it's one we'll hear a lot more about in the near future. And of course, folks in Eastern Washington are becoming well versed on the issue. It's an issue that we in agriculture need to address and we need to make our efforts noticed by the public. I will talk about this subject from a resource perspective; The soils, climate and agricultural land uses.

Before we talk about wind erosion and PM < 10, let me fill you in on some of the background -- what the situation is and why it is.

The 1990 Amendments to the Clean Air Act brought with them the responsibility to monitor and control particulate matter 10 microns and smaller as established in 1987. This is referred to as PM-10. To give you an idea of the size of 10 microns, imagine how small 1/40 the diameter of a human hair is. It is small enough that our filtering systems can't prevent it from accumulating in our lungs. These small particulates have been identified as a major health problem.

The Environmental Protection Agency was given the charge to implement the Air Quality Standards of the Clean Air Act using PM < 10 as the standard for measurement. Monitoring stations were set up in urban areas, Safety levels were set for PM < 10 at 50 micrograms per cubic meter for a daily average, and no more than 150 micrograms per cubic meter on a single day. (This would be about 50 pounds of dust in a volume of air 1 mile by 1 mile by 600 feet tall annually or 150 pounds in the same space on a single day.)

Those areas that exceed the health standards are classified as non-attainment areas. Of particular importance to us in Eastern Washington is the City of Spokane, which has been classified as a non-attainment area.

If the non-attainment exceed the standards once during a year, they are required to develop State Implementation Plans (SIP) and carry them out to deal with the problem.

Now what does all of this have to do with agriculture? Agriculture fugitive dust is identified as one of the causes of the PM < 10 problem in the non-attainment areas. For example, some areas in Washington have soils that readily blow during the wind events in late summer and early fall. Other areas experience wind storms generally during the spring time of the year.

Dust is not, of course, the only cause of the PM< 10 problem. We may ask what about wood smoke, ear emissions and dust from construction sites? Why is agriculture being asked to deal with this issue? Isn't blowing dust a natural part of farming?

Blowing dust is a part of farming. PM < 10 is a health and economic issue for rural areas as well as the cities identified as non-attainment areas.

The health problems and dangers of poor visibility on roads affect rural residents too. Rural residents pay taxes that go toward ditch cleanup, road closures, and overtime for transportation and emergency personnel. We all pay for long term medical problems.

There are less obvious economic setbacks also. If an area cannot achieve the PM < 10 standards, then any new industry may be subject to severe restrictions. It may be enough to discourage new industry from settling in the area.

The non-attainment areas identified are working within their jurisdictions to control the PM< 10 problem. Spokane, for instance, must address high PM < 10 occurrences during two primary times of the year. I'm excluding the grass burning and wood burning. During late winter, winter traction materials are a source of dust. The traction materials in the past contained large amounts of silts. When the roads dried sufficiently, vehicles entrained the fine silts into the air. Hopefully using cleaner traction sand materials and use of chemical de-icer will clean up this problem.

The other critical time Eastern Washington experiences PM c 10 problems is in late summer and early fall when the major wind events come from the southwest. There is evidence that the origin of that dust is agricultural. Although more research is needed in this area,, a correlation has been observed of wind events, wind erosion, and high PM c 10 readings in Spokane in late summer and fall with the winds from the southwest.

The stage of wind erosion that plays the largest role in PM < IO is suspension.

Wind causes the soil particles to bounce along the soil surface; each time they strike the soil surface! they dislodge other soil particles. This is called saltation. This repeating process results in soils being moved by wind.

The finer, silt-sized, particles become suspended in the air. This suspension is the airborne material that can end up miles or hundreds of miles from the source.

When we think of wind erosion we generally think of sandy soils and wind erosion evidence as seen in these slides. Accumulations of fine sand size soil particles that have been deposited on:

- fence rows
- in the furrows
- ditch banks
- and sand dunes.

In order to get a perspective of how soils land and wind erosion influences agricultural fugitive dust, let's take a look at the state of Washington and geographic locations of the major soils that play a role in PM < 10 problems in the state. This is a State General Soil Map.

Point out:

Columbia Basin
Palouse

This is a general soil map of the SE quadrant of WA.

Point out:

Spokane
Tri-Cities

The dark brown areas area deep sandy soils located in a 6-9 inch precipitation zone. These soils are used for irrigated cropland.

DEEP, SANDY SOILS
Quincy soils - Six or Seven to about Nine or Ten inches precipitation

LAND USE

1. Irrigated cropland - Precipitation is too low and available water capacity is to low for non-irrigated cropland
2. Potatoes, grapes, asparagus, spring grains, and mint are the main crops grown.

RESOURCE CONDITIONS

1. These soils are subject to saltation - minor amounts enter suspension. They lack the silt size soil particles to go into suspension.

2. They are subject to wind erosion in spring of year when tilled for seedbed preparation, and prior to the time the crop germinates and achieves enough size to prevent soil blowing.

3. Also subject to wind erosion in fall where crop residue or cover is not present.

4. Because it is irrigated there are several options available to reduce soil blowing. These are:

Wind break plantings, follow-up cover crops: and delayed tillage.

These soils are also subject to FSA/FACTA. Although severe wind erosion may occur on these soils, they are not a major agricultural fugitive dust source. This is due to the fact that they do not readily go into suspension, they are irrigated and therefore, many different lands of conservation measure can be readily applied.

SE Quadrant of State General Soil Map -
Map Units Ll, L2, Lt2
RED area on map.

LOESS SOILS - DEEP SILT LOAM SOILS
- 2.7 M acres in Washington.

Typically in seven to twelve or thirteen inches of precipitation.

1. Fifty percent very fine sand
2. Fifty percent silt, (high amount of very fine sand and silt combined)
3. Two to three percent clay, which is low
4. Less than one percent organic matter, which is low
5. Very weak structure - Structure is easily destroyed
6. Soils have an ash component

LAND USE

1. Non-irrigated cropland for winter wheat
2. Summer fallow system
3. Large fields

The climate particularly affects this non-irrigated area. Low precipitation between 6-12 inches results in low yields and low amounts of residue. About the only way this area can be cropped is with a winter wheat-summer fallow rotation.

RESOURCE CONDITIONS

1. Soils subject to both saltation and suspension
2. Low yields resulting in low residue levels
3. Seeding time in late August or September which coincides with major wind events.

At the end of the summer fallow year when seeding is done in the fall, the soils are the most susceptible to wind erosion. Residue and clods have been broken down by tillage. Large fields have soil surfaces that are bare, dry and powdery or fluffy and very susceptible to wind erosion. This is due to the low amount of clay (1 to 3 percent) and organic matter (< 1 percent). The soil lacks "glue" It is at this same window of time that the wind events occur.

The wind erosion on these soils is much more subtle than the wind erosion we see from the sandy soils. The silt size loam particles readily go into suspension. As you can see, this field is in very powdery or fluffy condition.

We don't see the sand dunes. We do see some evidence of the filling of the deep furrow drill rows with the very tine sand soil particles. .

Roth the saltation and suspension stages of wind erosion result in poor visibility and the consequences that may on Highway occur. Numerous. accidents have happened on highways during big wind events. These have resulted in loss of property and life. These soils are the primary source of the agricultural fugitive dust concerns of PM < 10

Most of these soils are not Highly Erodible for water or wind erosion by FSA criteria and therefore are not subject to Conservation Compliance.

Not Highly Erodible:

Wind Erosion	Water Erosion
Low "C" Value (30)	Low "R" Factor
Deep Soils (T=5)	Deep Soils (T=5)
Low "I" Value (86)	

Some solutions to reduce wind erosion on non-irrigated cropland include:

- permanent cover (grass seedings)
- crop residue management
- wind strips
- straw mulching on isolated blow out prone areas
- soil roughness

Due to the low precipitation, the traditional wind breaks and/or cover crops cannot be established or maintained unless irrigation is provided. The conservation options are less than those on irrigated lands.

Traditionally wind erosion research has not been oriented toward agricultural fugitive dust, We have been more concerned with measuring what ends up in a fence line or road ditch than with what's in the air.

Currently, SCS is working with the Agricultural Research Service (ARS) to better predict wind erosion. We jointly established a Wind Erosion Prediction System (WEPS) site in the Horse Heaven Hills of Central Washington 3-4 years ago and have been collecting data since.

Although we can be getting conservation on the ground now, research still needs to be done. We need to:

determine how much PM < 10 varies from soil to soil
determine what part of agricultural fugitive dust in suspension is PM< 10
-support the development of tools necessary to accuratdv/ estimate PM <10 due to wind erosion
-quantify PM < 10 reductions resulting from conservation practices
do further soil analysis (especially on soils with ash content).
-establish what intensity of wind event should we be planning conservation practices for?

15 mph wind event
or
50 mph wind event

-determine the economics of resource practices for PM < 10

The complexity of wind erosion and how it related to agricultural fugitive dust is significant. For example:

Pilots have reported observing the dust from a few individual fields. Only a handful of fields were covering all of eastern Washington with dust. Adjacent fields with the same land use were not eroding. We need to learn from this. What makes the difference?

The main reason this has been on the agenda today is because we have recognized that wind erosion and agricultural fugitive dust is a problem. We need to further evaluate the extent and severity of the problem.

It's a big job. No one can do it alone. This is an opportunity for those of us in agriculture to work as partners. We need to approach this task as a coalition committed to solving the problem.

We need to develop strategies and methods to tackle the problem. Progress is made when we adopt the best technology to our knowledge but then continually ask ourselves, "What more can we do?"

In Washington, SCS and the Conservation Districts are working with DOE, EPA and local Air Quality authorities in order to address this problem. Through our technical knowledge and delivery system, we are assisting the agricultural and environmental communities with:

- identification of problem areas
- providing data for establishing quality criteria
- information activities
- educational activities
- technology improvements
- planning assistance

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In order to assist with technology improvement, the SCS is evaluating:

- residue reduction with associated tillage
- soil structure and clodiness with associated tillage.
- soil moisture
- accuracy of synthetic erosion inhibitors
- soil erodibility "I"
- effects of clodiness on wind erosion
- economics

We need to adopt, implement and apply new techniques to field conditions. Hopefully we can make progress in the development and implementation of new techniques to reduce wind erosion and blowing dust from the agricultural lands.

The public awareness of air quality is increasing. For instance, the health of over a 1/2 million people in Eastern Washington is being adversely affected by agricultural fugitive dust from 2.8 million acres of cropland. In the Western U.S. approximately 45 million acres have been identified as contributing to PM < 10.

As conservationists we are challenged to provide the best possible technology and solutions to maintain and improve the air quality.

Thank You.

Any Questions?

A CENTURY MINUS FIVE --- AND COUNTING

West-Midwest Soil Survey Conference
Coeur d'Alene ID June 1994

Dick Arnold, Director, Soil Survey
USDA-SCS, Washington, DC

1. Have you heard the rumors? Soil surveys are almost completed. The once-over is going to happen. The Soil Survey is obviously on a one way track and will pass over the far horizon into oblivion.

2. Others have rumored that we have passed our zenith and are really over the hill. The glory days were in the 1960s and 1970s they say, certainly not in the 1990s.

3. But if we look all around us we see nothing but change. Everywhere there is change, beautiful, wonderful, exciting, and to some extent predictable.

4. ILet me tell you something ladies and gentlemen the world is changing and your soil survey will be changing with it. Take heart and get on with life. It is far too short to waste.

5. There will be no ruins perched high on the slopes waiting the return of unknown ghosts of yesteryear.

6. There will not be any reason to dredge for gold again with a fever that consumes reason and caution. We don't need rusting buckets to remind us of what might have been.

7. The sky is gray and ominous. The forest closes sin around us. But look, there ahead in the bend in the road is a golden promise of a bright new day. A ray of hope that pushes aside the gathering storm clouds.

8. It is not a new beginning. It is not a rebirth. It is not the smoke and mirrors of magicians. It is the adherence to the reality of living in a world which continues to evolve and grow and recycle the goodness thereof.

9. Remember when outsiders used to tell us that the only thing we knew to do was look at "holes in the ground"?

10. What some folks have never understood is that we learned the value of teamwork, From the smallest to the strongest we set our minds to the task at hand and pulled, and pulled, and pulled together.

11. We stretched that little hole in the ground into a trench reaching across the landscape a6 far a6 we needed it to go. We Paw new relationships, and learned how the underground world was put together. We created the Pedosphere.

The U.S., like much of the rest of the world, ha6 recognized the significance of *clean water - for man* and beast, for land and feast. It is Crucial for a sustainable, productive nation.

13. The quality of water is more than the sediment load swirling by on it6 way to degrade other part6 of the *environment. It* is also the way water travel6 through the landscape. Gently, peacefully, meaningfully - or in a destructive rush to engulf all that lie6 ahead.

14. The quality of animal habitat is receiving deserved attention a6 we search for an appropriate balance of what will remain a6 the biodiversity of plant and animal life.

.15. Ecosystem-based assistance for integrated total resource management. It is far more than a catchy phrase. It is cognizance of the relevance of sustainable "humanized" ecosystems.

16. When you no longer can see the forest because of the trees, it just might be those majestic redwood6 that hold each of us spellbound at the grandeur of Nature.

37. Resilience is the ability or capacity to return to a former state when disturbed. But perhaps more interesting is the concept of adaptability - that ability or capacity to change with changing Conditions. This is north central California, not the Andes mountain6 of Peru.

18. Like and amoeba - stretching, groping, encircling and digesting it6 own environment. The social system is a6 important a6 the ecosystem in making this a "one world". There are 60 many potential customer6 for soil information.

19. Ho matter what we do, or say, or think, it is other people who make the major decisions about land use, farming systems, and managing resources. But we can promote stewardship. Stewardship of all resources. Stewardship. Consider this, "Stewardship is the social acceptance of sustainability".

20. Prom space one can glance across the Hawaiian islands to the farthest horizon and see the curvature of the earth. What goes around, comes around. What comes around is surely connected to that which wa6 before and that which is yet to come.

21. There are many acres of public land and land of Native Americans that would benefit from detailed *inventories as* plans are **prepared** the changing conditions in the decades ahead.

22. With a policy of "no net loss of wetland", there likely will be more and more "reconstructed" wetlands such as these vernal pools. Getting it right the first time is not at all easy.

23. Monitor the status, condition and trend of natural resources. conduct sophisticated research. Delineate special features. But for goodness sake, get the geographic coordinates - because it is a world of cadastral accuracy and geographic information systems.

24. Caring for renewable resources means knowing which species of seedlings to plant on which sites. Rotations, once started, are not so easy to change. The margins for error are small when you tinker with the risks of 'sustainable ecosystems that are in concert with the rest of the environment.

25. Efficient, thrifty fanners: effective, thrifty farming systems; integrated, thrifty ecosystems. Headed for a productive nation in harmony with a quality environment.

26. Do we really understand soils like this? Will we ever know the story of their genesis? Was it dry once? Has it always been wet? So much yet to learn about that which we have made maps of.

27. Use dependent properties can be measured. Techniques have been developed. NASIS will likely be able to store and manage such information. How far and how fast will we move toward measuring the quality of soils?

28. Soil Taxonomy has led us into strange new ventures, helped us meet new friends, and lt us search for improved understanding together. It is a stimulus, not an answer. It is a thermometer, not a climate. It is the most comprehensive system devised - and yet it's flaws will eventually destroy it.

29. Teamwork. Shoveling together. Filling in something. Teams change the way we do things and help us find better ways.

30. And after the filling in, there is often a brief moment of silence, the bowing of heads. Collectively there is recognition of the passing of a friend whose time had come.

31. **Yes, a** team - maybe two teams - or more, have worked long and hard to bury the concept that the only way to present soil information is the paper bound standard soil survey report. There is light at the end of the tunnel. There is sunshine at the bend in the road ahead.

32. Soil survey is a global science. It is helping others who want help. It is teaching, reaching, and preaching. The opportunities that exist today have never presented themselves before in our lifetime. If this is possible, what next?

33. Well, **for** one thing, equality for those who see a place for themselves in the scheme of things. Equality in training, in job opportunities, and in being the best we can make each other be.

34. Another thing is equality of ecosystems as they are integrated into an interactive wholeness not before perceived as necessary, nor particularly desirable as implemented.

35. And still there is the challenge to obtain food from healthy, uncontaminated soils. Clean environments now - and far, far into the future. Where? For how long? Who will protect all of this?

36. Diversity ***means*** different things to different people. Uniformity is not diversity. Standards appear to be essential for meaningful feedback, yet conformity is not diversity. Concepts, ideas, theories, laws, incentives, regulations, lawmakers, governance for the good of the many and not the few - these are a few of diversity things. Diversity is what made us strong and it will keep us strong if we once again embrace the value of such a reality.

37. There will be some unexpected events in the years ahead. Things aren't always predictable or the same as before. Chaos is ordered, it is simple, and it has a charm of its own.

38. Weather vanes patterned after pigs or rabbits? Possibly, but not a good choice. This is the silhouette of reversible plows. Some things are a one way trip.

39. Protected in the cornfields of the Midwest from the harvest of eawloge in the West, I had no perception of what a sheared stump might look like. Awesome.

40. A century minus five. Not much time left is there? You can get us there by leading. you can't push wet noodles, but you can pull them. How does Nature lead a river? Change a baselevel and you change the playing field.

41. Be delighted when beauty graces beauty. Enjoy the unusual, the unexpected.

42. Be sensitive to the little things that disturb the environment around you. Great care will have rewarding results.

43. Shake up those things that cling too tightly to the past, to tradition for tradition's sake. There are new ways. There are times to try and times to fail. Progress is a process, not a place.

44. Turn a corner and there may be another illusion beckoning you to venture further. False starts are acceptable but not blindly following the wrong signs. Illusions are a challenge, an opportunity to re-evaluate where we are.

45. A century will come and go, yet our mission of helping others will still be there in shining golden letters.

46. Always read the landscapes before you. They are witnesses to the behavior of society. They have clues that can help unravel the pieces of the puzzle about how mankind has fared on his journey through space and time.

47. Yes, you can read stewardship. In the eye of the beholder is the reflection of a value system.

48. Social acceptance of conservation is dependent on cultural aspects, economic impacts, and available technology. Social acceptance of sustainability is what we call stewardship.

49. There it is. Right before your eyes. The beauty of the countryside is a measure of man's love for the land and his diligence in caring for its resources.

50. A few of the marvels of the world are not of man's doing. Icebergs beneath the mist shrouded hills of Glacier Bay National Monument are one of those marvels.

51. Another are the oblique dunes in the Oregon Dunes Natural Resource Area.

52. A century minus five. Ninety-five years of marvelous beauty and still looking great. Changes are a part of our history, vital to our traditions, and hold forth promise of success. Success, as we have learned, is a journey, it is not a destination.

THANK YOU.

NATIONAL HIERARCHICAL FRAMEWORK OF ECOLOGICAL UNITS

ECOMAP, USDA Forest Service, Weshlngton, D.C.

October 7, 1993

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PREFACE

The National Hierarchical Framework of Ecological Units was developed to provide a scientific basis for Ecosystem Management. Use of the Framework will improve consistency in developing and sharing resource data and inlormation at multiple geographic scales and across administrative and jurisdictional boundaries. Implementation of the Framework will help integrate the principles of Ecosystem Management info national, regional and forest planning and assessment efforts. The required use of consistent terminology, common maps and standard data will improve communications internally and wkh our publics and partners. This Hierarchical Framework has taken a year to develop and active participation in its development came from all regions, several research stations and with input from several federal and state agencies and universities. The Framework is hereby adopted for use. As we learn from its application, coordination with other agencies and from newly developed information, adjustments will be made as needed. The process of use and development of this Framework can best be viewed as a journey.

Chief

Date

Summary
NATIONAL HIERARCHICAL FRAMEWORK OF ECOLOGICAL UNITS

ECOMAP, USDA Forest Service, Washington, D.C.

The National Hierarchical Framework of Ecological Units is a regionalization, classification and mapping system for stratifying the Earth into progressively smaller areas of increasingly uniform ecological potentials for use in ecosystem manage. ment Ecological types are classified and ecological units are mapped based on associations of those biotic and environmental factors that directly affect or indirectly express energy, moisture, and nutrient gradients which regulate the structure and function of ecosystems. These factors include climate, phys-iography. water, soils, air. hydrology, and potential natural communities.

The hierarchy is developed geographically from both the top-down and bottom-up; conditions that change at broad scales such as climate and geology are continually related lo conditions that change at finer scales such as biotic distributions and soil characteristics. This approach enables scientists and managers to evaluate broader scale influences on finer scale conditions and processes, as well as to use finer scale inlormation to determine the significance of broader scale influences. In this iterative procedure, Ecoregion and Subregion levels of the hierarchy are developed by stratification as fine scale field classifications and inventories are being completed.

This regionalization, classification, and mapping process uses available resource maps Including climate, geology, soils, water, and vegetation. In some cases. however, additional Information is needed. Data bases and analysis techniques are being developed to provide interpretation of the ecological units.

Uses of the hierarchy vary according to manage-ment information needs and level of inlormation resolution. These applications are summarized below. The hierarchical framework is largely a Forest Service effort, although there has been involvement by the US. Soil Conservation Service. Bureau of Land Management, Fish and Wildlife Service, U.S. Geological Survey, The Nature Conservancy and other national and regional agen-cies. Our goals are to develop an ecological classifi-cation and inventory system for all National Forest System lands. and to provide a prototype system acceptable to all agencies. Nationally coordinated ecological unit maps will be developed for Ecore-gion and Subregion scales covering all U.S. lands.

National hierarchy of ecological units.

PLANNING AND ANALYSIS SCALE	ECOLOGICAL UNITS	PURPOSE, OBJECTIVES, AND GENERAL USE	GENERAL SIZE RANGE
Ecoregions Global Continental Regional	Domain Division Province	Broad applicability for modeling and sampling RPA assessment. International planning.	1,000,000's to 10,000's of square miles.
Subregions	Sections Subsections	RPA planning. Multi-forest, statewide and multi-agency anatysis and assessment.	1,000's to 10's of square miles.
Landscape	Landtype Association	Forest or area-wide planning, and watershed analysis.	1,000's to 100's of acres.
Land Unit	Landtype Landtype Phase	Project and management area planning and analysis.	100's to less than 10 acres.

NATIONAL HIERARCHICAL FRAMEWORK OF ECOLOGICAL UNITS

ECOMAP[1], USDA Forest Service, Washington, D.C.

INTRODUCTION

To implement ecosystem management, we need basic information about the nature and distribution of ecosystems, To develop this information, we need working definitions of ecosystems and supporting inventories of the components that comprise ecosystems. We also need to understand ecological patterns and processes, and the interrelationships of social, physical, and biological systems. To meet these needs, we must obtain better information about the distribution and inter. action of organisms and the environments in which they occur, including the demographics of species, the development and succession of communities, and the effects of human activities and land use on species and ecosystems (Urban et al. 1987). Research has a critical role in obtaining this information.

This paper presents a brief background of regional land classifications, describes the hierarchical framework for ecological unit design, examines underlying principles, and shows how the framework can be used in resource planning and management. The basic objective of the hierarchical framework is to provide a systematic method for classifying and mapping areas of the Earth based on associations of ecological factors al different geographic scales. The framework is needed to improve our efforts in national, regional. and forest level planning; to achieve consistency in ecosystem management across National Forests and regions: to advance our understanding of the nature and distribution of ecosystems; and to facilitate interagency data sharing and planning. Furthermore, the framework will help us evaluate the inherent capabilities of land and waler resources and the effects of management on them.

Ecological units delimit areas of different biological and physical potentials. Ecological unit maps can be coupled with inventories of existing vegetation, air quality. aquatic systems. wildlife, and human elements to characterize complexes of life end environment, or ecosystems. This information on ecosystems can be combined with our knowledge of various processes to facilitate a more ecological approach to resource planning. management, and research.

Note that ecological classification and mapping systems are devised by humans to meet human needs and values. Ecosystems and their various components often change gradually, forming continua on the Earth's surface which cross admin. istralive and political boundaries. Based on their understanding of ecological systems, humans decide on ecosystem boundaries by using physical, biological, and social considerations.

We recognize that the exact boundaries for each level envisioned in this process and developed in map format may not fit every analysis and management need. Developing boundaries of areas for analysis, however, will not change the boundaries of ecological units. In some cases, an ecological unit may be the analysis area. In other cases, watersheds, existing conditions, management emphasis, proximity to special features (e.g., research natural, wilderness, or urban areas) or other conditions may define an analysis area. In these cases, ecological units can be aggregated or divided if needed to focus on relevant issues and concerns.

BACKGROUND -- REGIONAL LAND CLASSIFICATIONS

Hierarchical systems using ecological principles for classifying land have been developed for geographical scales ranging from global to local. Using a bioclimatic approach at a global scale, several researchers have developed ecological land classifications: Holdridge (1967), Walter and Box (1976), Udvardy (1975), and Bailey (1989a,b). Wertz and Arnold (1972) developed land stratification concepts for regional and land unit scales. Other ecologically based classifications proposed at regional scales include those of Driscoll et al.

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[1]Peter E. Avers, David T. Cleland, W. Henry McNab, Mark E. Jensen, Robert G. Bailey, Thomas King, Charles B. Goudey, and Walter E. Russell. Others who contributed to this paper through helpful review comments and suggestions include many Forest Service employees, and members of other federal and state agencies, The Nature Conservancy and universities. A list of reviewers and commenters appears in Appendix 1 of this paper.

(1984), Gallant et al. (1989), and Omernik (1987) in the United States and those of Wiken (1986) and the Ecoregions Working Group (1989) in Canada. Concepts have also been presented for ecological classification at subregional to local scales in the United Stales (Barnes et al. 1982), Canada (Jones et al. 1983, Hills 1952), and Germany (Barnes 1984).

But no single system has the structure and flexibility necessary for developing ecological units at continental to local scales. Each of these systems have strong points that contribute to the strength of the national hierarchy. The concepts and terminology of the national system draws upon this former work to devise a consistent framework for application throughout the United States,

ECOLOGICAL UNIT DESIGN

The primary purpose for delineating ecological units is to display land and wafer areas at different levels of resolution thal have similar capabilities and potentials for management. Ecological Units are designed to exhibii similar patterns in: (1) potential natural communities, (2) soils, (3) hydrologic function, (4) landform and topography. (5) liihology. (6) climate. (7) air quality and (8) natural processes for cycling plant biomass and nutrients (e.g. succession, productivity, fire regimes).

It should be noted that climatic regime is an important boundary criteria for ecological units, particularly at broad scales. In fact climate, as modified by topography, is the dominant criteria at upper levels. Other factors, such as geomorphic process, soils and potential natural communities take on equal or greater importance than climate at lower levels. The discussion under the Classification Framework section and Table 2 provide more details on map unit criteria for each hierarchical level.

An ecological type is defined as 'A category of land having a unique combination ot potential natural community soil, landscape features, and climate; and differing from other ecological types in its ability to produce vegetation and respond to management' (FSM 2080.05). An ecological unit is defined as 'A mapped landscape unit designed to meet management objectives, comprised of one or more ecological types' (FSM 2060.05).

It follows, then, that ecological map units are differentiated and designed by multiple components including climate, physiography. landform. soils, water, and potential natural communities (FSM 2060, FSH 2090.11). These components may be analyzed Indiiidually and then combined or multiple factors/components may be simultaneously evaluated to classify ecological types which are then used in ecological unit design (FSH 2090.11). The first option may be increasingly used as geographic Information systems (GIS) become more available. The Interrelationships among independently defined components, however, will need to be carefully evaluated, and the results of layering component maps may need to be adjusted to identity units that are both ecologically significant and meaningful to management. When various disciplines cooperate in devising integrated ecological units, products from existing resource component maps can be modified and integrated interpretations can be developed (Avers and Schlatterer. 1991).

CLASSIFICATION FRAMEWORK

The National Ecological Unit Hierarchy is presented in Tables 1, 2. and 3. The hierarchy is based on concepts and terminology developed by numerous scientists and resource managers (Hills 1952, Crowley 1967, Wertz and Arnold 1972, Rowe 1980. Allen and Starr 1982, Barnes et al. 1982. Forman and Godron 1986, Bailey 1987. Meentemeyer and Box 1987, Gallant et al. 1989, Cleland et al. 1992). The following is an overview of the differentiating criteria used in the development of the ecological units. Table 2 summarizes the principal criteria used at each level in the hierarchy.

ECOREGION SCALE At the Ecoregion scale, ecological units are recognized by differences in global. continental. and regional climatic regimes and gross physiography. The basic assumption is that climate governs energy and moisture gradients. thereby acting as the primary control over more localized ecosystems. Three levels of Ecoregions, adapted from Bailey. are identified in the hierarchy (Bailey 1980):

1. **Domalns -** s&continental divisions of broad climatic similarity, such as lands that have the dry climates of Koppen (1931). which are affected by latitude and global atmospheric conditions. For example. climate Of the Polar Domain is controlled by arctic air masses, which create cold, dry environments where summers are short In contrast, the climate of the Humid Tropical Domain is influ-

enced by equatorial air masses and there is no winter season. Domains are also characlerired by broad differences in annual precipitation, evapotranspiration, potential natural communities, and biologically significant drainage systems. The four Domains are named according to the principal climatic descriptive features: Polar, Dry, Humid Temperate, and Humid Tropical.

2. **Divisions** - subdivisions of a Domain determined by isolating areas of definke vegetational affinities (prairie or forest) that fall within the same regional climate, generally at the level of the basic types of Koppen (1931) as modified by Trewartha (1968). Divisions are delineated according to: (a) the amount of water deficit (which subdivides the Dry Domain into semi-arid, steppe, or arid desert, and (b) the winter temperatures, which have an important influence on biological and physical processes and the duration of any snow cover. This temperature factor is the basis of distinction between temperate and tropical/subtropical dry regions. Divisions are named for the main climatic regions they delineate, such as Steppe, Savannah, Desert, Mediterranean, Marine, and Tundra.

3. **Provinces** - subdivisions of a Division that correspond to broad vegetation regions, which conform to climatic subzones controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soil orders. The climatic subzones are evident as extensive areas of similar potential natural communities as mapped by Kuchler (1954). Provinces are named typically using a binomial system consisting of a geographic location and vegetative type such as Bering Tundra, California Dry-Steppe and Eastern Broadleaf Forests.

   Highland areas that exhibit altitudinal vegetational zonation and that have the climatic regime (seasonality of energy and moisture) of adjacent lowlands are classified as Provinces (Bailey et al. 1995). The climatic regime of the surrounding lowlands can be used to infer the climate of the highlands, For example, in the Mediterranean Division along the Pacific Coast. the seasonal pattern of precipitation is the same for the lowlands and highlands except that the mountains receive about twice the quantity. These provinces are named for the lower elevation and upper elevation (subnival) belts, e.g., Rocky Mountain Forest-Alpine Meadows.

SUBREGION SCALE Subregions are characterized by combinations of climate, geomorphic process, topography, and stratigraphy that influence moisture availability and exposure to radiant solar energy, which in turn directly control hydrologic function, soil-forming processes, and potential plant community distributions. Sections and Subsections are the two ecological units mapped at this scale.

1 **Section** - broad areas of similar geomorphic process, stratigraphy. geologic origin, drainage networks, topography, and regional climate. Such areas are often inferred by relating geologic maps to potential natural vegetation 'series' groupings as mapped by Kuchler (1964). Boundaries of some Sections approximate geomorphic provinces (for example Blue Ridge) as recognized by geologists. Section names generally describe the predominant physiographic feature upon which the ecological unit delineation is based. such as Flint Hills, Great Lakes Morainal. Bluegrass Hills, Appalachian Piedmont.

2 Subsections - smaller areas of Sections with similar surficial geology. lithology. geomorphic process, soil groups, subregional climate, and potential natural communities. Names of Subsections are usually derived from geologic features, such as Plainfield Sand Dune, Tipton Till Plain, and Granite Hills.

LANDSCAPE SCALE At the Landscape scale, ecological units are defined by general lopography. geomorphic process, surficial geology, soil and potential natural community patterns and local climate (Forman and Godron 1986). These factors affect biotic distributions, hydrologic function, natural disturbance regimes and general land use. Local landform patterns become apparent at this level in the hierarchy, and differences among units are usually obvious to on-the-ground observers. At this level. terrestrial features and processes may also have a strong influence on ecological characteristics of aquatic habiiats (Plans 1979, Ebert et al. 1991). Landtype Association ecological units represent this scale in the hierarchy.

Landtype Associations - groupings of Landtypes or subdivisions of Subsections based upon similarities in geomorphic process, geologic rock types, soil complexes. stream types. takes, wetlands. and series, subseries, or plant association vegetation communities. Repeatable patterns of soil complexes and plant communities are useful in delineating map units at this level. Names of Landtype Associations are often derived from geomorphic history and vegetation community.

LAND UNIT SCALE At the basic Land Unit scale, ecological units are designed and mapped in the field based on properties of local topography, rock types, soils. and vegetation. These factors influence the structure and composition of plant communities, hydrologic function, and basic land capability. Landtypes and Landtype Phases are the ecological units mapped at this scale.

1. **Landtypes** - subdivisions of Landtype Associations or groupings of Landtype Phases based on similarities in soils, land. form, rock type, geomorphic process and plant associations. Land surface form that influences hydrologic function (e.g., drainage density, dissection relief) is often used to delineate diflerent landtypes in mountainous terrain. Valley bonom characteristics (e.g.. confinement) are commonly used in establishing riparian landtype map units. Names of Landtypes are to include an abiotic and biotic component (FSH 2090.11).

2. **Landtype** Phsse - more narrowly defined Landtypes based on topographic criteria (e.g.. slope-shape, steepness, aspect, position, hydrologic characteristics, associations and consociations of soil taxa, and plant associations and phases. These factors influence or reflect the microclimate and productivity of a site. Landtype phases are often established based on inter-relationships between soil characteristics and potential natural communities. In riparian mapping, landtype phases may be established to delineate different stream type environments (Herrington and Dunham 1967). Naming is similar to Landtypes (FSH 2090.11).

The Landtype Phase is the smallest ecolog ical unit recognized in the hierarchy. However, even smaller units may need to be delineated for very detailed project planning at large scales (Table 1). Map design criteria depend on project objectives.

PLOT DATA Point or plot sampling units are used to gather ecological data for inventory, monitoring, quality control and for developing classifications of vegetation, soils or ecological types This plot data feeds into data bases for analysis, description, and Interpretation of ecological units (Keane et al. 1990). The plots can serve as reference sites for ecological types. Plots, while not mappable, can be shown on maps as point data.

In summary, the national framework has an extensive scientific basis, and provides a hierarchical system for mapping ecological units ranging in size from global to local. At each level abiotic and biotic components are integrated for delineation of geographical areas with similar ecological potential. These ecological units, combined with information on existing conditions and ecological processes, provide a basis for managing ecosystems.

UNDERLYING PRINCIPLES

ECOSYSTEM CONCEPT Ecosystems are places where life and environment interact; they are three dimensional segments of the Earth (Rowe 1960). Tansley introduced the term 'ecosystem' in 1935. and the explicit idea of ecological systems composed of multiple abiotic and biotic factors was formally expressed in our language (Major 1969). The ecosystem concept brings the biological and physical worlds together into a holistic framework within which ecological systems can be described, evaluated, and managed (Rowe 1992).

Ecosystems exist at many spatial scales, from the global ecosphere down to regions of microbial activity. The level of discernible detail, the number of factors comprising ecosystems, and the number of variables used to characterize these factors progressively increase at finer scales, Hence the data and analysis requirements, and investments for ecosystem classification and mapping also increase for finer scaled activities.

The structure and function of ecosystems are largely regulated along energy, moisture, nutrient, and disturbance gradients. These gradients are affected by climate, physiography, soils hydrology, flora, and fauna (Barnes at al. 1962. Jordan 1962. Spies and Barnes 1965). And while the association of these factors is all important in defining ecosysterns. all factors are not equalty important at all spatial scales. At coarse scales, the important factors are largely abiotic, while at finer scales both biotic and abiotic factors are important.

The conditions and processes occurring across larger ecosystems affect and often override those of smaller ecosystems, and the properties of smaller ecosystems emerge in the context of larger systems (Rowe 1984). Thus. ecosystems are conceptualiied as occurring in a nested geographic arrangement, with many smaller ecosystems embedded in larger ones (Allen and Starr 1982, O'Neill et al. 1986, Albert et al. 1986). This nested arrangement forms a hierarchy that is organized in decreasing orders of scale by the dominant factors affecting ecological systems.

At global, continental, and regional scales, ecosystem patterns correspond with climatic regions, which change mainly due to latitudinal, orographic, and maritime influences (Bailey 1987, Denton and Barnes 1988). Within climatic regions, physiography or landforms modify macroclimate (Rowe 1984, Smalley 1986, Bailey 1987). and affect the movement of organisms. the flow and orientation of watersheds, and the frequency and spatial pattern of disturbance by fire and wind (Swanson et al. 1988). Within climatic-physiographic regions, waler, plants, animals, soils, and topography interact to form ecosystems at Land Unit scales (Pregitzer and Barnes 1984). The challenge of ecosystem classification and mapping is to distinguish natural associations of ecological factors at different spatial scales, and to define ecological types an5 map ecological units that reflect these different levels of organization.

LIFE AND ENVIRONMENTAL INTERACTIONS Lie forms and environment have interacted and co-developed at all spatial and temporal scales, one modifying the other through feedback. Appreciating these interactions is integral to understanding ecosystems.

At a global scale, scientists have theorized that the evolution of cyanobacteria. followed by terrestrial plants capable of photosynthesis, carbon fixation and oxygen production converted the Earth's atmosphere from a hydrogen to an oxygen base and still sustain it today. At a continental scale, the migration of species in response to climate change, and the interaction of their environmental tolerances and dispersal mechanisms with landform-controlled migration routes formed today's patterns in species' distributions. At a landscape scale, life forms, environment and disturbance regimes have interacted to form patterns and processes. For example. pyrophilic communities tend to occupy droughty soils in fire-prone landscape positions, produce volatile foliar substances, and accumulate litter, thereby increasing their susceptibitii to burning. At yet finer scales, vegetation has induced soil development over time through carbon and nutrient cycling, enabling succession to proceed to communities with higher fertility requirements,

In each of these examples, life forms and environ. ment have modified one another through feedback to form ecological patterns and processes. These types of relationships underscore the need to consider both biotic and environmental factors while classifying, mapping and managing ecolog ical systems.

SPATIAL AND TEMPORAL VARIABILITY The structure and function of ecosystems change through space and time. Consequently, we need to address both spatial and temporal sources of variability while evaluating, classifying, mapping, or managing ecosystems (Delcoun et al. 1983, Forman and Godron 1966). At a Land Unit scale, for example. the fertility of particular locations Changes through space because of differences in soil properties or hydrology, AND at Ecoregion scales, conditions vary from colder to warmer because of changes in macroclimate. These relatively stable conditions favor certain assemblages of plants and animals while excluding others because of biotic tolerances, and processes such as competition. These environmental conditions are classified as ecological types and mapped as ecological units.

Within ecological units, ecosystems may suppon vegetation that is young, mature, or old, and they may be composed of communities that are early, mid-, or late successional. These relatively dynamic conditions ALSO benefii certain plant and animal species and assemblages. Conditions that vary temporally are classified and mapped as existing vegetation, wildlife, water quality, and so forth.

These examples illustrate that ecological units do not contain all the information needed to classify, map and manage ecosystems. Ecological units address the spatial distributions of relatively stable associations of ecological factors that affect ecosystems. When combined with information on existing conditions, the National Hierarchy of Ecological Units provides a means of addressing spatial and temporal variations that affect the structural and functional attributes of ecosystems. Adding our knowledge of processes to this information will enable us to better evolve into ecosystem management

USE OF *ECOLOGICAL UNITS*

Ecological units provide basic information for natural resource planning and management. Ecological unit maps may be used for activities such as delineating ecosystems, assessing resources, conducting environmental analyses, establishing desired future conditions, and managing and monitoring natural resources.

ECOSYSTEM MAPPING To map ecosystems, or places where life and environment interact, we need to combine two types of maps: maps of existing conditions that change readily through time, and maps of potential conditions that are relatively stable. Existing conditions change due to particular processes that operate within the bounds of biotic and environmental, or ecological, potentials. Existing conditions are inventoried as current vegetation. wildlife. water quality. and so forth. Potential conditions are inventoried as ecological units. When these maps are combined, biotic distributions and ecological processes can be evaluated and results can be extrapolated to similar ecosystems The integration of multiple biotic and abiotic factors, then, provides the basis for defining and mapping ecosystems.

Fundamental base maps are key to mapping ecosystems and integrating resource inventories. These maps include the primary base map series showing topography, streams. lakes, ownership, political boundaries, cultural features, and other layers in the Cartographic Features File. On this base, the next set of layers could include ecological units, watersheds and inventories of aquatic systems at appropriate spatial scales. Next would be layers of information on existing vegetation, wildlife populations, fish distribution. demographics, cultural resources, economic data, and other information needed to delineate ecosystems to meet planning and anatysis needs.

GIS will provide a to0 for combining these separate themes of information, and representing the physical, biological, and social dimensions to define and map ecosystems. But scientists and managers using this technology must actually integrate information themes, comprehend processes, and formulate management strategies; These tasks will not be accomplished mechanically.

RESOURCE ASSESSMENTS **The** hierarchical framework of ecological units can provide a basis for assessing resource conditions at mukiple scales. Broadiy defined ecological units (eg. Ecoregions) can be used for general planning assess. ments of resource capability. Intermediate scale units (e.g., Landtype Associations) can be used to identify areas with similar natural disturbance regimes (e.g., mass wasting, flooding, fire potential). Narrowfy defined Land Units can be used to assess site specific conditions including distributions of terrestrial and aquatic biota; forest growth, succession, and health; and various physical conditions (e.g., soil compaction and erosion potential, water quality).

High resolution information obtained for fine scale ecological units can be aggregated for some types of broader scale resource assessments. Resource production capability, for example, can be estimated based on potentials measured for landtype phases, and estimates can be aggregated to assess ranger district. national forest, regional, and national capabilities.

ENVIRONMENTAL ANALYSES Ecological units provide a means of analyzing the feasibility and effects of management alternatives. To discern the effects of management on ecosystems, we often need to examine conditions and processes occurring above and below the level under consideration (Rowe 1980). For example, the effects of timber harvesting are manifest not only at a land unit scale, but also at micro-site and landscape scales. Although the direct effects of management are assessed at the local ecosystem scale, indirect and cumulative effects take place at different points in space or time, often at higher spatial scales. Ecological units defined at diierent hierarchical levels will be useful in conducting multi-scaled analyses for managing ecosystems and documenting environ. mental effects (Jensen et al. 1991).

WATERSHED ANALYSIS The national hierarchy provides a basis for evaluating the linkages between terrestrial and aquatic systems. Because of the interdependence of geographical components, aquatic systems are linked or integrated with surrounding terrestrial systems through the processes of runoff, sedimentation, and migration of biotic and chemical elements. Furthermore, the context of water bodies affects their ecological significance. A lake embedded within a landscape containing few takes, for example, functions differently than one embedded within a landscape composed of many lakes for wildlife, recreation and other ecosystem values. Aquatic systems delineated in this indirect way have many characteristics in common, including hydrology and biota (Friiell et al. 1986). Overlays of hierarchical watershed boundaries on ecological mapping units are useful for mast watershed anatysis efforts. In this case, the watershed becomes the anatysis area which is both superposed by and composed of a number of ecological units which affect hydrologic processes such as water runoff and percolation, water chemistry, and ecological function due to context.

DESIRED FUTURE CONDITIONS Desired future conditions (DFC's) portray the land or resource conditions expected if goals and objectives are met. Ecological units will be useful in establishing goals and methods to meet DFC's. When combined with information on existing conditions, ecological units will help us project responses to various treatments.

Ecological units can be related to past present, and future conditions. Past conditions serve as a model of functioning ecosystems, and provide insight into natural processes. It is unreasonable, for example, to attempt to restore systems like oak savannas or old growth forests in areas where they did not occur naturally. Moreover, natural processes like disturbance or hydrologic regimes are often beyond human control. Ecological units will be helpful in understanding these processes and in devising DFC's that can be attained and perpetuated.

Desired future conditions can be portrayed at several spatial scales. We can minimize conflicting resource uses (e.g., remote recreational experiences versus developed motorized recreation, habitat management for area sensitive species versus edge species) if we consider the effects of projects at several scales of analysis Ecological units will be useful in delinealing land units at relevant anatysis scales for planning DFC's (Brenner and Jordan 1991).

RESOURCE MANAGEMENT Information on ecological units will help establish management objectives and will support management activities such as the protection of habitats of sensitive, threatened, and endangered species, or the improvement of forest and rangeland heaith to meet conservation, restoration. and human needs. Information on current productivity can be compared to potentials determined for Landtype Phases. and areas producing less than their potential can be identified (Host et al. 1988). Furthermore, long term sustained yield capability can be estimated based on productivity potentials measured for fine scale ecological units.

MONITORING Monitoring the effects of management requires baseline inlormation on the condition of ecosystems et different spatial scales. Through the ecological unit hierarchy, managers can obtain information about the geographic patterns in ecosystems. They are, thus, in a position to design stratified sampling networks for inventory and monloring. Representative ecological units can be sampled and information can then be extended toanalogous unsampled ecological units, thereby reducing cost and time in inventory and monitoring.

By establishing baselines for ecological units and monitoring changes, we can protect landscape., community., and species-level biological diversity; and other resource values such as forest productivity, and air and water quality. The results of effectiveness and validation monitoring can be extrapolated to estimate effects and set standards in similar ecological units.

Evaluation of air quality is an example of how the National Hierarchical Framework of Ecological Units can be used for baseline data collection and monitoring. The Forest Service is developing a National Visibility Monitoring Strategy that addresses protection of air quality standards as mandated by the Clean Air Act, along with other concerns (USDA Forest Service 1993). Key to this plan is stratification of the United Stales at the subregion level of the national hierarchy info areas that have similar climatic, physiographic, cultural, and vegetational characteristics. Other questions dealing with effects of specific air-borne pollutants on forest health, such as correlation of ozone with decline of ponderosa pine and other trees in mixed conifer forest ecosystems in the San Bernardino Mountains of southern California, will require establishment of sampling networks in smaller ecological units at landscape or lower levels.

CONTEMPORARY AND EMERGING ISSUES
The National Hierarchical Framework of Ecological Units is based on natural associations of ecological factors. These associations will be useful in responding to contemporary and emerging issues. particularly those that cross administrative and jurisdictional boundaries. Concerns regarding biological diversity, for example, can be addressed using

the ecological unit hierarchy (Probst and Crow 1991). Conservation strategies can be developed using landscape level units as coarse lifters, followed by detailed evaluations and monitoring conducted to verify or adjust landscape designs. We can rehabilitate ecosystems and dependent species that have been adversely affected through fire exclusion, fragmentation or other results of human activities if we grow to understand the natural processes that species and ecosystems co-developed with, and then mimic those processes through ecosystem management.

Species may become rare, threatened or endangered because their habitat is being lost or degraded, because they are endemic to a particular area, or because they are at the edge of their natural range. In the first two instances, protection or recovery efforts are warranted. In the latter case, however, it may be futile to try to maintain biota in environments where they are pre-disposed to decline. At a minimum, populations at the edge of their range can be evaluated for genetic diversity, and recovery programs can be administered accordingly. Species and community distributions can often be related to ecological units, which can be useful in their inventory and protection.

The new emphasis on sustaining and restoring the integrity of ecosystems may aid in arresting the decline of biological diversity, and preempt the need for many future protection and recovery efforts. Developing basic information on the nature and distribution of ecosystems and their elements will enable us to better respond to issues like global warming. forest heahh, and biological diversity

CONCLUSION

The hierarchical framework of ecological units was developed to Improve our ability to implement ecosystem management Thislramework. in combination with other information sources, is playing an important role in national, regional, and forest planning efforts; the sharing of information between forests, stations, and regions: and inter-regional assessments of ecosystem conditions.

Regions and stations, with national guidance, are coordinating their design of ecological units at higher levels of the national hierarchy. Development of landscape and land unit maps is being coordinated by appropriate regional. station, forest and ranger district level staff. As appropriate, new technologies (e.g., remote sensing, GIS, expert systems) should be used in both the design, testing and refinement of ecological unit maps.

The classification of ecological types and mapping of ecological units pose a challenge to integrate not only information, but also the concepts and tools traditionally used by various disciplines. The effort brings together the biological and physical sciences that have too often operated independently. Specialists like foresters, fishery and wildlife biologists, geologists, hydrologists, community ecologists and soil scientists will need to work together to develop and implement this new classification and mapping system. The results of these concerted efforts will then need to be applied in collaboration with planners, social scientists, economists, archaeologists and the many other special. ties needed to achieve a truly ecological approach to the management of our nation's National Forests and Grasslands.

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Table 1. National hierarchy of ecological units.

PLANNING AND ANALYSIS SCALE	ECOLOGICAL UNITS	PURPOSE. OBJECTIVES, AND GENERAL USE
Ecoregions Global Continental Regional	Domain Division Province	Broad applicability for modeling and sampling. RPA assessment
Subregions	Sections Subsections	RPA planning. Multi-forest, statewide and multi-agency analysis and assessment.
Landscape	Landtype Association	Forest or area-wide planning, and watershed analysis.
Land Unit	Landtype Landtype Phase	Project and management area planning and analysis.
Hierarchy can *be* expanded by user lo smaller *geographical areas end more detailed ecological units if needed,*		Very *detailed project planning*

Table 2. **Principal** map **unit** design **criteria** of **ecological units.**

ECOLOGICAL UNIT	PRINCIPAL MAP UNIT DESIGN CRITERIA'
Domain	• Broad climatic zones or groups (e.g., dry, humid, tropical).
Division	• Regional climatic types (Koppen 1931, Trewanha 1968). • Vegetational affinities (e.g., prairie or forest). • Soil order.
Province	• Dominant potential natural vegetation (Kuchler 1964). • Highlands or mountains with complex vertical climate-vegetation-soil tonation.
Section	• Geomorphic province. geologic age, stratigaphy. lithology. • Regional climatic data. • Phases of soil orders, suborders or great groups. • Potential natural vegetation. • Potential natural communities (PNC) (FSH 2090).
Subsection	• Geomorphic process, surficial geology, lithology. • Phases of soil orders, suborders or great groups. • Subregional climatic data. • PNC-.formation or series.
Landtype Association	• Geomorphic process, geologic formation, surficial geology. and elevation. • Phases of soil subgroups. families, or series. • Local climate. • PNC--series, subseries, plant associations.
Landtype	• Landform and topography (elevation. aspect slope gradient and position). • Phases of soil subgroups. families, or series. • Rock type, geomorphic process. • PNC--plant associations.
Landtype Phase	• Phases of soil families or series. • Landform and slope position. • PNC--plant associations or phases.

' It should be noted that the criteria listed are broad categories of environmental and landscape components. The actual classes of components chosen for designing map units depend on the objectives for the map.

Table 3. **Map scale and polygon size of ecological units.**

ECOLOGICAL UNIT	MAP SCALE RANGE	GENERAL POLYGON SIZE
Domain	1:30,000,000 or smaller	1000,000's of square mllrs
Division	1:30,000,000 to 1:7,500,000	100,000's of square mllrs
Province	1:15,000,000 to 1:5,000,000	10,000's of ● qusro mllrs
Section	1:7,500,000 to 1:3,500,000	1,000's of ● qusro miles
Subsection	1:3,500,000 to 1:250,000	1 D's to low 1 ,000's of ● qusro miles
Landtype Association	1:250,000 to 1:60,000	high 100's to 1,000's of acres
Landtype	1:60,000 10 1:24,000	10's to 100's of acres
Landtype Phase	1:24,000 or larger	<100 acres

APPENDIX 1:

The National Hierarchical Framework of Ecological Units has evolved based on the ideas and contributions of many persons. The Forest Service appreciates the time and effort put forth by these contributors to strengthen the scientific credibility of this Framework. We have compiled a list that we believe includes most of the contributors, although we have likely overlooked others who deserve to be recognized. A sincere 'Thank you' is extended to everyone who contributed toward this paper.

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A POLITICAL PERSPECTIVE ON ECOSYSTEM MANAGEMENT AND ITS CONSEQUENCES FOR IDAHO

Sen. Mary Lou Reed 6/17/94

Headline, November 1993: "ECOSYSTEM MANAGEMENT. An Idea Whose Time Has Come...but are we ready?"'

Good question. By now, June 1993, most of you scientists are probably convinced that Ecosystem Management is the key to tomorrow. Each of you probably enthusiastically agree that "the system is the solution".

You've probably known all along that the whole is greater than the sum of its parts. Integration. Cooperation. Participation. Comprehensiveness. Connections. Change. Sustainability. All are words you are comfortable with as operating words for implementing a holistic approach to resources management. You're probably happy and relieved that the top guns in charge of the show are finally getting with the program. The generals at the top are finally looking at the big picture and are now calling for a comprehensive systems approach.

So you are, in fact, READY. You are READY AND EAGER.

But what about the rest of the world? What about THE PUBLIC? Are the) ready? What about the politicians? Are we ready?

In a word, NO. The general public is in the dark. Politicians see through the proverbial glass dimly. The public needs to be informed, politicians need to be reassured and special interests need to be interrupted and diverted. I want to talk with you today about ways to turn the lights on and up.

I have been asked to bring a political perspective to ecosystem management. The questions would seem to be: Will the public and its leaders embrace a new approach to shepherding the resources of the earth we live on, which will preserve and protect that earth, even if it requires human restraint and self-discipline? Does good science make good politics? Can the human species with all its clutter and greed exist in its natural ecosystem without mucking it up?

When you think of politics you may think of power and manipulation in the backrooms and boardrooms. I would suggest in a democracy, political power does in the final say reside with the people. Persuasion must first be aimed at the people. Their leaders are never very far behind.

Let me list some of the human factors and political realities that I see as barriers to easy implementation of Ecosystem Management:

1. COMMUNICATION. We have to start with definitions that reflect the good **sense** of the concept. At this point the public isn't sure whether ecosystem management is a sound bite or sound science. We have to surmount the ever-present language barriers. I want to give you one good example that I ran across of how NOT to define Ecosystem Management, if you want to reach out to those of us who are uninitiated and

unready.

One otherwise helpful article states: "EM is an era of management for outcomes instead of outputs, multi-valued systems instead of multiple products, and sustainable production of all the ecosystem pieces - as 'multiple-use' implies."

Well, that paragraph may have much meaning to you all, but it is genuine Greek to the rest of us.

We are all going to have to work very hard to make sure we are speaking a common language if we are to develop shared goals. Most people have a real and intuitive feel for natural processes. The use of simple, even mythic, language can help in communicating. Earth and Sky, running like a river, forest health.. are examples of basic phrases that reflect the connectedness of all things and all creatures. We have to seek and establish common language, and we have to work at it.

2. EDUCATION OF THE GRASSROOTS. Public involvement and grassroots participation have been key elements in the successful implementation of any ecosystem management pilot programs. Public/ private partnerships have to be established on a common ground of mutual respect. A public hearing, if it really is a public listening, always serves to remind me of the basic common sense and wisdom of a caring public. For example: people hate clearcuts. Public outcry against clearcuts has gone on for years. People have an instinctive dislike for practices that appear to be unnatural. And common sense conclusions have become common knowledge. Such as: clearcuts may damage your watershed, or may cause soil erosion into the lake or stream, or would probably alter the wildlife activity and reduce the number of birds.

We must never sell the public short. Their wisdom is there to be tapped.

3. SPECIAL INTERESTS. Concurrently, we must never underestimate the power of special interests to persuade and influence that same public. Money does talk. Money pays for talk. Talk pays off.

One of Idaho's U.S. Senators ballyhoos the Clinton Administration's so-called War on the West. The senator's goal is to maintain the status quo provided by an older-than-Custer Mining Act, a grazing policy that destroys streams and adds to the destruction of species, and a timber program that overcuts forests and alters ecosystems. The senator hopes to reap political hay in the process.

The so-called Wise Use Movement, which promotes a reincarnated Sagebrush Rebellion, is a serious roadblock toward implementing Ecosystem Management on federal lands, since Wise Use proponents believe that federal lands exist for their private purposes.

Demagoguery abounds when industry-backed spokesmen appeal to the very real economic fears that ordinary people who live in resource dependent towns hold in their hearts toward change and an uncertain future.

4. RESPECT FOR DIVERSITY. One of the basic goals of Ecosystem Management is to preserve bio-diversity. I have my doubts that folks who live in small communities, smack in the middle of vigorous, dynamic ecosystems, consider diversity of any sort to be of unique value - be it bio-diversity, political diversity, economic or social diversity.

In our attempts to speak in a common language, reach out to the public, we must also teach and persuade. We must convince local people of the value of preserving and promoting diversity. At the same time we can reassure communities that their ecosystem is not just for us to study, or to look at and recreate in. The commodities they produce are needed and their work is of value.

5. STUDY VS. ACTION. I mention that ecosystems are not just their for us to study as a reminder of the public's impatience with studies. You hear it all the time. Don't study the problem. DO SOMETHING. We are not a people with much patience for planning. And we all know that planning is another word for thinking.

Because a major component of Ecosystem Management is further analysis and intensive research, part of the communication with the general public must include good strong explanations of the importance of additional knowledge to the design of a management strategy. Respect for the SHOW ME needs of the public requires short term action at the start, to run concurrently with a long range planning process.

So, a summary of some political hurdles we must surmount in order to implement ecosystem management includes:

1. definitions, language and communication,

2. the public's lack of knowledge and understanding,

3. special interests, the Wise Use Movement, political games,

4. the importance of the production of commodities to the lives of individuals and their communities . . . to their identities and their livelihoods,

Add to the mix an American discomfort with abstractions. After all, Ecosystem Management *is* a philosophy - a bundle of ideas.

Mix in the scary specter of change - any change.

Plus the human propensity to gravitate toward the simple and away from the complex.

Ecosystems are by definition "intricate, complex, change constantly, and are not always predictable."

Will the public ever be ready for Ecosystem Management? Is it contrary to the human imperative?

Despite the hurdles, the answer is a solid yes. I just believe it is important to keep identifiable components of the human condition in mind in setting forth on a course that involves an ecosystem, including the people who inhabit it.

Let me give you some examples of forays into ecosystem management that have very positive political ramifications. You can see that the principles of good ecosystem management do transfer into good politics.

1. Here in North Idaho we have been engaged for several years in our own fumbling attempt to apply many of the same principles of Ecosystem Management to the restoration of the Coeur d'Alene Basin. The situation has been ripe for a cooperative effort. At the headwaters of the Coeur d'Alene River lies one of the world's most productive silver, lead and zinc mining areas. One of the nation's most contaminated Superfund sites is encompassed in the 21 square mile former Bunker Hill complex at Kellogg. Mining activity over the past 100 years has sent over 72 million tons of metals down the river to Coeur d'Alene Lake. The lakebed is encrusted with a layer of heavy metals.

In 1989 the Coeur d'Alene Basin Interagency Group (CBIG) was organized - a loose collection of federal, state and county agency staff members, industry representatives, members of local lake and river protection groups, all with a common concern.. the health of Coeur d'Alene watershed. The spirit of cooperation and coordination **has held** sway over the years. A more formal structure has been imposed along with funding, by the state and EPA, and a full blow-n restoration project is in progress with a lake management plan expected to be produced within the year.

Research dollars and projects have been coordinated, the public has been included from the beginning, and the effort has broad political support.

2. A unique experiment was conducted in the 1994 session of the Idaho legislature. Conservationists and industry spokesmen came together with legislators of all stripes to consider drafting a state Endangered Species Act. All parties sparred cautiously as the concepts were discussed. The air was filled with mistrust. But painstakingly a program that was drafted to address ways to eliminate reasons for new listings of endangered species and to foster de-listing of species. Knowledge that the federal Endangered Species Act was not going to go away, and a desire for the state to play a larger role provided the necessary incentives. The result amounted to a habitat enhancement act. The timber, mining and cattle folk stayed on board as did the wary conservationists. Only the ever-difficult Farm Bureau jumped ship.

As the bill went to the Senate floor it scored a first -- the first time the Association of Commerce and Industry and the Idaho Conservation League had circulated their green sheets of endorsement for the same piece of legislation. The bill passed the Senate 24 to 11 in the late days of the session. In another year it should make it into law.

All the elements of ecosystem management were there, even if the political support came for the wrong reasons. No question but that the federal Endangered Species Act served as a hammer, just as the threat of Supetfund status acts as a prod for action in the Coeur d'Alene Basin.

3. A parallel exists in Idaho in the salmon issue. Opposing political entities throughout Idaho stand together in support of Andrus's Idaho plan, which favors a restructuring of the federal dams on the lower Snake River to permit the salmon smolts a swifter passage to the sea. Unanimity of purpose is inspired by the larger threat posed to Idaho's water all the way to the Upper Snake, if Idaho's water is seen as the way to save the endangered salmon. The economic threat to Idaho's agricultural base is taken very seriously by water users and politicians alike. Making the river run like a river, returning it to its natural process, is seen by most participating parties as good business as well as good ecosystem management. Certainly better than draining the state's rivers and reservoirs.

The salmon issue is fraught with controversy and political disagreement. But in Idaho, except for Lewiston, a fragile agreement holds the groups together, united in a common goal of saving water, saving salmon.

From my vantage point, the major obstacles to saving the salmon continue to be immovable institutions such as the Army Corps of Engineers and the Bonneville Power Administration, who have no interest in restoring the river's natural processes.

In conclusion, I see glimmers of hope for the political progress of ecosystem management in Idaho. If the process of setting common goals -- goals that reenforce economic well-being coinciding with sound stewardship -- are clearly defined, and are inclusive of a well-informed public, I believe ecosystem management can be accepted in Idaho, just as anywhere else. Further analysis of my examples would underscore the need for strong laws and strong leadership.

* This 1st page quote and others are from People and Forests, U.S.F.S. Cleatwater Forest publication, Nov. 1993.

WESTERN/MIDWESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

Committee 1 Report
Role of NCSS in Site Specific Soil Survey

Charges

1. Develop NCSS guidelines and certification standards.
2. storage, retrieval and maintenance of attribute and spatial data.
3. Interpretation and use of site specific data, resolution of conflicting data.
4. Interaction between providers of site specific data.

In our changing world, there is an increased need for site specific soil surveys and investigation. Not all site specific soil investigations will be an order 1 soil survey. The specific land use will determine some data obtained. The following guidelines are recommended for multi-use order 1 soil survey.

1. The legend is to be separate from order 2 soil survey. Scale differences between order 1 and order 2 soil surveys do not permit use of same legend.

2. Phases of soil series are mapped

3. Generally no dissimilar inclusions in soil mapping units.

4. Scale is at least 1:6,000

5. Observations will be made on transects or grids, will be georeferenced and will be made to a depth of 2 meters generally.

6. Detail descriptions are required of each soil series or potential soil series. A detailed description will be made in each soil mapping unit Other observations may be described in how they differ from the representative pedon.

7. A map unit description that includes the range(s) of taxonomically related data must be prepared.

HETA data will be submitted with each order 1 soil survey. These data will serve for certification. The Soil Conservation Service will keep the HETA file.

The Soil Conservation Service will have responsibility for storing and maintaining order 1 soil surveys.

The SCS will correlate order 1 soil surveys but a correlation is not required.

If laboratory data are to be collected, the laboratory procedures in the "Soil Survey Laboratory Methods Manual" by Soil Survey Laboratory staff are to be used. Analyses that assist in correlation and classification should be included.

Interpretations will not be stored, only data. Interpretations can be generated by computers.

Conflicts will be minimized if good guidelines are followed.

The NCSS should develop a meaningful memorandum of understanding with private soil scientists through the National Society of Consulting Soil Scientists at the national level.

These recommendations should be distributed to the other regions and to appropriate agencies as soon as possible.

The committee should be continued to follow up on these recommendations.

Committee

Delbert Mokma, Michigan, Chairperson
Bruce Frazier, Washington, Vice-Chairperson
Ferris Allgood, Utah
Alan Amen, Colorado
George Hall, Ohio
Randall Miles, Missouri
Gerald Miller, Iowa
Henry Mount, Nebraska
Curtis Munger, New Mexico
Gerald Nielson, Montana
Ken Olson, Illinois
Pierre Robert, Minnesota
Richard Schlepp, Kansas
Gary Stienhardt. Indiana
Tim Sullivan. Colorado
Carol Wettstein, Colorado

COMMITTEE 2 - DRASTICALLY ALTERED SOIL

Committee Chair: Sam J. Indorante, USDA-SCS, Belleville, IL

Objective of Committee

To review concept, applications, and research on what is known about disturbed soils and to formulate a working definition of drastically disturbed (altered) soils.

Charae #1

Develop definition of drastically altered soil.

Recommendation

A soil which, by human activity, has been physically altered, and/or formed to a lithic contact or to a depth $\geq$ 2 meters, whichever is less.

Charae #2

Develop procedures for inventorying drastically altered soils.

Recommendation

Use existing data to obtain information on the nature of the drastic alteration and their acreages (by state).

A form would be sent to all State Soil Scientists. Information can be gathered from various state and federal agencies (i.e., state universities, state departments of mining and minerals, etc. Information would be compiled by state and then made available to NCSS cooperators.

Example of form to be sent out.

Date _________

State _________

Type of Alteration	Approximate Acreage

Charae #3

Provide guidelines for updating soil surveys with drastically altered soils.

Recommendations

1. Use current/correct imagery.

2. Map at update soil survey scale: 1:24,000 1:12,000

3. Collect history and background of alteration. (i.e., mining and reclamation methods).

4. Establish time benchmarks in selected drastically altered soils (i.e., time zero) to monitor pedogenesis.

5. Reinvestigate, reclassify and reinterpret drastically altered soils to meet current NCSS standards.

6. Record deficiencies in Soil Taxonomy and suggest improvements.

Charses for Continuins Committee

1. Develop and recommend a sampling protocol that addresses the unique horizontal and spatial variability of drastically altered soils (i.e., coarse fragments).

2. Recommend appropriate physical, chemical, and biological characterization methods for these soils - in addition to the traditional soil characterization methods (i.e., acid/base accounting).

3. Recommend or propose suffixes to designate specific kinds of master horizons and layers in drastically disturbed soils (i.e., "tt" suffix to indicate fritted soil structure in a horizon).

Committee Recommendations

1. This committee should continue as a function of the NCSS until the duties of the international committee on disturbed soils is defined.

2. The committee should function in both the Midwest and West regions.

3. Committee report should be sent to international committee (Dr. Ray Bryant, Cornell University, Chair). International committee report should be sent to Midwest and West committees.

COMMITTEE THREE: ECOSYSTEM BASED SOIL SURVEYS FOR RESOURCE PLANNING

Charges :

1. Refine objectives and goal statements for ecosystem based soil surveys.
2. Develop model for conducting ecosystem based soil surveys.
3. Develop funding strategies.

Following are discussion points and recommendations for each of the charges. Note that most of the recommendations are really short term action items that can and should be implemented immediately. The more general recommendations requiring longer term, interagency effort, are at the end of the report and identified with a" asterisk.

CHARGE 1. REFINE OBJECTIVES AND GOAL STATEHENTS FOR ECOSYSTEM BASED SOIL SURVEYS.

Discussion points:

Following are some of the key discussion points. They reflect the complexity of the charge and wide range of views about ecosystems, soil surveys, and their interrelationships. Some examples are: "we need to clearly define an ecosystem based soil survey;" it is "a soil survey that records the basic soil properties, one that is consistent, and one that represents the landform or landscapes; rather than one that has map units designed strictly to meet the needs of one federal or state program;" "many soil surveys have used a" ecosystem approach, although the ecosystem label may have been absent;" "map units should be named based on their landform and/or vegetation characteristics: " "ecosystems atr complex;" "must have interdisciplinary teams;" "they are tailored to user needs;" and "there is need for deeper sampling or exploration." The comments suggest there is a vagueness about the meaning of "Ecosystem Based Survey." Perhaps this reflects the complexity of ecosystems and the information requirements for their management.

Goals/ or objectives:

- Produce and deliver timely, high quality, cost effective surveys. with a record of important properties, based on sound scientific principles.
- Evaluate and update surveys in light of "customer" needs.
- Maximize use of interdisciplinary teams. This applies to updating or re-interpretation of existing surveys, or conducting new surveys.
- Provide for flexibility to meet customer needs or respond to key issues or land uses within a "landscape" area.
- Provide information transfer to help society understand, value and wisely ❑ a"age soil, land and water resources.

Specific objectives/actions:

- Conduct and maintain surveys by physiographic region, ecoregion, river basin. or other large scale geographic area. For example, MLRA, Section or Subsection of the Forest Service Hierarchy of Ecological Units, USGS defined river basin or sub basin.

- Provide users with statements of important patterns and shapes of natural bodies on specific landscape segments. Give more emphasis to soil-geomorphic relationships.

- Provide users with reasonable estimates of accuracy and variability of the survey. Use appropriate statistical techniques to characterize data sets.

- Identify data gaps and develop a strategy to fill the gaps

- Continually evaluate and update interpretations in light of new knowledge. Develop interpretations from multiple models of soils.

CARGEE 2. DEVELOP A MODEL FOR CONDUCTING ECOSYSTEM BASED SUREVEYS

Discussion points:

The comments for this charge centered on four themes. They are: (1) conduct and manage surveys on broad geographic scales such as MLRA or the Forest Service Hierarchy of Ecological Units; (2) use technology, especially spatial and attribute data systems, and remote sensing; (3) have greater interdisciplinary and interagency cooperation; and (4) improve characterization of the soil/landscape system by giving more attention to standardizing landform terminology, giving more emphasis to landform delineation, using multiple, integrated models for characterizing and interpreting soils, and emphasize both spatial and temporal variability.

Recommendations:

A "model" for conducting ecosystem based surveys would contain several elements as follows: Survey Areas-Planning and Implementation, Multiple, Integrated Models of Soils, Effective Use of Technology, and Technology and Knowledge Transfer.

I. Survey Areas-Planning and Implementation:

- Set interagency goals, objectives, and schedules by Ecoregion. eg, MLRA, Section, Subsection, River Basin. (Based on natural systems-not political boundaries.)

- Assess the adequacy of existing data and information and use cost effective approaches for providing current, accurate, and "useful" information to natural resource planners, managers, scientists, and other interested parties. (Recognize the realities of limited financial resources and set clear, interagency priorities for conducting and maintaining surveys and data bases.)

II. Use Multiple, Integrated Models of Soil for Characterization and Interpretation:

A. For example, models of soil after Meurisse and Lammers, (1993); and Dumanski, (1993).

ECOSYSTEM OR COMPONENT
- o Dynamic interactions/rates of change
- o Nutrient cycles/transport processes
- o Decomposition/Trophic relations
- o Environmental filter
- o Time scale 10 to 10' yrs.

WATER-TRANSMITTING MANTLE
- o Movement/storage of water/energy
- o Soil physical properties
- o Erosion processes
- o Pedotransfer functions
- o Time scale 10 to 10 yrs.

NATURAL BODIES
- o State factors
- o Weathering processes
- o Geomorphic history
- o Soil individuals
- o Classification
- o Mapping
- o Time scale 10^2 to 10^3 yrs.

MEDIUM FOR PLANT GROWTH
- o Available ❑ oisture/nurrfents/heat
- o Aeration/anchorage
- o Plant physiology
- o Response to ❑ anagemrjnt
- o Time scale 10 to 10 yrs.

STRUCTURAL MATERIAL
- o Mechanical properties (strength/plasticity)
- o Drainage/porosity
- o Conductivity--heat/water/energy
- o Time scale 10 to 10 yrs.

B. Recommended actions, regardless of model:

1. Emphasize the model of soil es natural bodies es the central concept. Others are derived from it.

2. Renew emphasis on the Jenny model of soil where S=f(Cl, Pm, O, R, T).

3. Increase characterization of soil organisms.

4. Provide insights to rates end magnitudes of material cycles, energy flows, pedotransfer functions, and transport processes.

5. Develop criteria and rate soils for resiliency to management impact.

6. Use multi-factor approach to design of mapping units, including geology, landform, potential natural community. end slope, with due consideration to the major uses. Increase emphasis on geomorphic process.

III. Make Effective Use of Technology:

- o Expedite development and implementation of readily accessable relational data base with common standards, and measures of data quality. Use compatible hardware and software among agencies.

- o Expedite development and implementation of digital data for analysis at multiple scales across multiple land ownerships or jurisdictions.

- o Make appropriate use of remote sensing, ground penetrating radar, DEMs, and other technology for data aquisition and interpretation.

IV. Improve Technology and Knowledge Transfer:

- o Identify continuing education needs and opportunities for soil scientists. Create a viable mechanism for implementing.

- o Maintain a staff of highly skilled soil scientists at strategic, subregional locations. Their purpose is to maintain data bases, provide current interpretations. and consult with users of surveys.

- o Dispense data and information to the public and agency personnel in multi-media formats such as CD ROM, graphic displays, and digital layers,

CHARGE 3. DEVELOP FUNDING STRATEGIES.

Points of Discussion:
This charge received little comment. However. there is some effort by the SCS to submit-budget proposals for surveys by MLRA. The Forest Service, in the Pacific Northewast Region, is attempting co manage funding within an Ecological Section (comparable to an MLRA).

Recommendation:
Set clear, interagency priorities and ensure cost effective measures are in place to conduct, maintain, and use survey information for sustainable land use. Seek opportunities and capitalize on them to share equipment, personnel, and financial resources.

General Recommendations:

- ★ Increase opportunities for soil scientists to increase their knowledge and skills through continuing education, special training sessions, and inter-agency details. Establish an interagency, NCSS task force, to identify training needs and continuing education opportunities.

- ★ Identify knowledge gaps and develop the research to aquire the needed information. Soil science practitioners need to be involved in the research process.

- ★ Develop a strategic plan for obtaining more knowledge, through research, about soil organisms. Relate to measurable soil properties as much as possible.

- ★ Develop a strategy for marketing the valuable data sets of ecological factors.

References:

Meurisse, R.T. and D.A.Lammers. 1993. Use of soil survey information for management of national forests and grasslands. In: Utilization of soil survey information for sustainable land use. J.M. Kimble, ed. Proceedings of Eighth International Soil management Workshop. USDA Soil Conservation Service, National Soil Survey Center. 271 p.

Dumanski, J. 1993. Strategies and opportunities for soil survey information and research. ITC Journal 1993-1. Pg. 36-41.

Committee Members:

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Carol Wettstein, USDA Soil Conservation Service
John Nesser, USDA Forest Service
Mark Kuzila, University of Nebraska
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Terry Brock, USDA Forest Service
Thomas M. Collins, USDA Forest Service
Terry Aho, USDA Soil Conservation Service
Bill Dollarhide. USDA Soil Conservation Service
Jerry Freeouf, USDA Forest Service,
Jim Culver, USDA Soil Conservation Service
Lyle Linnell, BLM Retired
Jim Frances, USDI Bureau of Land Management
Tom Reedy, USDA Soil Conservation Service
Bill Ypsilantis, USDI Bureau of Land Management
Bob McLeese, USDA Soil Conservation Service
Dave Smith, USDA Soil Conservation Service

Appendix

Definitions:

Ecology: The science that deals with the interrelations of organisms and their environment. (Glossary of Science Terms, Soil Science Soc. Amer. 1975)

Ecosystem: Any unit including all of the organisms (i.e., the "community) in a given area interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles within the system. (E.P. Odum, 1971)

Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space. (A Glossary of terms used in Range Management, (ISBN o-9603692-8-7) Jacoby)

The organisms of a particular habitat together with the physical environment in which they live: a dynamic complex of plant and animal communities and their associated non-living environment. (Biological Diversity on Federal Lands, Report of a Keystone Policy Dialogue. 1991)

The complex of a community of organisms and its environment functioning as an ecological unit in nature. (Websters dictionary)

Ecological Type: A category of land having a unique combination of potential natural community, soil, landscape features, climate, and differing from other ecological types in its ability to produce vegetation and respond to management. (USDA Forest Service Handbook, FSH 2090.11, Ecolgical Classification and Inventory Handbook)

Ecological Unit: A mapped landscape unit designed to meet management objectives, comprised of one or more ecological types. (USDA Forest Service Handbook, FSH 2090.11, Ecological Classification and Inventory Handbook)

Inventory: A detailed descriptive list of articles with number, quantity, and value of each. (2) A survey of natural resources: an estimate or enumeration of the (wildlife, soils, etc.) of a region. (3) A detailed study or recapitulation:survey. (Websters dictionary) Note:Inventory and survey often used interchangebly.

Potential Natural Community: The biotic community that would be established if all sequences of its ecosystem were completed without additional human-caused disturbances under present environmental conditions. Grazing by native fauna, natural disturbances such as drought. floods, wildfire, insects, and disease are inherent in the development of potential natural communities which may include naturalized nonnative species. (USDA Forest Service Handbook, FSH 2090.11, Ecological Classification and Inventory Handbook) **Note: Often used interchangebly with Potential Natural Vegetation (PNV).**

COMMITTEE 4 - DISTRIBUTION AND ACCESS TO SOIL SURVEY DATA

Committee Chair: Scott Davis

Charges:

1. Access to spatial and attribute data from soil surveys.
2. Certification of data.
3. Users' fees.
4. Update and coordination procedures.

DESCRIBE WHAT DATA NEEDS ARE AND REASONS FOR THOSE NEEDS:

First, provide analysis to determine what fundamental principles are needed. Separate the job by asking questions of what is desired and why is it necessary, and design systems accordingly. Develop a system or framework within which one can provide the capability without restrictions and conflicting requirements to satisfy a whole plythora of users' needs.

Identify base map needs and the methods to describe data. Describe limitations of data, i.e., method of how it was collected (derived, field, laboratory), reliability, levels of precision, etc. Next, provide the capability to link data.

NEXT DESCRIBE METHODS OF DATA STORAGE AND TRANSFER:

Four soil data bases and data element dictionaries are in the construction stages. They are the Soil Conservation Service's National Soil Information System (NASIS), the Bureau of Land Management's Soil Information System (SIS), the Forest Service's Soil Resource Information System (SORIS), and the work by the Tri-Services (Navy, Corps of Engineers, and Coast Guard). The need for widespread and diverse data interpretations have been large enough to warrant numerous separate data base products.

Three soil database concepts include a national standards database (official series description and soil interpretations record), and a site specific database (pedons, transects, and lab data).

Inter-agency committee efforts began in November 1992 in Denver. Work groups divided soil data set needs into four groups of data elements -- soil morphology/properties, soil chemical/physical properties, map unit, and site characteristics. The objective of this meeting was to identify a minimum dataset for the soils portion of the ecological database. The Soil Conservation Service and Forest Service continued this effort in Lincoln, in 1993, consolidating data elements into the following four data element groups -- pedon, map unit, interpretations, and lab-field-site. The third meeting (April, 1994, Denver) continued work of identifying a minimum data set for the transfer of soils data -- both map unit/aggregated data, and site/point data -- as directed by the Soils Subcommittee of the Federal Geographic Data Committee (FGDC).

- To fulfill the requirements of the FGDC, a coordinate effort evolved to develop a data dictionary to store soils data. This includes--developing guidelines, determining data elements, establishing a common data structure, and establishing a procedure for changes or additions to the dictionary.

It was recommended that a core team be established to review and to make changes to the data element dictionary. This process is outlined in the report by Jim Fortner (Attachment 1).

Inter-agency efforts have focused on the development of a soil minimum data set, expanded soil and ecological data sets, and integrated resource data sets. It is desired to develop an integrated system by combining current data sets, keeping them current and consistent, removing redundancy, and standardizing access to all data.

Many data elements are interpretative and are needed to answer land management decisions involving soil-water-vegetative relationships. The minimum soil data set will focus on soil survey information which will be aggregated. Many elements falling under "interpretative kind" as well as some site data will not be aggregated.

Part 648, Geographic Databases (430-VI-NSSH, Nov. 1993) provides the basis for data format and exchange.

Keep methods flexible to accommodate assorted needs of users and collectors. Must be in an understandable format. Methods available include INTERNET, ARC-INFO, CD-ROM, and GIS.

COMMITTEE RECOMMENDATIONS

1. All agencies, entities, collectors, and users need a minimum data set with a common data dictionary and data structure. Data sets should cover all elements for all users. Storage of data bases can be separate, but must provide linkages for other data bases such as forestry, rangelands, plants, production yields, etc.

2. Data bases need to be linked to NASIS (the central storage of the SCS for the data dictionary, elements and

definitions), including multiple resource data bases, research initiatives such as INTO SHARE, and a data base layer to describe Potential Natural Vegetation. These extra data bases will create the need for additional point-site data tables.

3. Include other disciplines such as plant scientists, ecologists, and data administrators in development of data bases.

4. Set standards for the limitations of data reliability. Establish agreement on common standards to share soil survey files, soil data information. Develop approach to address use-dependency among assorted agencies/entities.

5. Utilize various network systems to accommodate transfer of data, i.e., DOS, UNIX. For transfer, have flexibility for use of INTERNET, CD-ROM, ARC-INFO, GIS, etc.

6. Refer to soil standards subcommittee to determine agency responsibility for storing data bases. Determine whether one agency or each agency should store/be responsible for updating individual resource data bases.

7. Refer to soil standards subcommittee to approve amendment recommendations on core team membership (see attachment 1).

8. Establish communication network with all entities (>18) through mailings and advertising in newsletters such as ASA and SWCS.

9. Set up certification approval/appear process for data elements/definitions. Refer to NSH Part 639, Soil Data Systems and Part 649, Geographic Databases (430-VI-NSSH, November 1993).

10. See attachment 2 (report from Dick Folsche) regarding digital soils data cost, archive and retrieval policies). Do not eliminate established or potential Memorandum's of Agreement among regional entities to exchange automated resource data.

Attachment 1

United States
Department of
Agriculture

Soil
Conservation
Service

National Soil Survey Center
Federal Building, Room 152
100 Centennial Mall North
Lincoln, NE 68508-3866

May 26. 1994

Jim Keys, US Forest Service, Atlanta, GA
Scott Davis, Bureau of Land Management, Denver, CO
Wayne Hudnall, Agronomy Dept., Louisiana State Univ. Baton Rouge, LA
Rick Bigler, NSSC, MS 36, SCS, Lincoln, NE

First I want to thank each of you for taking time to participate in our data base workshop in Golden, Colorado. I really appreciate the cooperation and interest in this project.

As promised at the workshop, I am sending you various products for your review. I will also be sending these same items to representatives of the other agencies, as we discussed. The enclosed products are as follow:

- a report of the workshop
- a listing of the data elements that we identified for the map unit data set, and for the pedon data.
- a printout showing the definition and other information about the data elements included on the above list.
- a conversion list showing the data elements from the 11192 meeting in Denver and the equivalent current data element.
- a draft of a set of minimum documentation to be included with proposals for change/addition to this data set. This is what we in SCS are currently using for NASIS.

Please review these documents and provide comments back to me by July 11, 1994, as previously discussed.

Representatives from SCS and USFS will be meeting in the near future to discuss the geomorphology issues. When they get something completed, I will send it to you.

Again thanks for your input and cooperation, and I look forward to continuing our work on this project.

Jim R. Fortner

JIM R. FORTNER
Soil Scientist
Mail Stop 33

Enclosures

ACTIVITIES:

The group first reviewed the proposed agenda items and identified priority items to address.

1. After the minimum data set is identified and accepted, there will be a need to keep it up to date. This will include a process to add new data elements or make changes to existing ones. Therefore, the group indicated that a "core team" would be needed to review and accept/reject these proposals.

The recommended membership of the Core Team is as follows:

- 2 members each from the Soil Conservation Service (SCS) and the university cooperators in the National Cooperative Soil Survey (NCSS). One university representative would represent the northeast and south regions, and the other the midwest and west regions.

- one member each from the following federal agencies: US Forest Service, Bureau of Land Management, Environmental Protection Agency, Corp of Engineers, and Agricultural Research Service.

- A representative from SCS will serve as team leader.

- we ask that each of the above mentioned agencies provide the name, location, and phone number of their representative to:

Jim Fortner
100 Centennial Mall North
Room 152, Mail Stop 33
Lincoln, Nebraska 68508
Phone: 402-437-5353

- we recommend that the NCSS national work planning conference representatives appoint the two university representatives to the core team.

Terms of membership would be for three years each, expiring on a staggered basis -- three expiring each year beginning after the first three years.

Other agencies/entities such as US Fish and Wildlife Service, Bureau of Indian Affairs, Bur. of Reclamation, Bur. of Mines, Biological Survey, Dept. of Transportation, and US Park Service would be contacted for input related to data relative to their specialties. These are thought to be mainly users of soils data.

We intend to use the existing NCSS Work Planning processes and state contacts to allow for input from industry, non-industrial landowners, and non-traditional users to the core team.

2. The following process to review proposed changes will be used.

* Each core team member will receive, review and organize proposals originating within their respective agency/entity. They will then forward a recommendation for action to the core team leader.
* The core team leader will route the proposal along with the originating agency's recommendation to core tean members for review and recommendation.
* The core team will make the final decision. Each represented agency will have equal voting rights -- one vote per agency/entity.
* An appeal procedure will be established to allow for direct presentation of proposals to the core team leader.
* The data set will be maintained by SCS.
* We will establish a feedback and tracking mechanism to ensure that the originators of proposals are informed of actions taken on their proposals.
* A mininum standard for documentation to accompany all proposals will be established. (a draft of this is attached to this report)
* A mechanism to get input and/or review of proposals from agencies not represented on the core team will be established.
* A scheme to ensure timely review and processing of proposals will be established.

3. Discussion then turned to selecting those data elements to be included in the minimum data set. Those identified for map unit/aggregated data and those for pedon/site data are listed on enclosed printouts. These are not intended to be complete lists as representatives needed to discuss the geomorphology and plants related data elements were unable to attend. We tentatively included some of the geomorphology data elements, but decided to wait on including most of those related to plants. These folks will be meeting in the near future to discuss those elements.

The enclosed printouts also list the definitions of the data elements, additional information dealing with type, length, and ranges, and where aoppropriate a choice list or list of domain values.

4. The group also discussed how the data should be stored. The SCS is developing a National Soils Information System (NASIS) to manage their soils data. The USFS is developing a Soils Resource Information System (SORIS), and BLM is developing the Soil Information System (SIS). Other agencies are developing their respective systems. After some discussion it was proposed that this minimum data set use the data structure of NASIS since SCS will be managing the data set. Other agencies will then need to develop a procedure to download their data to that structure for transfer.

5. Discussion was also held as to what is the appropriate kinds and precision of data to be included with spatial data at significantly different map scales, ie. 1:12,000 vs 1;250,000 or 1:1,000,000. This isssue will need further discussion at a later date after it is known as to how FGDC is planning to deal with this kind of issue.

6. We then discussed what steps are needed to be able to present a product to FGDC for approval. The following were identified:

- SCS will route this report and lists of data elements and definitions as discussed above to the participants of the workshop and other appropriate representatives, by May 20, 1994. We will also provide a proposed set of minimum documentation to be included with proposals for changes and/or additions to the data set, and a copy of the data structure of NASIS for review and information.

- Those receiving the report and lists are asked to review the lists of data elements and definitions and provide comments to me by July 1, 1994.

- Depending on the response received, there may be a need to hold a teleconference to resolve issues.

- Representatives from SCS and USFS will be meeting in the near future to discuss a method to describe and store geomorphic information. When this is available, it will be routed for review and acceptance.

- We will be following up on the effort to include or link with vegetation data.

- As stated earlier, we will first concentrate on getting a minimum data set identified for map unit or aggregated data. We will then work on site or pedon data, and later ***on getting*** laboratory data included. Plans are to have the map unit data set ready to present for approval by October 1, 1994, and the pedon data set by January 1, 1995.

'JIM R. FORTNER
Soil Scientist
NSSC, SCS

United States Department of Agriculture
Soil Conservation Service

SOUTH NATIONAL TECHNICAL CENTER
P. 0. Box 6567
501 Felix Street
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June 3, 1994

Scott Davis
Bureau of Land Management
Colorado Slate Office CO-933
2650 Youngfield Street
Lakewood, Colorado 60215

Dear Scott

This is in response to your May 15. 1994. request for information regarding access and distribution of soil survey data. The National Cartography & GIS Center (NCG) has some responsibilities that your committee will find of interest.

We are in a pilot stage of providing a list of soils data available through NCG on the Mosaic in Internet. Those are attached.

NCG has worked with states on a process for the certification of STATSGO and SSURGO. this process is a draft Soil Manual for the Soil Conservation Service.

At the present time, NCG is charging S500 for a state coverage of STATSGO and S500 for a county coverage of SSUAGO. including the attribute data. This fee could be terminated ii the government funds and opens up access to the information highway.

The standaras for updating and coordinating procedures are now in the process of being updated everything else is either completed or in draft form of the Soiis Manual.

I hope this is of some help. I will be at the meeting in Idaho. but will have lo leave on Thursday.

W. R. FOLSCHE. Head
National Cartography & GIS Center

Attachment

DIGITAL SOILS DATA FACT SHEET

U.S. Department of Agriculture
Soil Conservation Service

DIGITAL SOILS DATA

I: 12.000 to 1:7.500.000-Scale Digital Soils Information from the SSURGO. STATSGO. and NATSGO Data Bases

Available from the National Cartography and GIS Center Fort Worth. Texas

The Soil Conservation Service (SCS) has the federal responsibility for the National Cooperative Soil Survey (NCSS) and federal leadership for collecting, storing. maintaining, and distributing soils information of privately owned lands in the United States. The Federal Geographic Data Committee and the Office of Management and Budget have formally assigned the responsibility for national coordination of digital soils data to the SCS.

As a step toward making digital soil data available. the SCS is releasing for sale. boundary and attribute data from it's major soil data bases.

SCS has established three digital soil geographic data bases representing different intensities of soil mapping. Common to each soil geographic (spatial) data base is the linkage to a soil interpretations (attribute) record data base. which gives the proportionate extent of the component soils and their properties for each map unit.

With these digital data bases, users can store. retrieve. analyze. and display soil data in a highly efficient manner. as well as integrate the data with other spatially referenced resource and demographic data in a Geographic Information System (GIS).

THE THREE DATA BASES

The three soil geographic data bases are the Soil Survey Geographic Data Base (SSURGO), the State Soil Geographic Data Base (STATSGO), and the National Soil Geographic Data Base (NATSGO). Components of map units in each geographic data base are generally phases of soil series. Phases of series enable the most precise interpretation. Interpretations are displayed differently for each geographic data base to be consistent with the level of detail mapped. The soil interpretations record data base encompasses more than 25 soil physical and chemical properties for approximately 18,000 soil series recognized in the United States.

Information such 3s particle size distribution, bulk density. available water capacity, soil reaction, salinity. and organic matter is included for each major layer of the soil profile. Also included are data on flooding. water table, bedrock. subsidence characteristics of the soil. and interpretations for erosion potential, septic tank limitations. engineering. building and recreation development. and cropland, woodland. wildlife habitat. and rangeland management.

The SSURGO Data Base

SSURGO. the most detailed level of information, is used primarily for farm and ranch conservation planning; range and timber management; and county, township, and watershed resource planning and management. Utilizing the soil attributes. this data also serves as an excellent source to review site development proposals 3nd land use potential. make land use assessments and to identify potential wetland areas.

Using national mapping standards, soil maps in the SSURGO data base are made by field methods, using observations along soil delineation boundaries and traverses, and determining map unit composition by field transects. Aerial photographs are interpreted and used as the field map base. Maps are made at scales ranging from 1:12.000 to 1:31.680 and incorporated with comprehensive descriptions to produce the NCSS publications.

Digitizing is by line segment (vector) in accordance with SCS-established digitizing specifications and standards for duplicating the original soil survey map. The mapping bases are normally orthophotoquads or 7.5 minute topoquads. Digitizing is done by *SCS* or by cooperating state and local governments.

SSURGO data are collected and archived in 7.5 minute topographic quadrangle units. and distributed as complete coverage for a soil survey area usually consisting of ten or more quadrangle units. The adjoining 7.5 minute units are matched within the survey areas.

The STATSGO Dara Base

STATSGO is used primarily for river basin, state, and multicounty resource planning, management. and monitoring.

Soil maps for STXTSGO were made by generalizing the detailed soil survey maps. Where more detailed maps are not available, data on geology. topography. vegetation, and climate were assembled. together with satellite images. Soils of analogous areas are studied. and 3 determination of the classification and extent of the soils is made.

Map unit composition for STXTSGO is determined by transecting or sampling areas on the detailed maps and expanding the data statistically to characterize the whole map unit.

STATSGO was mapped on the U.S. Geologic31 Survey's 1:250,000-scale topographic quadrangle series. Soil boundaries were digitized by line segment (vector) to comply with national guidelines and standards.

STATSGO data are archived and distributed as complete coverage for a state. STATSGO data are joined between states.

The NATSGO Dara Base

NATSGO is used primarily for national, regional, and multistate resource appraisal. planning. and monitoring.

The boundaries of the major land resource area (MLRA) and land resource regions were used to form the NATSGO data base. The MLRA boundaries were developed primarily from state general soil maps,

Map unit composition for NATSGO was determined by sampling done as part of the 1982 National Resources Inventory. Sample data were expanded for the MLRAs. with sample design being statistically significant to state parts of the MLRAs.

The NATSGO map was digitized at a scale of 1:7.500.000. also by line segment (vector). and is distributed as a single data unit for U.S. coverage.

DATA CONTENT AND FORMAT

Spatial Dara

SSL'RGO. STATSGO. and NATSGO spatial data are distributed to the public from the National Cartography and Geographic Information System Center (NCG) in the USGS Digital Line Graph (DLG-3) Optional Distribution Format.

SSL'RGO data are archived in various formats. Depending on the format requested. the customer's request may be delayed to reformat the data of the DLG-3 Optional format. SCS soil map symbols (AbC) are not normally carried within the DLG-3 Optional format. However. these map symbols are made available as a unique ASCII file when SCS soils data are distributed in the DLG format.

The NCG primarily operates a Geographic Resource Analysis Support System (GRASS) GIS. SCS-GRASS and other GIS formats may be made available by mutual agreement.

The distribution medium for spatial data will normally be 9-track magnetic tape at 1600 bits per inch (bpi), but may be cartridge tape. also by mutual agreement.

Additional information regarding file formats for data, as well as the technical specifications for digitizing SCS soils data, is available from the NCG.

Attribute Data

SCS's attribute data for SSURGO and STATSGO are stored in a relational data base. This format is a nonfixed length. tab delimited. ASCII file. SATSGO is stored in a flat ASCII file. Attribute data are distributed on a 9-track magnetic tape or cartridge tape media.

Additional information regarding tile formats for attribute data are available from the NCG.

KNOWING WHAT TO BUY

Before pttrchasine digital soil data. the user needs to identify the area of interest and examine the anticipated use of the data. More importantly. the user should be knowledgeable of the software and/or data format capabilities available on the computer system intended for use. The user should be knowledgeable of soils data and their characteristics. If you need assistance. contact an SCS soil scientist for help or contact:

National Soil Survey Center
U.S. Department of Agriculture
Soil Conservation Service
Federal Bldg.. Rm 152
100 Centennial Mall. Sorth
Lincoln. NE 68508
(402) 437-5423

To obtain data. contact:

National Cartography and GIS Center
U.S. Department of Agriculture
Soil Conservation Service
P.O. Box 6567
Fort Worth. Texas 76 115
(817) 334-5559
FAX (817) 334-5290

DIGITAL SOILS DATA COST

Product
- 0 Coverage
- 0 Price

SSURGO
- o County/ Area
- 0 $500

STATSGO

- State
- $500

NATSGO
- United States
- $500

Placing Orders

STATSGO data mav be ordered bv clicking here!

Submit a request to the NCG specifying the data being ordered. accompanied by a check made out to "USDA-SCS." Provtde the name and telephone number of a technical contact. Any special handling, which may require additional charges, will be discussed with the user before completion. A data base listing. describing the characteristics and status of available data. and status maps are also available.

All programs and services of the Soil Conservation Service are offered on a nondiscriminatory basis. without regard to race. color. national origin. religion. sex. age, marital status. or handicap.

JUNE 1992 /1005853DRevised

Return to Geographic Databases Page.

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Send comments and/or suggestions to www@ncg.scs.ag.gov.

GIS DATA ATLAS AND CATALOG

This catalog is a textual listing of the holdings of the National Cartography and GIS Center (NCG) media library. Many of these data were collected from soil survey digitizing projects performed in-house, by state soil staffs or from contracting sources. It is recognized that much of the soil data catalogued is the property of the Soil Conservation Service state soil staffs and may exist in a more current version elsewhere: the only exceptions include the certified SSURGO and STATSGO data bases that the NCG is responsible for storing and cataloging.

All vector or line-segment spatial data is distributed in the DLG-3 Optional Format or in the GRASS vector format unless otherwise noted. The attribute data may be distributed in a relational data base structure or in a flat ASCII format. Raster data are in the GRASS cell or raster format and are distributed as full GRASS mapsets unless otherwise noted. Raster attribute data are distributed in a relational data base format or in 3 flat ASCII format.

The NCG can provide data in a variety of media types. which include: 9 – track magnetic tape. quarter inch cartridge tape of several densities. 8 mm tape. erasable optical disk. compact disk – read only (CD–ROM) as well as floppy disks and diskettes.

FOR ADDITIONAL INFORMATION ABOUT THE DATA LISTED IN THIS CATALOG CONTACT:

National Cartography and GIS Center
U.S. Department of Agriculture
Soil Consenation Service
P.O. Box 6567
Fort Worth. Texas 76115

(817) 334-5559 *FAX (817) 334–5469*

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Send comments and/or suggestions to www@ncg.scs.ag.gov.

NCG DIGITAL **DATA ARCHIVE** POLICY

The National Cartography and Geographic Information Systems (NCG) center hosts a variety of digital spatial and attribute data as a service to several agency Divisions. In an effort to serve our customers better NCG staff are constantly trying to improve data access. storage. backup, archive. and distribution efficiencies.

Though a number of different data management options are available at NCG. the staff relies upon the data stewards to provide metadata and to define the client Division's requirements for data handling. A memorandum of understanding between NCG and the client Division, stating data storage, access, archive, and distribution requirements, will be drafted and signed.

NCG DATA ARCHIVE POLICIES

The term archive *as used in this document implies the management of digital data. other rhan temporary work space. on magnetic or optical media. This includes backups of online data. rapes on a shelf, and data on any hard* **disk.** *magnetic or optical. on any NCG computer.*

When no clear requirements are stated for data management. NCG staff will implement the following:

1. Once categorized as "archivable" by agency data stewards. all data will be maintained offline either on magnetic tape or on optical media.. Offline **being** on a shelf within the premises.
2. Agency-owned data archived at NCG will be duplicated and stored off-site. under the provisions of the SNTC contract with "One Safe Place", which allows for routine monthly retrieval, or same-day service with the use of a courier. Within five days of receipt of the data. NCG staff will read the data with the appropriate software. If data are readable, duplication and off-site storage are done within 60 working days.
3. All data will be entered into a relational database maintained at NCG within ten days of receipt in the geodatabase section, including basic properties and as much metadata as are available.
4. All data at NCG will be inventoried once a year. and the database updated with any new or removed items. All public, SCS-owned. data archived at NCG will be listed on a public catalog, hardcopy and electronic. and made available to agency staff nationally as well as to the general public upon request, except when limitations are expressly stated in the relevant MOU.
5. Archive, retrieval. and database access service are available during working hours through any member of the geodatabase section staff. Randy English is the section head. Online read-only access to the database is provided upon

request. and access to data are provided either online or on electronic media within two working days or less.

ARCHIVING PROCEDURES

Upon receipt of data. information is entered into a database by the geodatabase section staff. If the data is on magnetic media it is duplicated for off-sire storage and shelved for retrieval upon request. Online storage is provided upon request once data are duplicated onto the appropriate media for off-site storage.

RETRIEVAL

Any data in the database can be retrieved by a member of the Geodatabase section. and duplicated on any available media or disseminated electronically upon request by an authorized client. Online data can be made available throughout the NCG nerwork. anonymous ftp, or Internet.

PRICING

Cost of services must be arranged between SCG management and Division representatives. This will vary according to the volume of data and type of service that is being requested.

SERVICES AVAILABLE

NCG employs a staff of data archive, management. and distribution specialists who are in charge of maintaining data and facilitating access to the specifications of the client Division. Some of the data-relative services available at NCG. and addressed within relevant MOUs with agency Divisions, are:

Off-site storage

. The SNTC maintains a contract with an off-site data storage facility for the safe-keeping of data tapes. 9-track and 8mm tapes are picked up and delivered to the center on a monthly basis, with same-day retrieval available

Online storage

. In addition to 15 Gbytes of RAID (Redundant Array of Inexpensive Disks - they are not inexpensive) storage, NCG computers have network access to over 10 Gbytes of distributed workspace storage.

Backups

- All online data on the server's RAID storage are backed up daily.

Inventory

- NCG's spatial and attribute data are inventoried at least once a year. and a data catalog is published for distribution, A pictorial data atlas is in the works.

Distribution

- Currently most distribution of data to customers, within the agency and to the public in general. is done via magnetic media: but a variety of alternatives are becoming available with the advent of optical media. increased storage capacities of small-format magnetic tapes, and with increased access to the nation's information superhighway.
  - **Media—The once** popular g-track magnetic tapes are rapidly being replaced by 8mm helical-scan cartridge tapes. Also available for storage and distribution at NCG are: 4mm tape cartridges. Quarter-Inch cartridges (QIC), 600 Mbyte erasable optical disks. 640 Mbyte ISO-9660 and rock ridge format CDROM disks. 5 and 3 -inch floppy disks. and 20 to 90Mbyte Bernoulli disks.
  - **Dial-up--**NCG has extensive dial-up capabilities, including modem access at various baud rates. asynchronous and synchronous packet switch service, Internet (currently 56k baud. but soon to be upgraded to either frame relav or T1 servicer. in-house X.25 protocol support. anonymous lip site support. and various UNIX uucp protocols.
  - **WAIS--**NCG maintains a WAIS server and offers WAIS-indexing support as an option for all in-house data upon request.
  - **Mosaic/WWW--**NCG **also** maintains a World Wide Web (WWW) server as a Mosaic client for MSwindows. Macintosh. and Xwindows customers.
  - **Charge-back--A** charge-back mechanism is in place at NCG, allowing for recovery of data duplication and dissemination expenses.

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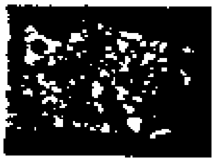
THIS IS A TEST FORM / MAY 1994

STATE SOIL GEOGRAPHIC DATABASE (STATSGO) ORDER FORM



Thank you for your interest in the SCS-STATSGO database. To order data using this form, you must use a browser with online form features. If you cannot find somewhere below to type your answers, you cannot use this form. Instead. please send mail to *www@ncg.scs.ag.gov*, and an email version of the form will be sent to you.

When you have filled out the form to your satisfaction, click on the "Mail Order" button at the bottom of the form. You should receive an email verification of your order within a day or so.

I would like to request State Soil Geographic Database (STATSGO) data for the following state(s):

At a cost of 5500.00 per state: total

Please mail remittance in the form of a cashier check. personal check, non-govt. purchase order, AD-i42 for USDA agencies, or OPAC billing for non-USDA agencies to:

Soil Conservation Service
National Cartography and GIS Center
STATSGO DATA
P. 0. Box 6567
Fort Worth. TX 76 11.5
(817)334-5292
FAX-(817)334-5469

Checks are to be payable to SCS-National Cartography and GIS Center.

Shipment of data will follow receipt of payment. For prompt. accurate shipment. please type the following label:

Name:

Email Address:

Telephone:

FAX:

Position:

Affilation:

Street Address:

City State Zip:

Please select the data format and type of media you prefer:

Spatial Data Format:

ARC Export

GRASS Vector

DLG-3 Optional

Tabular Data Format:

ARC Export

Prelude

Media:

9-Track Tape

8mm Tape

1/4" Cartridge Tape

To send your order. press here:

To clear the form. press here:

Return to Geographic Databases Page.

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Send comments and/or suggestions to www@ncg.scs.ag.gov.

Redefining The Cooperative Role In NCSS

Committee report submitted to:
Western/Midwestern Regional Cooperative Soil Survey Conference
Coeur d'Alene, Idaho
June 17, 1994

Committee Chair – Paul McDaniel

Committee Members and Participants –

Mickey Ransom	Robert Klink
Wayne Robbie	Sian Conway
Joe McCloskey	Dennis Heil
LeRoy Daugherty	Jerry Nielsen
Eugene Kelly	Janis Boettinger
Harold Maxwell	Tom Fenton
Tim Gerber	Russ Langridge
Gordon Huntington	Don Franzmeier
Gary Muckel	

The National Cooperative Soil Survey (NCSS) is a nationwide partnership of Federal, regional, State, and local agencies and institutions (National Soils Handbook). The NCSS represents a long-standing cooperative soil survey effort that has served as a viable model for other countries. As such, redefinition of cooperative roles should consist of 'fine tuning' rather than a complete overhaul. It should be emphasized that the NCSS program is not 'broken' and therefore wholesale changes are neither required nor desired.

The committee considered the 4 charges set forth by the Conference Steering Committee. These charges are listed and discussed in the following sections.

1. Identify current NCSS cooperators

A definition of an NCSS cooperator is needed. It is important to distinguish between cooperators, collaborators, and users for purposes of accountability. Technically, a cooperator is any federal, state, or local agency or institution that has entered into a working agreement with the NCSS. These agreements are usually memoranda of understanding (MOU). Although MOUs are not legally binding contracts, they do provide the framework for operations and responsibilities related to soil survey activities.

On a more descriptive level, an NCSS cooperator should be thought of as an agency or entity that has a long-term commitment to 'investigate, inventory, document, classify, and interpret soils and disseminate, publish, and promote use of information about the soils of the United States and its trust territories' (NSH).

2. Describe the future role of each cooperator

White the role of the SCS is described in detail (see NSH), the roles of other NCSS cooperators is less well-defined. As such, future roles of NCSS cooperators need to be re-examined. Recent changes in cooperators' resources and priorities necessitate that existing MOUs be evaluated. Many MOUs are outdated and contain language that cooperators are uncomfortable with. It may be appropriate for all MOUs to be updated in order to more accurately describe actual cooperator roles.

It is generally agreed that MOUs are, by design, fairly vague and allow a certain degree of flexibility. However, agency and institutional administrators are increasingly reluctant to enter into agreements that may be perceived as a commitment of limited resources. All parties entering into a cooperative agreement should therefore be comfortable with both the wording and intent of an MOU.

Committee representatives from various cooperating agencies and institutions generally do not foresee immediate drastic changes in their current NCSS roles. For example, state agricultural experiment station representatives indicate that some traditional NCSS activities such as providing large-scale laboratory support have been cut back or eliminated because of budgetary and time constraints, However, participation in other activities such as soil survey planning conferences, field reviews, and peer review of technical documents is of substantial mutual benefit and will continue in the future.

All cooperators have been subject to declining budgets and, in many cases, personnel cutbacks. In view of this, there will be a need for more sharing of specialists among NCSS cooperators. This is especially true with the increasing locus on developing an ecosystem approach lo soil survey.

3. Determine where cooperator input is needed

Cooperator input is perhaps one of the major reasons that the NCSS program has been successful. As soil survey technology and application continue to evolve, it is extremely important for cooperators to work together to develop a strategic plan for the NCSS program.

Annual state-level soil survey work planning conferences are required (see NSH). There appears to be a widespread perception that these meetings tend to focus on what has been done rather than on true planning. Therefore, all participating agencies should be encouraged to take a more pro-active approach with regard to these conferences. One means by which to at least partially offset declining resources is by more efficient planning.

Continued cooperator input is needed in many areas. Continued peer review of technical documents such as proposed taxonomic changes and soil series descriptions is considered critical. Development and incorporation of new technology will result in rapid evolution of databases and information delivery systems. These areas will continue to require cooperator input. New opportunities of cooperator input will also present themselves. Implementation of NASIS will provide an opportunity at the local level for cooperators to provide appropriate data elements.

NCSS cooperators can also provide means to insure that priority items are delivered in a timely fashion. As an example, delays in publishing of soil surveys by the U.S. Government Printing Office have circumvented through publication of these materials as Agricultural Experiment Station Bulletins, U.S. Forest Service reports, etc. These types of arrangements can be put into MOUs when rapid delivery of soil survey data may be required.

4. Identify potential new NCSS cooperators (and collaborators)

In addition to some of the traditional cooperators, there are several agencies, organizations, institutions, and even individuals that will become major players in the NCSS. It is important that the need to involve these parties at various levels of the NCSS be recognized.

As an example, management of Indian tribal resources has been directed by the Bureau of Indian Affairs (BIA). The BIA has been a long-standing NCSS cooperator. New laws provide for more autonomy in the management of tribal resources, and as a result, tribal governments will be directly involved in regulation and management of their lands. At present, there are an estimated 12 million acres of tribal lands needing an initial soil survey. Thus, inclusion of tribal governments as NCSS cooperators will likely be appropriate for soil survey activities related to these lands.

Examples of other potential new cooperators include the Intertribal Agriculture Council, U.S. Department of Defense, U.S. Department of Energy, Corps of Engineers, state GIS agencies, state heritage programs, state and local health departments, conservation organizations such as the Nature Conservancy, and private individuals. All of these groups have recently demonstrated many of criteria for cooperators described in a previous section of this report. Many of the new cooperators and collaborators may best be identified at the state and local levels.

Committee Recommendations

Based on the discussion summarized above, the committee recommends that cooperators take the following steps to insure the continued success of the NCSS program:

- Maintain the distinction between cooperators, collaborators, and customers.
- Update and amend memoranda of understanding as needed.
- Encourage pro-active, annual coordination of soil survey activities.
- Continue to encourage diversity among cooperators, collaborators, and customers.

REDEFINING THE COOPERATIVE ROLE IN NCSS
Committee Recommendations
June, 1994

1. Distinguish between cooperators, collaborators, and customers.
Although the distinction between cooperators, collaborators, and customers may not always be well defined, a distinction is needed for purposes of accountability and strategic planning of NCSS activities. A cooperator is defined as a federal, state, or local agency or entity that has entered into a working agreement with the NCSS. Additionally, a cooperator should have a long-term commitment to "investigate, inventory, document, classify, and interpret soils and disseminate, publish, and promote use of information about the soils of the US and its trust territories".

2. Update and amend memoranda of understanding as needed.
Many cooperators are working with outdated memoranda of understanding (MOUs). All cooperators are encouraged to examine existing MOUs and amend them as necessary to more realistically describe their role in NCSS. MOUs are often general by design, but it is nevertheless important that involved pat-lies are comfortable with both the actual wording and implied intent of these documents.

3. Encourage pro-active, annual coordination of soil survey activities.
Annual soil survey work planning conferences at the state level are required according to the National Soils Handbook. Too often these conferences focus on past accomplishments rather than on future efforts. In order to make optimum use of declining cooperator resources for soil survey activities and develop an ecosystem-based approach, it is especially important that these conferences be used to plan and coordinate NCSS efforts.

4. Continue to encourage diversity among cooperators and collaborators.
Changing political and economic climates have necessitated the need for new cooperators and collaborators. As an example, recently passed legislation has given greater responsibility to Indian tribal governments for management and inventory of their lands. As a result, these tribal governments will need to become cooperators in NCSS. Other potential new cooperators include: US Dept. of Defense, US Dept. of Energy, Army Corps of Engineers, state GIS agencies, state heritage programs, state and local health departments, conservations organizations, and private consulting soil scientists. Furthermore, an ecosystem-based approach to soil survey will require greater input from cooperator specialists that have not traditionally been involved with NCSS.

COMMITTEE SIX- ALTERNATIVES TO TRADITIONAL SOIL INTERPRETATIONS

Committee Chair: Arlene Tugel, SCS, WNTC, Portland, OR

Charges:

1. Identify new methods to make interpretations.
2. Initiate development of a new method.

Committee Report
June 14, 1994
Coeur d'Alene, ID

The committee had a teleconference on March 14, 1993 to brainstorm ideas for charge no. 1, "Identify new methods to make soil survey interpretations." Minutes of the teleconference are attached. Committee members voted by mail to rank the proposed new methods. See below for a ranked list of suggested new methods with their item number and a brief description.

New Ways to Make Interpretations

Vote	Item #	Description
12/5	6.	Make interpretations on interrelationships between the landscape and soil.
B/3	2.	Interpretations that rate suitability with alternative measures applied.
S/3	5.	Identify and define soil behavior processes (such as nutrient cycling, shrink-swell, water transmission) and present alternatives to display the information (narrative, digital illustrations).
8/2	1.	Interpretations that emphasize positive qualities of soil.
7/3	7.	Affect of use dependent processes on soil properties.
6/3	15.	Start with a specific use. Then list the soil properties or characteristics that are needed to achieve optimal use. Bump those properties up against the existing database to find best

area for that use.

6/3 9. Develop criteria and standards to assess soil and watershed conditions.

6/2 13. Use soil potential to give relative values to different types of land uses.

5/2 4. Identify probability of "x" behavior based on spatial distribution of component or property. This is important where component property range overlaps the property use requirement.

4/1 3. Display interpretations as relative values of capabilities.

3/1 8. Define minimum amount of cover on rangeland to protect the soil.

2/1 10. Prepare guidelines to develop interpretations for miscellaneous land types, higher taxonomic units and geologic units.

l/l 11. Identify positive long term use of landscapes.

l/l 12. Identify suitability of geographically associated soils and landscapes.

0 14. Other - add as you are inspired.

Expanded descriptions of eight of the ideas were prepared prior to the Coeur d'Alene meetings and presented to the committee on Tuesday, June 14, 1994. These descriptions are attached (idea #2, 5, 6, 7, 9, 10, 13, 15).

At the Coeur d'Alene meeting, we had a discussion of the committee charges. The committee name, "New Ways of Making Soil Survey Interpretations," was changed to "Alternatives to Traditional Soil Interpretations." We clarified our charge to mean, "How else can we convey information about soil behavior?"

After presentations and discussions of the eight ideas, we grouped the alternatives into three categories:

Monitoring and assessment

9. Soil health/proper functions condition.
7. Affect of use dependent properties.

Making interpretations

7. Affect of use dependent properties.
2. Suitability with alternative measures applied.

Displaying information

15. Pick use query database for listing of optimal sites.
13. Use soil potentials to give relative values to different types of land use.
10. Miscellaneous land types.
5. Identify soil behavior processes.

We then discussed methods to implement the ideas. It was suggested that items 2, 5, 7, 13 and 15 would be pilot projects on on-going soil surveys. Number 7 could be implemented by gathering data on use dependent properties. Work groups consisting of various disciplines and agencies including NCSS would be the best approaches to initiate ideas 5 and 7. A literature search is needed for numbers 2 and 7. Idea 10, Soil Survey Enhancement - Interpretations for Miscellaneous Land Types could be carried out today with some minor expansion of existing procedures for the Soil Interpretations Record.

The committee identified three ideas/alternatives that would provide the greatest benefit for the least input. These were #15 Pick a Use, Query the Database; #10, Interpretations for Miscellaneous Land Types; and #5, Identify Soil Behavior Processes (Pedologic).

Recommendations

Recommendation 1:

The eight alternatives to traditional soil interpretations should be integrated into soil survey activities. (Current national level activities on soil health and use dependent properties should be continued.)

Recommendations 2:

#15 Pick use, query database: Begin development of #15 as a pilot project on a new soil survey project.

Recommendation 3:

#10 Interpretations for miscellaneous land types: Implement #10 immediately using existing SIR procedures as modified to meet the needs for miscellaneous land types.

Recommendation 4:

#5 Identify soil behavior processes (pedologic): Establish a development committee of NCSS cooperators, modelers, other discipline specialists and universities to begin work on #5. Set up a pilot project to identify and display pedologic process information in a new soil survey.

Western/Midwestern Regional Cooperative Soil Survey Conference

Minutes of Committee Six Teleconference
March 14, 1994
New Ways of Making Soil Survey Interpretations

Charges: 1. Identify new methods to make interpretations.

2. Initiate development of a new method.

Participants:
*Wayne Backman, Assist State Soil Scientist, South Dakota
*Ken Vogt, Assist State Soil Scientist, Missouri
*Jon Gerken, Acting State Soil Scientist, Ohio
*Jim Carley, State Soil Scientist, Washington
*Cam Loerch, Soil Scientist, QAS, Lincoln, Nebraska
*Carol Franks, Soil Scientist, QAS, Lincoln, Nebraska
Bill Broderson, Soil Scientist, QAS, Lincoln, Nebraska
*Chris Smith, State Soil Scientist, Hawaii
Bill Volk, BLM, Billings, Montana
Carl Wacker, Assist State Soil Scientist, Wisconsin
Don Last, College of Nat. Res., Univ. of Wisconsin
*Dick Page, ELM, Salt Lake City, Utah
*Arlene Tugel, Chair, Committee Six, WNTC, Portland, Oregon

* - will attend Coeur d'Alene Conference

We reviewed the background material on current examples of soil interpretations. General discussion on charge 1 followed.

Can Loerch asked if we know what our customers need in regards to interpretations. Arlene said that the book "Soil and Water Quality: An Agenda for Agriculture," National Research Council, 1993 stated 4 objectives. She recommended we should ask if current interpretations meet these objectives. The 4 objectives are:

- conserve and enhance soil quality as a fundamental first step to environmental improvement;

- increase nutrient, pesticide, and irrigation use efficiencies in farming systems;

- increase the resistance of farming systems to erosion and runoff: and

- make greater use of field and landscape buffer zones.

Discussion:

Bill Volk, BLM, indicated that for rangeland, there is a need to define the minimum amount of cover to protect the soil. Each seral stage of the plant community could have different amount of cover. Organic carbon content of the surface layer lags behind changes in plant cover, particularly with changes in land use.

Chris Smith discussed soil qualities. We will need to ask what is: (1) a soils maximum potential? and (2) to what level can we allow a property degrade, (3) what is our target of use? There is considerable work in the tropics on properties in systems changing from forest to cultivation (porosity, root proliferation, organic carbon, nutrient status). We will need a protocol to measure and monitor quality: we already have the techniques of measurements.

Bill Broderson suggested that we become aware of other efforts that are ongoing. There is a Soil Quality Committee (SCS-ARS-University-EPA) to establish protocols for addressing soil quality. Committee Chair is Gary Muckel, SCS, Lincoln.

Bill Volk described a current BLM activity that requires the use of criteria and standards to assess soil and watershed conditions. It includes riparian areas and upland areas. Real life challenges are short time frame to define and apply criteria and the many categories of land ownership.

Carol Franks stated that the Soil Quality Committee discussed watersheds and has a list of potential indicators.

Another on-going activity is the use of Fuzzy logic to assist in presenting interpretations.

Dick Page recommended that we prepare guidelines for developing interpretations for miscellaneous land types, higher taxonomic units and geologic materials. He is working on this with Ferris Allgood, State Soil Scientist, SCS, Utah.

Bill Volk suggested we identify positive long term use of landscapes. Different components of the landscape have different highest and best uses that are not necessarily in line with the limitations of the soil. This will minimize the problem of avoiding severe rated hillside positions as building sites and ending up building on farmland.

Chris Smith asked where would this information be presented? in the map unit description? We should identify the suitability of geographically associated soils.

Soil potentials were discussed. They are an existing method. Unless changes to the method are needed, reviewing potential is probably not within the scope of our charges.

Jon Gerkin recommended we consider the use of soil potentials to give relative values to different types of land uses.

Chris Smith stated that the land capability classification system doesn't work well for specialty crops.

Chris Smith suggested that we compile possible products that can be generated with our data. This could be handled under the advertising and marketing by another group.

Charge 1. Identify new ways to make interpretations. We had a review discussion of items 1 thru 7 from the 2-17-94 list.

No. 1 Bill Broderson explained he developed a proposal about 7 years ago that focused on positive qualities of soil called "smart systems."

Bill Volk suggested indicators for soil quality should be simple to observe - example platy structure changed to granular structure.

Chris Smith said that the quality of organic matter needs to be a part of soil quality standards, not all organic matter sources have the same quality.

No. 2 Discussion ?

No. 3 Discussion ?

No. 4 Chris Smith explained that we should rate all components, including inclusions and identify percent of map unit with a certain rating or behavior.

No. 5 Arlene explained that identifying and defining soil processes is a prerequisite to developing soil quality standards. An understanding of processes, such as water movement, nutrient cycling, organic matter accumulation/oxidation is fundamental to making predications about soil behavior. ? suggested that a package of tutorials on soil processes should be developed. Organic matter would be a good example.

No. 6 Carol Franks stated an example of interrelationships between landscape and soil is runoff and runon.

No. 7 Discussion ?

<u>The next step</u>

The committee agreed on the following process to fulfill our charges.

1. Brainstorm list for Charge 1 will be sent to committee for review. We will use the TQM voting process thru the mail to select the highest priority items from the list.

2. Committee members will prepare 1 page summaries of the high priority items selected by vote to present as part of the report in Coeur d'Alene. Write-ups will include Definition, Description, Application and Methods of Display.

3. Committee will select at least one item to address for Charge 2. A draft write-up for Charge 2 will be sent to members prior to June meeting.

4. Charge 2 will be further developed at June meeting.

Follow-up

1. Distribute minutes of Soil Quality Committee to members - Tugel.

2. Send Fuzzy logic overview to committee - Broderson.

3. Send BLM information on criteria and standards to assess watersheds to members - Volk.

4. Send information on Smart System to members - Broderson.

DUE DATE: APRIL 25, 1994

Action: Review and mark priority 1, 2, 3, and 4. Send vote to Arlene Tugel by April 25.

Charge 1. Identify new ways to make interpretations (Second Draft) 3/14/94

1. Interpretations that emphasize positive qualities of soil.

2. Interpretations that rate suitability with alternative measures applied.

3. Display Interpretations as relative capabilities.

4. Identify probability of "x" behavior based on spatial distribution of component or property. This is important where component property range overlaps the property use requirement.

5. Identify and define soil processes and present alternatives to display the information (narrative, digital illustrations).

6. Make interpretations on interrelationships between the landscape and soil.

7. Affect of use dependent processes on soil properties.

8. Define minimum amount of cover *on* rangeland to protect the soil

9. Develop criteria and standards to assess soil and watershed conditions.

10. Prepare guidelines to develop interpretations for miscellaneous land types, higher taxonomic units and geologic units.

11. Identify positive long term use of landscapes.

12. Identify suitability of geographically associated soils and landscapes.

13. Use soil potential to give relative values to different types of land uses.

14. Other - add as you are inspired.

Return to: Arlene Tugel BY: APRIL 25
West National Technical Center
511 N.W. Broadway, Rm. 248
Portland, OR 97209-3489

FAX: (503) 326-6308 or 5578

INTERPRETATION METHODS (A DRAFT)

Suggested Mea: No. 2. Interpretations that rate suitability wlth alternative measures applied.

Name of method: Soil Suitability with Alternative Ratings for Crop Production

Description: Current soil limitstion and suitability procedures generally emphasize rating Soils for engineering Interpretation. There is also a need to rate soils for the production of specific crops. This method, therefore, is associated more with crop Production and includes suitability retinas before and after appropriate management inputs.

This method duplicates the UNESCO FAO land evaluation procedure where the so-called land use system (LUS) is made up of (l) the land utilization type (LUT) and (2) the land map unit (LU). Depending on the intensity of the soil survey, the LUT can be brief or detailed, the latter describing the levels of input, etc. for a specified use. The LU, on the other hand, lists the appropriate interacting soil characteristics of a land in question.

In brief, the LUT describes the crop requirements with different levels of management input, while the LU is associated with the appropriate soil properties end behavior. The LUS, therefore, is the matching of the land (soil) use requirements with the land (soil) characteristics.

Application: Soil suitability ratings can be more meaningful if the ratings can be associated with the desired performance of, for example, 6 crop rather than only the status of the soil with its restrictive properties. That is, the ratings could reflect the correction of the manageable rstrictive properties with appropriate input.

For example, the Leilahua soil series in Hawaii (Ustic Kanhaplohumults, clayey, oxidic, isohyperthermic), according to the table of suitability ratings is poor for the production of corn.

We could specify that we would like to produce corn in the Leilehua soil wlth supplemental irrigetion, with the soils limed to pH 6.0 and phosphorus fertilizer epplied et the rate of 500 P pounds/acre, and with appropriate levels of the other nutrients.

The table of rstings could show not only the dominant mineralogy (e.g., oxldic. kaolinitic) with its rstings but al60 the input of phosphorus fertilizer with its ratings et different level6 of application. Depending on the different levels of lime and the phosphorus fertilizer, we could change the suitability rating of the Leilehua soil from poor to fair or good, depending on the man-cgomont input.

Method of display: Use of GIS.

Other Information: The proposed method Is not like the soil potential approach because a numerical rating of a group of soils is not used. Instead the mothod can be used to rate soils from different locations for o specified crop.

Further Work: Unknown

Submitted by: H. Ikawa (University of Hawaii), 06/08/94

New Interpretation Methods

Suggested idea: No. 5. Identify and define soil behavior processes (such as nutrient cycling, shrink-swell, water transmission) and present alternatives to display information (narrative, digital illustrations.)

Name of method: Soil Behavior Processes

Description: This method of interpreting soil behavior relies on the identification and characterization of pedoloqic processes that occur in a soil and that contribute to the daily or yearly functioning of the ecosystem (natural or aqroecosysteme).

Pedoloqic processes characterize soil behavior, not soil genesis. Performance of pedoloqic processes is effected by physical, chemical and biological properties of the soil. Pedoloqic processes can result in temporal variations in measured soil property values. Temporal variability may occur at any time frequency (diurnal, seasonal, etc.) Temporal variability can occur in response to use and management, successional statue, climate and weather.

Examples of pedoloqic processes are nutrient cycling, water movement through soils, freezing and thawing).

Application: An understanding of pedoloqic processes would add quality to all soil management decisions. Pedoloqic processes information could be applied at any scale (field, watershed, ecosystem). A description of the performance of pedoloqic processes of a given soil would be used in decision making for many activities. Examples include: designing management plane to improve soil health or condition: supporting ecosystem based planning, selecting suitable manaqement practices, or scheduling time of operation (such as logging, irrigation).

Methods of Display: Needs further brainstorming.

Other information: None

Further committee work needed: Identify and define pedologic processes.

Submitted by: *Arlene* **J. Tugel, 5/19/94**

Soil Survey of Aquila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona

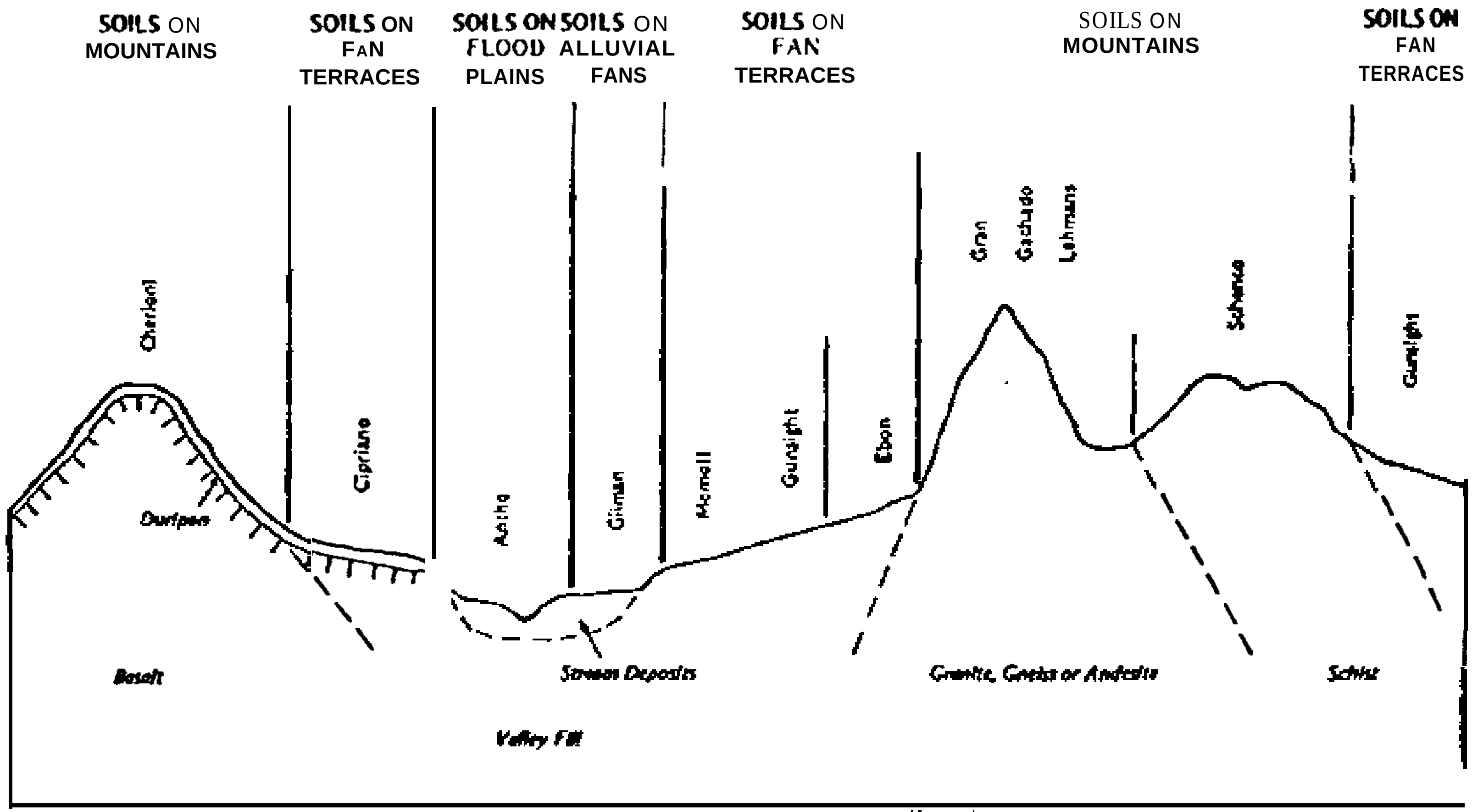


Figure 13.—Idealized soil-landscape profile.

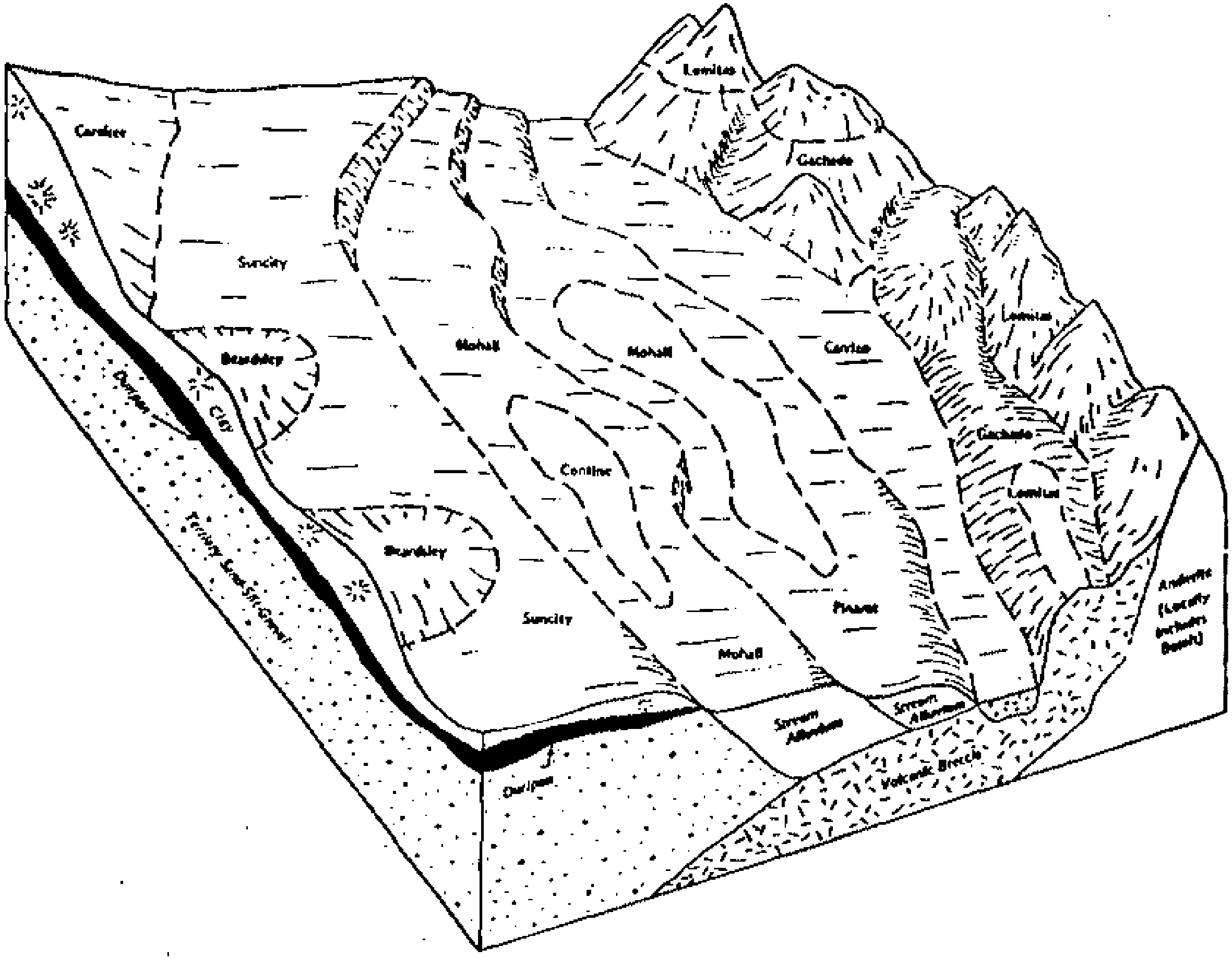
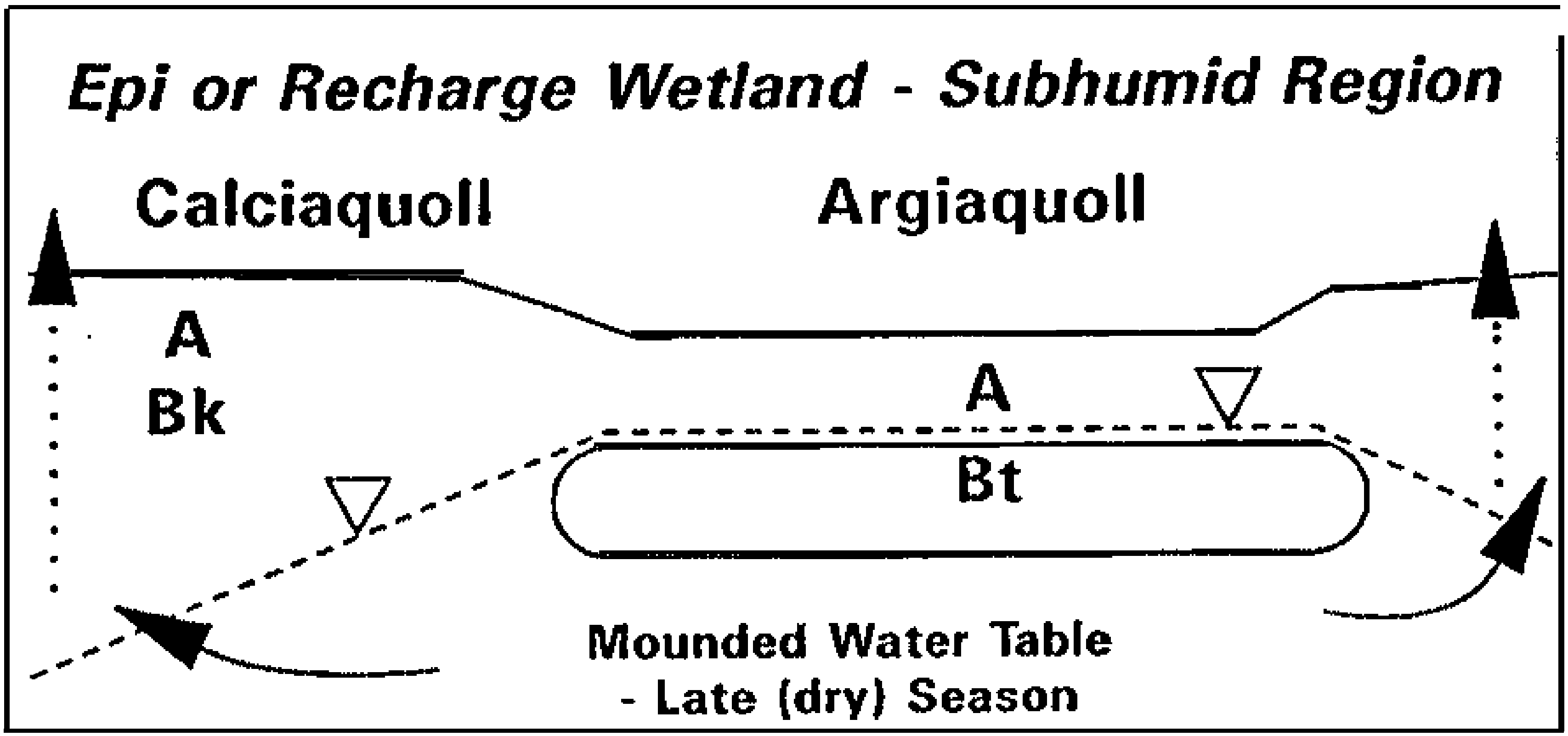


Figure 14.--Diagram of Agua Fria River-Lake Pleasant area.

Epiaquic or Recharge Depression During the Dry Down Phase



(after Richardson, 1993)

Figur ?

Epiaquic or Recharge Depression with a Mounded (Perched) Water Table

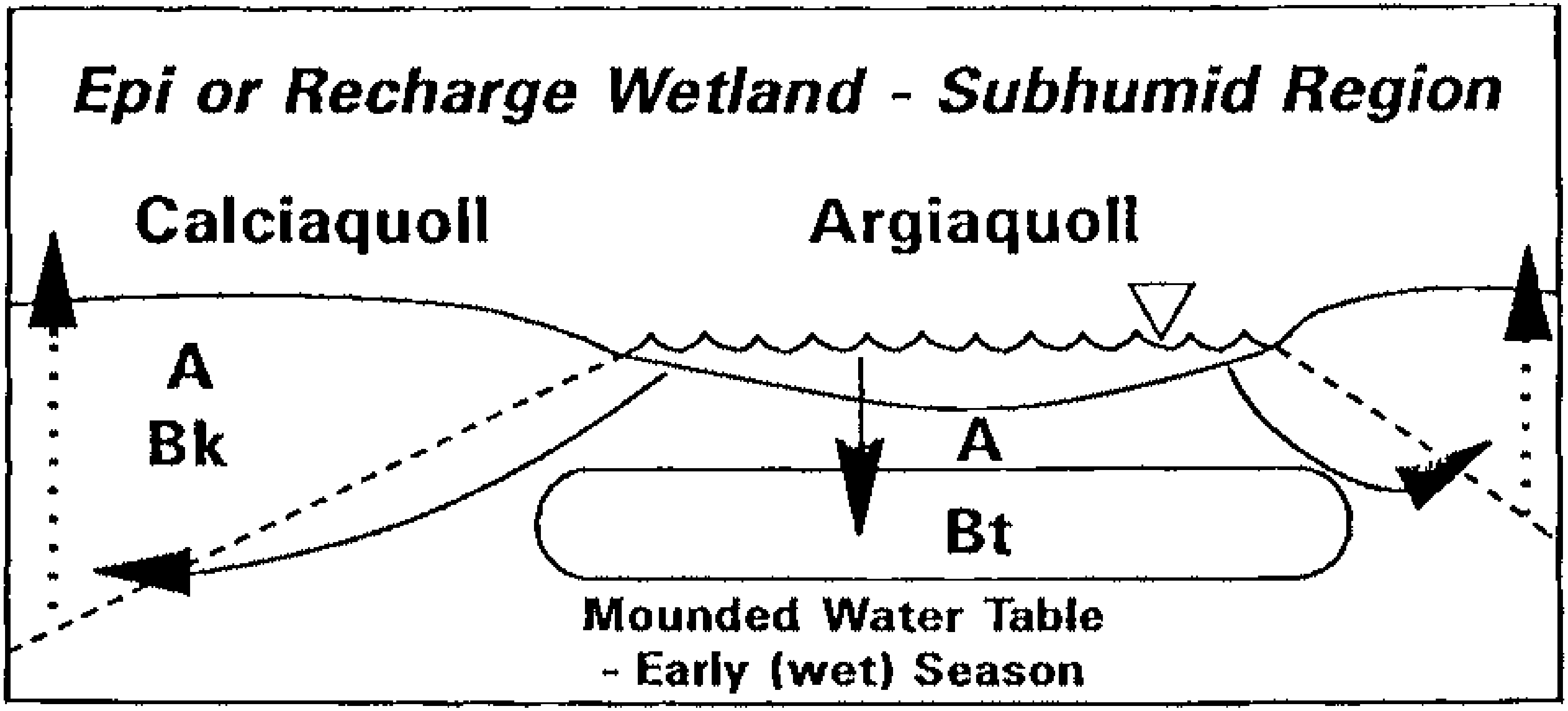


Figure 6

(after Richardson, 1993)

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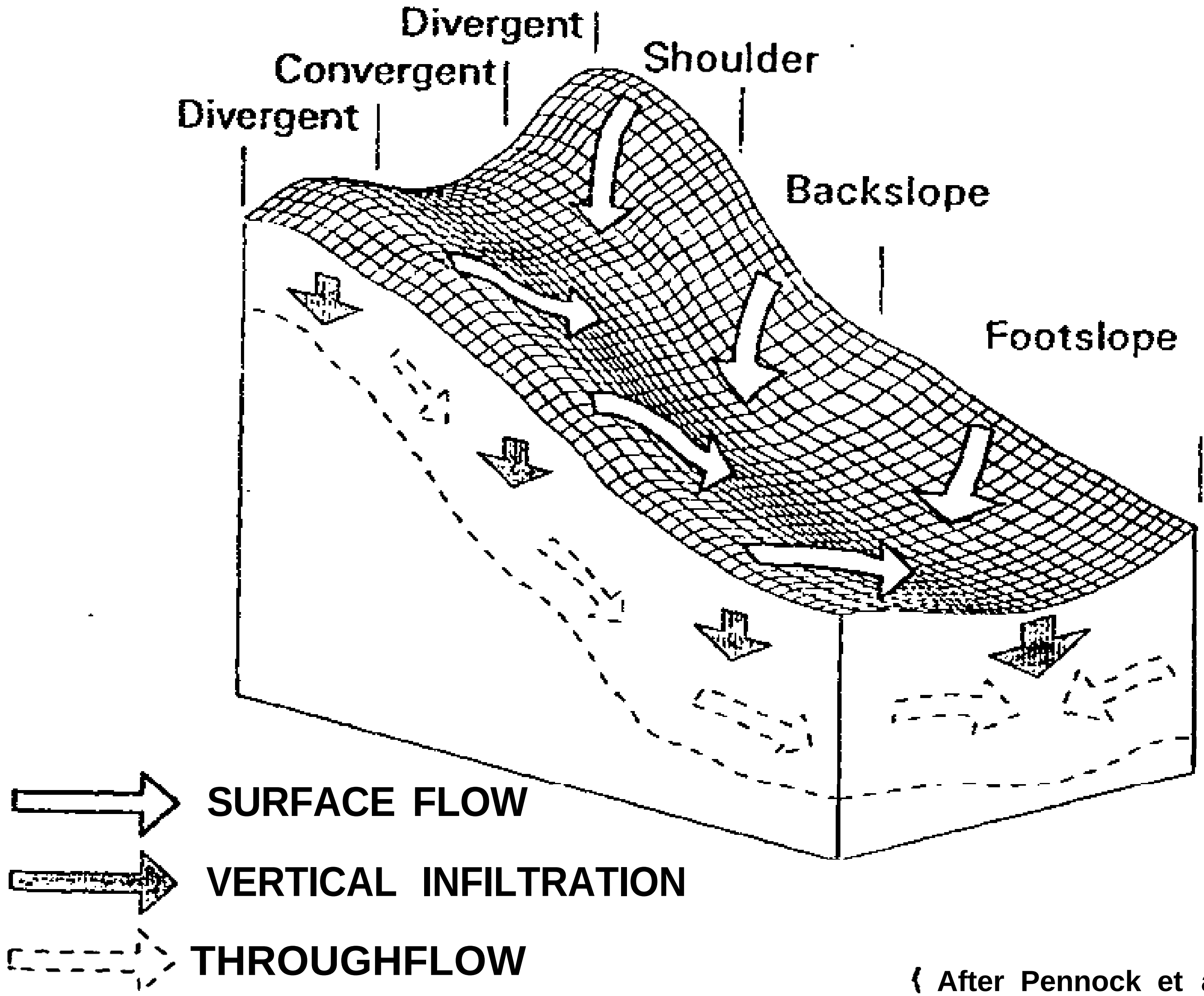

(After Pennock et al., 1987)

re 5.

DEVELOPING NEW WAYS TO DISPLAY INTERPRETATIONS

Suggested idea: No. 6 Make interpretations between the landscape and soil.

Name of method: Displaying Landfonn/Landscape Soil Relationships

Description: Additional information about landform and landscape soil relationships is needed by soil survey user. This information is needed to meet the requirements of FSA, HEL, CRP, NEPA, Clean Water Act and others. Clearer presentation of our existing knowledge and better understanding of these relationships (and hence the 'local landscape model') will begin to meet the above needs. Developing new ways to present this information will help us identify wetlands and riparian areas and develop leaching indices. In addition it will help us determine the impact of applied conservation practices or changes in land use.

The following questions should be considered when developing additional information and new display systems:

1. Which soils are associated with which landforms and landscapes?

2. What is the relationship between the soils on the landscape/landform?

3. How do these relationships affect:

   water movement across the soil surface and within the soil profile?
   erosion and deposition?
   groundwater movement and leaching?
   soil genesis and soil survey?

Application: Traditionally soil surveys have presented much of the landscape/landform information as narrative in mapping units and taxonomic units. Some soil surveys also present some information about soil series as block diagrams and topographic sequences. Block diagrams and topographic sequences could be modified to present map unit, component or general soil unit information rather than just series relationships. Computer graphics, GIS or image processing or landscape pictures could update these traditional presentations of soils information.

Methods of display: Block diagrams or topographic sequences could be developed for general soil units. They could be developed of the major landforms where the units occur, showing the landscape positions they include.
The named components (or their symbols) could be displayed on the diagrams rather than just the soil series names as we have done traditionally.

Diagrams could be developed for soil surveys at any level of detail. Order 2 consociations could have 2 or 3 of the associated map units displayed on one landform diagram or the potential location of inclusions. The components of complexes and associations could be displayed similarly.

Toposequences with the parent material identified could be developed for each major drainage within the soil survey. The location of each block diagram along the toposeguence could be identified leading to better understanding of the landform/landscape relationships of the entire survey.

Color or black and white pictures of the landforms/landscapes of a survey area could be used to display the typical location of the map units or components. Image processing makes it possible to delineate the landforms and landscapes on a picture of a typical area and show the direction of water movement.

Dr. Richardson of Montana State University has also developed a series of diagrams showing landscape hydrology. He indicates the direction of water movement within the soil and the vadose zone. He shows where wetlands tend to develop based on lateral movement, where salts will tend to accumulate and what types of soils will tend to develop in groundwater recharge and discharge zones. These types of diagrams also have potential to display additional soil information more clearly. These diagrams could be used to display map units, components, inclusions, etc. They could also be developed on landscape pictures using image processing.

Submitted by: Carol Franks

NEW INTERPRETATION METHOD

Submitted by: Christopher W. Smith 6/6/94
(808) 541-2605

Suggested idea:
No. 7 Affect of use dependent processes on soil properties.

Name of Method:
Use dependent soil properties.

Description:
Soil properties that are altered with use vary as a function of initial soil conditions, use, management, and other environmental factors. The uses encompassed here include agriculture, forestry, and grazing land or those that make use of the natural soil and not those that drastically disturb the soil such as in many construction activities. Major changes can occur in organic matter content, structure, bulk density, pore size distribution and continuity, acidity or alkalinity/sodicity, surface crusting, fertility level, cycling and balance, CEC or buffer capacity, soil organism populations and heterogeneity, temperature and moisture retention, and transmission/characteristics. Many of these changes, while changing from an uncultuvated state, change within a crop cycle as well.

Application:
Users need to know how properties vary between and within uses to facilitate planning and modeling efforts. As examples: fertility tests report nutrient contents on a mass basis while fertilizers are applied into a volume of soil. Bulk density for a pasture is different than under cultivation for the same soil. Bulk density is different at the beginning of a planting than at harvest. Hydrologic modeling is affected by changing infiltration rates through the season. Pesticides are sorbed and degraded at different rates as a function of organic matter content say in forest understory competition eradication vs. in a cornfield. Nutrient retention and leaching rates would be less for a soil higher in organic matter at higher pH values vs. the same soil acidified by fertilizer applications with lowered organic matter contents due to cultivation.

Methods of Display:
By soil phase within NASIS by use and management typical for that soil by temporal sorting such as "newly cultivated, mature cropped fields", early, mid and late season or whatever is appropriate. Programming algorthms would be better in that and date could be input for refined output. This type of approached is being used in RUSLE for parameters like the C factor.

Other information:
Considerable literature exists on the topic.

Further Committee Work Needed:
Collating data after assistants perform literature search. Suggest further research for Universities, soil tilth lab, ARS, etc.

NEW INTERPRETATION METHODS

Suggested idea: No. 9 Develop criteria and standards to assess soil and watershed conditions.

Name of Method: Soil Health/Proper Functioning Condition

Description: Field evaluation of soil health relies on the identification and characterization of pedologic properties which control or contribute to the daily functioning of a natural ecosystem.

Soil physical and/or chemical properties strongly influence, and in many instances control, the biological functions of a soil. Variability within and by the many soil types occurs in response to use, management, plant community or seral stage and climate.

An example of soil properties vital to biological functions is: vesicular crusts versus granular structure of a soil surface horizon.

Application: Identification and evaluation of minimum soil attributes to address its current health status and aid in the development of soil management strategies and decisions. When combined with vegetative and hydrologic attributes an assessment of watershed health could be determined.

Methods of Display: After evaluation soils would be placed into one of three groups: A) Proper functioning condition, B) Functioning at Risk, and C) Not functioning.

Other information: Soil attributes are to be selected for use on soils and landscapes that are under native plant species (non-natives included). Attributes should relate to a tiered system. A two or three tiered system would allow for attribute assessments to be done at different intensities for uses varying from site specific to a watershed or Major Land Resource Area (Ecological area).

Further committee work needs: Assistance in selecting soil attributes and the methods (point or plot) used for field evaluations varying from specific to broad in scope.

submitted by: William P. Volk

SOIL SURVEY ENHANCEMENT

INTERPRETATIONS FOR MISCELLANEOUS LAND TYPES

Suggested idea: No. 10 Prepare guidelines to develop interpretations for miscellaneous land types, higher taxonomic units and geologic units.

It is proposed that suitable soil interpretations for badland, rock outcrop, rubbleland, and similar type mapping units be developed for BLM multiple use management programs. These types of mapping units have soil limitations that generally preclude their use for commercial crop production, etc. They, however, have important watershed, wildlife, and scenic resource values. Physical, chemical, vegetative, and other management data have not been developed for these mapping units. The management problem is further compounded because of the acreage involved, i.e., lots of rangeland without adequate soil interpretative data. Management interpretations are needed for these mapping units.

Name of Method: Development of geologic/sol form 5 for these landscape/mapping units including associated vegetative conditions suitable for ecological site identification at a total mapping unit level. Example of a geologic 5 is attached.

Description: ELM particularly needs management interpretations on these mapping units for:

- Watershed analysis as it relates to water quality and reclamation potential to meet salinity control goals for the Colorado River.

- Resiliency rating on these particular and other mapping units is needed for various BLM management actions.

- Associated vegetative conditions suitable for ecological site determination is needed. Many of these areas have limited vegetative production capability even though they support the potential natural community for the area.

In summary, work here means identifying existing soil/vegetative attributes for the mapping unit.

Application:

- Salinity ratings in excess of 16 mmhos/cm is needed. Plant growth is occurring above 16 mmhos/cm ratings. Significant categories need to be developed. Off-site salinity contributions are important.

- Reaction of geologic materials (pH) is needed and we expect to use guides similar to those for soils.

- Potential wind and water erosion hazard ratings are also needed. Updating for acceptable "T" values on shallow and very shallow soils should accompany this effort. Any soil loss on these kinds of mapping units is extremely detrimental to the productive capacity of the soil.

- Soil resilience determinations are needed as this soil property is affected by BLM management actions. Particular attention is needed for identification of associated geologic formation and its condition.

- Runoff characterization/hydrologic groupingdeterminationis needed for watershed management planning and various project design.

-Ecological site interpretations suitable for ecosystem management is needed.

In summary, greater understanding is needed on the interaction of the landscape/soil/parent (geologic) material and the planned uses.

Methods of Display: Similar to soil interpretations with geologic supplements

Cther information: Further research is needed to develop physical, chemical, and associated plant relationships.

Further committee work needed: BLM would appreciate committee recommendation that SCS/BLM soil scientists complete an interagency agreement covering this action in FY95.

Submitted by Dick Page
BLM Utah State Office
6/10/94

SOIL

GEOLOGIC INTERPRETATIONS RECORD

(SAMPLE)

MLRA(S) | KIND OF UNIT | UNIT NAME

DATE | RECORD SC | AUTHOR(S) | DATE | REVISED | UNIT MODIFIER

CLASSIFICATION:

BRIEF SOIL DESCRIPTION:

LANDSCAPE AND CLIMATE PROPERTIES

ANNUAL AIR TEMPERATURE	FROST FREE DAYS	ANNUAL PRECIPITATION	ELEVATION (FT)	DRAINAGE CLASS	SLOPE (PCT)

ESTIMATED SOIL PROPERTIES

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT >10 IN (PCT)	FRACT 3-10 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	CLAY (PCT)

DEPTH (IN.)	LIQUID LIMIT	PLASTICITY INDEX	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SAR	CEC (ME/100G)	CACO3 (PCT)	GYPSUM (PCT)

DEPTH (IN.)	ORGANIC MATTER (PCT)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	T	WIND ERODIBILITY GROUP	WIND ERODIBILITY INDEX	CORROSIVITY STEEL	CONCRETE

FREQUENCY	DURATION	MONTHS	DEPTH (FT)	KIND	MONTHS	DEPTH (IN)	HARDNESS	DEPTH (IN)	HARDNESS	INIT. (IN)	TOTAL (IN)	HYD GROUP	FROST ACTION
FLOODING			SATURATED ZONE			CEMENTED PAN		BEDROCK		SUBSIDENCE			

Geologic Interpretation Record

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NEW WAYS TO MAKE INTERPRETATIONS

Suggested item: No. 13 Use soil potential to give relative values to different types of land values.

Name of method: Relative soil potential.

Description: This method of developing soil interpretations uses the standard concepts used in developing soil potentials for a specific land use and compares the results for one land use with the results for other land uses. This method could be used to determine the best use of land within a given area.

Soil potentials are used to provide more definitive information regarding an areas potential for a given land use than those provided through the soil interpretations record. However, soil potentials and soil interpretations records share a common characteristic, they both show relatively good ratings for one group of soils for most land uses and relatively poor ratings for another group of soils for most land uses with no way of relating the information to allow the determination of the best use of a given area.

Application: Developing soil potentials for common land uses in an area can provide useful information about the potential of a given area for a given land use. However, soil potentials could also be used to assist in providing comprehensive land use plans. This could be done by comparing the potential for one land use with potentials for other land uses to develop a relative soil potential for each spot within a given area. This type of system could allow an area that has severe limitations for both cropland and homesites and medium potential for both cropland and homesites to have a "highest potential" for homesites because the cost of implementing this land use and the cost of dealing with continuing limitations may be lowest for that proposed land use.

Methods of display: Hard copy maps/text, GIS.

Other information: None

Further work: Method of calculating relative values.

Submitted by: Jon Gerken

Soil Survey Conference Committee 6:
New Ways of Making Soil Survey Interpretations

An outcome of the group discussion resulted in the breakdown of what we understood of the charge. In lieu of "New ways of making soil survey interpretations" we decided on the following title and subject divisions.

Alternatives to Traditional Soil Interpretations
1. Monitoring and Assessment
2. Making Interpretations
3. Dieplaying Information

The proposed action I am presenting here is involved vlth item 3 - Displaying Information but also involves item 2.

In a teleconference • easlon prior to the conference an emphasis on supporting thr positive qualities of soils vas brought out. With that in mind I proposed an approach to displaying interpretations for uses of soils based on soil properties that does not rely on the negative interpretation such as a severe rating.

Suggested Idea: No. 15. Select a specific use, determine the soil properties affecting the use, then query the database for a listing of optimal rites based on appropriate soil properties and characteristics.

Name Of Method: Selection of optimal site for intended use based on soil properties and characteristics utilizing the NASIS Interpretations Generator Module (IGH).

Description: This method is basically the reverse of the current method used to display soil interpretations in soil survey roports. Instead of having the site picked out and then look up the suitability for a given use this method allows a manager/user to start with a specific us6 and then find the optimal soil typo location for such use.

currently under development in NASIS is the Interpretations Generator Module (IGM). The IGM uses roil interpretive criteria to construct and • xeoute a query of the soil component properties database (MUIR), then reports the resulting interpretations. That is to say the IGM starts with a use, determines the criteria, looks at the roll properties, and lists soils meeting selected criteria.

The IGM consists of two modules; Interpretation Criteria module, Jnterpratation Generator Module. A user selects criteria for a specific use with the Interpretation Criteria Module then invoke6 the Interpretation Generator Module that joins the criteria with the soil component properties data (MUIR) to generate a rating.

Application: This method not only focuses on tha positive aspects of the soil but is designed to be flexible to the manager/user.

I proposa to select a soil survey that is ● ithax in the maintananca mode as part of a MLRA Update, or a survey that is ongoing. Posaibla survey areas include the update of tha Island of Hawaii or a rurvry on Forest Service lands such as the Wat Mountains/Spanish Peaks survey area in Colorado. Choosing a Purvay on the Forest presents us in SCS with an opportunity to promote the soils database and illustrate ways to utilize the information.

Methods of Display: Reports that list and rank roils from most optimal for tha use to least optimal. Also, linkaga with spatial data through a GIS oould provide a "picture" of the optimally suited areas.

Further **work needed:** Specific study site determined. Availability of the Interpretations Generator Module la not ● xpactad until February or March of 1995. Actual use of the IGM will have to wait until such time as its available for testing.

Submitted By: Cameron Loerch 8/29/95

South Dakota asked if there was an ***interest*** in a Sunday meeting. It was decided to send out a questionnaire to see about interest,

The **ASA** meeting is set for November **12-18**, 1594 in Seattle. A steering committee meeting during the NCSS meting is set for San Diego in June or July 1995. Steve Shetron motioned the meeting be adjourned and it was seconded by Wayne **Bachman,** South Dakota. The meeting was adjourned.

Midwest Region Business Meeting
June 17, 1994

Meeting was called to order by Nathan McCaleb, Chairman.

About 40 members from the Midwest attended this years joint conference. South Dakota was nominated by Steve Shetron, Michigan and Jon Gierken, Ohio seconded the motion to host the 1996 Midwest National Cooperative Soil Survey conference. The rotation set up has the Missouri Experiment Station listed to host the 1998 conference.

Old Business:

Taxonomy Committee: There should be 3 NCR and 3 SCS members on the taxonomy committee. At the present time only one of the three SCS members are known. Two years ago in St. Paul, it was decided that the national leader for taxonomy would receive any regional suggested changes or additions to soil taxonomy instead of going to the Midwest National Technical Center lead soil scientist. Because of reorganization, it was motioned by Bob Ahrens that Soil Taxonomy suggestions or additions go directly to him at the National Soil Survey Center and then he would distribute to the members of the regional committees. This was agreed upon by the attending representatives. Also, it was suggested that members of the committee would be selected by alphabetical order or on a regional approach. Nathan will review both methods for selecting the SCS members and let them.

Committee reports for the joint meeting were accepted during the general session.

New Business:

Next steering committee will be set up in the near future. At this time it includes Nathan McCaleb, Ken Olson, and Jerome Schaar.

Nathan McCaleb left a few charges that members of the Midwest NCSS need to let there ideas be known to the steering committee prior to final arrangements for the 1996 South Dakota meeting. They were: consider current format, length of meeting, has it been efficient, is there a better format, and can there be a better electronic transfer of information.

Ken Olson summarized 50 questionnaires from the St. Paul Meeting that discussed some of the items Nathan wanted each member to review. One of the answers was that the committee work needed to be expanded. Another was that there needed to be an accountability from the MNTC and NSSC staffs for the charges.

The present membership of the West Regional Taxonomy Committee is as follows:

Permanent Chair:	Robert Ahrens
Permanent Member:	Dennis Heil
State Representatives:	Randy Southard
	Chein Lu Ping
	Dave Hendricks*
Federal Representatives:	John Nesser*
	Terry Aho

* New Members

Site for 1996 Conference:

Two states, Colorado and Montana, volunteered to host the 1996 Regional Conference. Due to the fact that too few voting members remained, the membership will vote on the site through mail vote. The two states will submit proposals to Dennis Heil to be circulated for voting.

There being no-further business, a motion was made by Neil Peterson, seconded by Chad McGrath, to adjourn. Motion carried.

WEST REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE
BUSINESS MEETING
JUNE 17, 1994

The Conference Business meeting was held on completion of the conference committee reports. The meeting was called to order by Dennis Heil, Chairman, at 10:00 am on Friday June 17, 1994. The minutes are as follows.

Conference Committees:

Motion was made by Neil Smeck to accept the Committee 1 report on 'The Role of the NCSS in Site Specific Soil Survey' as presented by Del Mokma. Seconded by Eddie Garner. Motion carried.

Motion was made by Del Mokma to accept the Committee 2 report on 'Drastically Altered Soils' as presented by Sam Indorante. Seconded by Ken Olsen. Motion carried.

Motion was made by Bill Ypsilantis to accept the Committee 3 report on 'Ecosystem Based Soil Surveys for Resource Planning' as presented by Bob Meurisse. Seconded by Dave Maurer. Motion carried.

Motion was made by Nathan McCaleb to accept the Committee 4 report on 'Distribution and Access to Soil Survey Data' as presented by Scott Davis. Seconded by Tommie Parham. Motion carried.

Motion was made by Karl Hipple to accept Committee 5 report on 'Redefining the Cooperative Role in the NCSS' as presented by Paul McDaniel. Seconded by Eddie Garner. Motion carried.

Motion was made by Bill Dollarhide to accept Committee 6 report on 'Alternatives to Traditional Soil Interpretations' as presented by Arlene Tugel. Seconded by Duane Lammers. Motion carried.

Regional Taxonomy Committee:

The membership of the West Regional Taxonomy Committee has been changed. This change, approved by a membership mail vote in late 1993, is to facilitate the processing of proposed amendments to taxonomy. The member ship of the committee will be as follows:

Permanent Chair: Lead Soil Scientist, Soil Taxonomy, SCS
Permanent Member: Regional Soil Scientist, WNTC, SCS
Three federal representatives
Three state representatives

The conference by-laws will be amended to reflect this change.

NATIONAL COOPERATIVE SOIL SURVEY

Western Regional Conference Proceedings

Flagstaff, Arizona
June 22-26, 1992

P R O C E E D I N G S

of the

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

JUNE 22-26, 1992

NORTHERN ARIZONA UNIVERSITY
FLAGSTAFF, ARIZONA

Western Regional Cooperative Soil Survey Conference

Sponsored by
Arizona Chapter, Soil and Water Conservation Society

Northern Arizona University
Flagstaff, Arizona
June 22 to June 26, 1992

Sunday, June 21

2:00 – 5:00 **Registration**
Havasupai Room – *University Union* **Building**

Monday, June 22

9:00 – 12:00 **Registration**
Havasupai **Room** – *University Union Building*

1:00 – 1:15 **Opening remarks**
– Wayne Robbie, Conference Chairman. Forest Service, Albuquerque, NM
– Gary Wendt. President-Elect, Arizona Chapter, Soil and Water Conservation Society

1:15 – 1:30 **Welcome by Soil Conservation Service**
– Donald Gohmert, State Conservationist, Phoenix, AZ

1:30 – 1:45 **Welcome by Forest Service**
– Doug Shaw. Acting Director, Watershed and Air Management, Albuquerque, NM

1:45 – 2:00 **Welcome by University of Arizona**
– Dr. Ian L Pepper, Department of Soil and Water Sciences, Tucson, AZ

2:00 – 2:15 **Welcome by Bureau of Land Management**
– John Stephenson, Branch Chief, Biological Resources, State Office, Phoenix, AZ

Agency Reports

2:15 – 2:30 **Soil Conservation Service**
– Bill Roth, SCS, National Headquaters, Washington, DC

2:30 – 2:45 **Forest Service**
– Wayne Robbie. Forest Service, Albuquerque, NM

2:45 – 3:00 **Bureau of Land Management**
– Colin Voight, Bureau of Land Management, Washington, DC

3:00 – 3:15 **Western Region Agricultural Experimental Stations**
– Dr. Lanny Lund, University of California, Riverside, CA

3:15 – 3:45 **Break**

3:45 – 5:00 **Agency Meetings**

USDA Soil Conservation Service
Havasupai Room A

USDA Forest Service
Sycamore *Room*

USDI Bureau of Land Management
Havasupai Room B

Western Region Agricukural Experimental Stations
Havasupai Room C

6:30 – 8:00 **Conference Reception**
Atrium Room – University Union Building

Tuesday, June 23

Identification and Understandlna of User Requirements
Session Moderator: Hayes Dye, SCS, Anchorage, AK

8:00 – 8:30 **World Soil Resources: Current and Future Activities**
– Paul Reich, SCS, National Headquarters, Washington,DC

8:30 – 9:00 **Public Participation Process Considerations**
– A. Keith Miller, Bureau of Land Management, Phoenix AZ

9:00 – 9:30 **What We Need to Know About Soil Water Relationships**
– Dr. Otto Baumer, National Soil Survey Center, Lincoln, NB

9:30 – 10:00 **Break**

10:00 – 12:00 **Committee Meetings**

Identification and Undemanding of User Requirements
Havasupai Roam A

Information Management of Soil Data
Havasupai *Room B*

Conducting Soil Surveys to Meet Management Needs of Wetlands and Riparian Areas
Havasupai Room C

Use of Soil Surveys for Environmental Issues and Concerns
Sycamore *Room*

12:00 – 1:00 **Lunch**

Information Management of Soils Data
Session Moderator: *Russ Krapf, BLM, Phoenix, A2*

1:00 – 1:30	**The Development of an Integrated Natural Resource Planning Environment** – Dave Anderson, SCS, Fort Collins, CO
1:30 – 2:00	**State Soil Geographic Data Base** – Dennis Lytle, SCS. National Soil Survey Center, Lincoln, NE
2:00 – 2:30	**Remote Sensing In Soil Science** – Dr. William Krausmann. Forest Service, Albuquerque. NM
2:30 – 3:00	Break
3:00 – 3:30	**Overview of the National Cartographic and Geographic Information System Services Center** – Hugh Allcon, SCS, Fort Worth, TX
3:30 – 4:00	**Recent Advances in Soil Taxonomy** – Robert Ahrens, SCS. National Soil Survey Center. Lincoln, NB
4:00 – 4:30	**Field Trip Orientation** – Dr. David Hendricks, University of Arizona, Tucson, AZ – Greg Miller, Forest Service, Flagstaff, AZ
4:30	Adjourn
8:00 – 9:30	Lowell Observatory Tour

Wednesday, June 24

CONFERENCE FIELD TOUR
Busses Depart from University Union Building at 7:00 am

stop #1	SUNSET CRATER NATIONAL MONUMENT – Carla Britton, Park Ranger, USDI NPS
stop #2	COCONINO NATIONAL FOREST – Francis Crater. Soil Pedon
stop #3	FORT VALLEY EXPERIMENTAL FOREST – Forest Service Research
stop #4	COCONINO NATIONAL FOREST – Fairfield Snowbowl, Soil Pedon
stop #5	COCONINO NATIONAL FOREST – Kendrick Park, Soil Pedon

Thursday, June 25

Conducting Soil Surveys to Meet Management Needs of Wetland and Riparian Areas
Session Moderator: *Earl Alexander, Forest Service, Ogden, UT*

8:00 – 8:30 **National Wetland Inventory Program**
– Warren Hagenbuck. Fish and Wildlife Service, Albuquerque, NM

8:30 – 9:00 **National Hydric Soils Committee**
– Lawson Spivey, SCS, National Headquarters, Washington. DC

9:00 – 9:30 **Forest Service Riparian Initiative in the Southwest**
– Russ LaFayette, Forest Service, Albuquerque, NM

9:30 – 10:00 **Break**

10:00 – 10:30 **A Landscape Approach to Riparian and Wetland Mapping**
– Mark Jensen, Forest Service. Missoula, MT

10:30 – 11:30 **The Future Role of University Agricultural Experimental Station Representatives** - *Open Conference Discussion*
– Experimental Station Representatives

11:30 – 1:00 **Lunch**

Use of Soil Surveys for Environmental Issues and Concerns
Session Moderator: Carol Wettstein, *SCS, Lakewood, CO*

1:00 – 1:30 **The Use of Ecological Unit Inventories to Implement Soil Quality Standards in the Intermountain Region**
– Tom Collins, Forest Service, Ogden, UT

1:30 – 2:00 **Global Change**
– Debby Potter, Forest Service, Albuquerque, NM

2:00 – 2:30 **Alteration of Soil and Hydrologic Properties In Rangelands Treated With Municipal Sewage Sludge**
– Dr. Richard Aguilar, Forest Service Research, Albuquerque, NM

2:30 – 3:00 **Mine-Land Reclamation Issues**
– Valdasue S. Crain, Buchanan Consultants, Farmington, NM

3:00 – 3:30 **Break**

3:30 – 5:00 **Committee Meetings**

Identification and Understanding of User Requirements
Havasupai Room A

Information Managemem of Soil Data
Havasupai Room B

Conducting Soil Surveys to Meet Management Needs of Wetlands and Riparian Areas
Havasupai Room C

Use of Soil Surveys for Environmental Issues and Concerns
Sycamore *Room*

Friday, June 26

Committee Reports

8:00 – 8:30 **Soil Science Practices Act**
– John Munn, California Department of Forestry and Fire Protection, Sacramento, CA

8:30 – 9:00 **Conducting Soil Surveys to Meet Management Needs for Wetlands and Riparian Areas**
– Mark Jensen, Forest Service, Missoula, MT

9:00 – 9:30 **Soil Survey Information Management**
– Ferris Allgood, SCS, Salt Lake City, UT

9:30 – 10:00 **Break**

10:00 – 10:30 **Identification and Understanding of User Requirements**
– Arlene Tugel, SCS. Davis, CA

10:30 – 11:00 **The Use of Soil Surveys for Environmental Issues and Concerns**
– Dr. Gene Kelly, Colorado State University, Fort Collins, CO

11:00 – 12:00 **Conference Business Meeting**
– Dennis Heil, SCS, Portland, OR

12:00 **Adjourn**

To advance the science and art of good land and water use worldwide

SOIL
AND WATER
CONSERVATION
SOCIETY

June 1992

To: Participants in the Western Regional Cooperative Soil Survey Conference

From: Doug Pease, President of the Arizona Chapter, SWCS

Dear Participants:

Welcome to Arizona. to Flagstaff, and to the Western Regional Cooperative Soil Survey Conference. We hope that your stay in Flagstaff will be pleasant and profitable. Our desire is that you return to your homes and to your jobs with a renewed desire to see an even greater cooperation in your soil survey efforts.

You may wonder why is the Soil and Water Conservation Society sponsoring this conference. There are several reasons. First, we were asked to be the sponsor. Secondly, the objectives of your conference is in part to complete a once over soil survey of the United States and to get more conservation on the ground. The objective of our Society is to provide a source of information on multidisciplinary, multi-institutional emphasis on land and water management issues. I believe that our basic objectives have a common thread. I could name other reasons, but I think you can formulate several yourself.

Many of you may already be members of the Soil and Water Conservation Society and also members of your local chapter. If you are not a member, I encourage you to stop back at the registration table to talk to one of our members and to pick up an application form. Excellence in land and water management demands the multidisciplinary attention of skilled scientists, like yourself. Your assistance is needed.

I have participated in several of the Western Regional Cooperative Soil Survey Conferences in the past. I know many of you personally and would enjoy renewing acquaitance with you. It would nice for me to be a participant in your conference this week. Unfortunately, I have other commitments in Phoenix during the week.

Enjoy your conference, have fun in Arizona and Flagstaff, and return home safely with renewed vigor.

Sincerely yours,

Doug Pease

WEST REGIONAL SOIL SURVEY CONFERENCE

June 22-26, 1992

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WELCOME

DONALD GOHMERT
State Conservationist
Soil Conservation Service,
Phoenix, Arizona

Thank you, Wayne. This is really my first opportunity to plug into a regional soils conference, and it's really my pleasure to do so. Before I get started with the remarks that I have, I would like to say a big "thank you" to NAU for sharing their hospitality and inviting us to the campus here. And certainly a thank you to the Soil and Water Conservation Society and the work that they are doing to facilitate this session, and I think Wayne is very modest when he introduces his steering committee which worked hard here, but certainly Wayne was the driving force behind that committee. He kept it going, and Wayne, we appreciate that.

On behalf of the Soil Conservation Service, let me welcome all of you to Arizona. It is the sixth largest state in the country, has been a state since 1912, and has about 73 million acres. I'd like to show you around our state by way of a few slides.

In a state of this size, larger than all six northeastern states combined, we only have 15 counties. But it is one of the fastest growing states. People are leaving the rust belt for the sun belt. Obviously that puts pressures on the resources here.

As people move from east to west, they are finding that states like Arizona, and many of the Western states represented here, are very desirable places to live. This is putting more and more pressure on the resources and it means that we need to be better at what we are doing in interpreting the strengths and weaknesses of the ability and capability of the soils that we have here to support these kinds of pressures.

In Arizona we have eight major land'resource areas: three are physiographic provinces - the Colorado Plateau, the Transition Zone, and the Basin and Range. We have all but two of the major soil taxonomic orders in this state, all but one of the major moisture regimes, and all but one of the major temperature regimes. So we are quite varied.

Elevation ranges from less than 100 feet in Yuma to over 13,000 feet. Precipitation ranges from 2 to 3 inches down in Yuma to more than 35 inches on Mount Humphreys Peak. A very interesting state, a very diversified state - one in which we have a presence statewide. On 96 percent of the state, the Soil Conservation Service through its delivery system, the Conservation Districts, services cooperators around the state.

Coordinated resource planning is very important to us because of this patch-quilt of ownership. The BLM and the Forest Service together operate about 32 percent of the public lands, the other 10 percent of the Federal lands are National Park, military reservations, Fish and Wildlife Service, Bureau of Reclamation, etc. So there is about 42 percent of the state under federal operation.

About 28 percent is in Indian Lands on 22 reservations, 17 percent is privately owned and about 13 percent is state owned.

Soil Conservation Service provides its assistance through the Conservation Districts, of which there are 39 - 38 in Arizona and 1 in California that we provide assistance to on an agreement with that state.

We have about 7,000 to 8,000 operating units. The 22 reservations and state land are considered private land. Basically, we are looking at about 58 percent of the state that we provide direct assistance to. We are working with the federal agencies primarily on a coordinated basis on the rest of it.

Because of the patch-work quilt ownership pattern, this activity is very important to us - the activity of coordinating soil surveys, trying to get them to national standards, because we need uniformity and consistency in the interpretations and applications of those interpretations statewide. Just because its on public land doesn't mean it doesn't have an impact on private land. And what they do on private land certainly has an impact on public lands. It is very important that we get together and work with the decision makers, whomever they are and whereever they are, with some consistency in interpretation and application of our soils data.

We provide assistance to all but two of the 22 reservations statewide - the Hopi and White Mountain Apache. The Hopi Reservation in the north and the White Mountain Apache Reservation in the east center of the state have chosen not to organize conservation districts. They can organize under state code or tribal code, but these two reservations have not yet decided to organize under either.

There are 15 counties in Arizona. Because of the size of the counties - ranging from less than 800,000 acres to 12 million acres - our soil surveys do not coinside with county boundaries like they do in most of the states east of here.

The Soil Conservation Service has divided the state into two administrative areas - Flagstaff being one area with an Area Conservationist that operates and supervises the operations in the Northern half of the state. The other Area Conservationist is located in Tucson and supervises all SCS operations in the southern half of the state.

We have eight different programs in the state provided through 22 field offices. We have 6 operational, functioning soil survey projects in the state. I am proud to say these are not just SCS projects, but cooperative projects with the BIA, the BLM, and we are looking forward to moving into a cooperative effort in Sedona and Black Hills with the Forest Service in the next few months.

Arizona has about 40 different vegetable type crops that they grow at any one time - that is in addition to the field crops of cotton, alfalfa, and grain crops. As you can see, with 40 different vegetable type crops grown in the state, soil surveys are very important to us, and to the user, and gives a lot of diversity to our agriculture in the state.

There are about 1.1 million acres of cropland in this state, most of which is irrigated. There is some dry land farming and some subsistance farming on the reservations. The Department of Water Resources dictates to the farmers in the active management areas of the state what the irrigation efficiencies are going to be. So our workload is heavy in the engineering.

Of course it has to start with soil surveys. We are looking at high-tech irrigation systems and beyond the irrigation systems, we are working with these farmers to take a look at what they can do to turn a profit. They are operating, in most cases, in a negetive margin; they cannot achieve irrigation water management in these soils with inherently less than 1 percent of organic matter and a high compaction rate. If equipment is operating in the fields when the soil is wet, the soil becomes compacted. This impacts the water management, and it impacts the health of the crop, because it reduces the space for the roots to develop.

Along with our engineering assistance, we provide agronomic assistance on the crop-residue, conservation tillage practice. Another priority we have in the state on the state and private lands is assisting the ranchers on range management - planned grazing systems, water developments, brush management, etc. One of the things that we feel is most important in this state is water developments, along with developing grazing systems to take advantage of the range, because like any habitat, water is a limiting factor. Again, our engineering assistance comes into play in the resource management system as we look at plant science, soil science and the engineering practices that it takes to make it work.

We are also hearing from the Department of Environmental Quality and the EPA. We have 214 operating dairies in this state and 7 or 8 pig farms. And basically this is a brand new problem for us. These dairies are 4,000 to 5,000 cow operations, some of them less than 1,000. Some of these are milking three times a day, and they are on full confinement. They bring the feed to them, they stand there and eat, and then they run them in for milking. Obviously we have a problem of importing nutrients, if you will, into these systems, and they have a problem handling these nutrients in the organic material. So we are looking at ag-waste management systems for these 214 dairies. Obviously when you are looking at ag-waste, you want to look at it as a resource - where can you apply this organic material. It is certainly welcome on these hot desert soils under irrigation, but you cannot put more out there than the crop are going to use, in terms of nutrients. So that becomes a limiting factor.

Then we've got the urban ag conflicts that you find anywhere - agriculture operating on the fringes of the urban area. The conflicts that you have there with the nuisances being developed - people moving out to the countryside. They don't like the smells, they don't like the sprays, they don't like farmers, they don't like farming, and they don't like tractors on the road. They like to be out in the wide open spaces, and yet they like to go the grocery store where the shelves are full of food. So here we also see in this state a situation where our earliest soil surveys were obviously around these urban areas, because we knew they were expanding then, and we needed good soils information. We have about 19 published surveys in this state - three of which are probably past their prime as far as being current. With this being a fast growing state, we are still 26 million acres from mapping all the soils that we need to map on state and private lands and Indian lands. We want to do that by the year of 2000. By then we will have 7 or 8 of these surveys that will be obsolete - these being ones around areas that are growing the fastest.

We are dealing with these kinds of conflicts here. How do we get this up-to-date information to the decision makers where we are having this fast growth and at the same time recognize the needs of our ag producers? What we have, and the Forest Service can certainly speak to this a lot better than I can, is these rural areas growing out into the forest. They are building into the flood plains, changing the drainage patterns, changing the runoff curve, and building into areas that are subject to wildfires. We have some very critical situations in this state for that reason.

Flood plain management and river basin studies are very important to us. We try to handle this type of growth in a logical sequence and be ahead of the curve a little bit, but they are building faster than we can work with the planners with good soils and good engineering information.

Our RC&D areas are our rural development, rural community type projects that we administer in this state. Pima County was just brought into the Coronado RC&D Area this year. The RC&Ds serve as a medium for us to get information to rural commuties, such as soil surveys, and help them plan and apply the conservation practices, measures and concerns that they should have dealing with growth.

RC&D is also working with some of these rural communities, such as the senior citizens home in Springerville, AZ, where they made a site for this senior citizens home and cut into a bluff causing extremely critically eroding area. The RC&D will take cost share funds and protect this area.

This is some of the growth that is happening faster than good planning can take place. But in the end, it all has to start with soil surveys.

Our snow survey program definitely is important to us. The Transition Zone in the middle part of the state is more or less the area that produces our surface water that we have in Phoenix. We have to be able to predict water supplies, stream flows, and what is good watershed management that protects water quality and water quantity downstream.

We have a Plant Materials Center (PMC) that operates in Tucson. Basically, it deals with the MLRAs that are south of the Mogollon Rim. The plant materials center in Los Lunas, NM, deals with the Colorado Plateau area, testing and evaluating superior performing species that address the critical conservation needs that we have in this state. Of course, we tie it back to ecological science - our range sites, our woodland sites. We need to do more and more of this ecological site evaluation and development and again, it starts with good soils information.

We are also getting into riparian species evaluation and development at the PMC as they are also in Los Lunas. That is of critical importance to all of us. I don't know of a single one of us, including the university people, that are not getting interested in riparian management. We are taking the techniques that we learned during the CCC days and they work just as well now as they did then. There is nothing magical about it. I'd like to say that we discovered it, and take credit for it, but it's those in the CCC that learned about it. We're just coming full circle now learning what they did. One of the things that I like about these pole plantings is that basically in the hotter climates of Arizona, you can stick them in the ground just before they break dormancy, and it's almost like playing God. This is a really popular idea with the environmentalist - extremely easy to do. But it does take some planning and some management. We know how to do that, the BLM knows how to do it, the FS knows how, the BOR is getting into it, and certainly the BIA has example after example on the reservations as one in which the low input-high labor intensive practices you can use to produce good results fast.

Our soil surveys, as I mentioned before, we have 6 active ones. We have 19 published surveys, one published just this year. It is really nice to see those things come out of the printer. We are chipping away at it, and I think if we ever got the publishers down in the pits, they would see it a little differently.

It's the people in this room that are going to make the difference in the quality of the soils program across agency boundaries in the West and as to how well we are going to get our job done.

The soils program is so important to us when we work with our clientele on cropland, on brush management practices, and on rangeland. When we are doing construction or floodway design, we need good soils informations and we need it consistently. We are going to have more and more people coming out here for jobs for recreation, and we need good soils information for all of those.

Jim Kimball with the Tonto National Forest in Phoenix said that the Tonto Forest has the greatest number of recreation days in the United States. We have 4 million people in Arizona, and in the winter, we have close to 8 million because of the snow birds. Think about what that does to the state. If you are going to have that many people here, you have to have the facilities to handle them just as if they live here full-time. This is a tremendous impact on Arizona to provide for the needs of 8 million people when there are only 4 million here.

We have some extremely good conservation practices going on on the Indian Reservations. We are working with the BIA and the tribes and the conservation districts to take what resources they have in the low initial cost-high maintenance-high labor and put them in there in very effective ways and show them how conservation can be done.

Let's not fool ourselves. This is not conservation at its best. What we are doing is treating the symptom, not treating the problem. We need to have good treatment of the watershed. We're not quite there yet in a lot of those communities, but we are getting there. But before we can get there, we need to have good soils information.

Some of this intermingled land that I was talking about, it's up to all of us to coordinate, cooperate, and get the job done the best we can according to standards.

Working with those folks, we take advantage of whatever they have to harvest what water they can for downstream use in their garden. It doesn't make any difference who we are working with, we need to have good information. You are the folks who can help us do that.

I hope that before you leave this week you identify some of the problems that keep us from implementing coordinated activities that deal with soil surveys across the West. Help us to carry the banner for you back to the policy makers, decision makers and the people that put the budgets together that we need more soils information, that we need better information.

You are in a position to do that - you, the folks here in the West, right here in this room. We must have the universities involved in this and the land management agencies-federal, state and local.

With that, let me again wish you success and a very profitable and enjoyable workshop this week. It has been my pleasure to be here today. I hope this gives you a little background on Arizona. We feel it is a wonderful state with a lot of diversity.

SCS National Headquarters Soil Survey Report

Bill Roth, Soil Survey Division

The Soil Survey Division is developing a strategic plan. This plan will provide the framework for the division as we move from completing the initial soil survey inventory to the improvement and modernization of both our spatial and attribute databases. A vision and mission statement have been written.

VISION

Quality Soil Resource Information for Science and Society.

MISSION

Provide leadership and service to produce and deliver scientifically based soils information to help society understand, value, and wisely manage global resources.

We have developed the following list of 15 Strategic Issues. This list may be revised as we continue to meet with our customers and review our strategic plan.

- Communicating to and educating our internal customers to get support for soil survey through a marketing plan.
- Automation system.
- Developing standards for data reliability to meet customers' needs.
- Team-building among our own soil scientists and other disciplines.
- Balance of technical services and soil survey program.
- Maintaining State Soil Scientists as Program Managers.
- How to address environmental issues.
- Funding alternatives.
- How to manage and fund soil surveys on MLRA basis.
- Program responsiveness and flexibility.
- R&D Strategies.
- How to get suitable digital imagery.

-- International responsibilities
- Maintaining quality when users are inclined to do whatever is most convenient.
- How to manage and fund soil surveys.

We are getting a lot of requests for STATSGO data from other agencies. We should all do our part to make sure we have a certified coordinated joined soil survey of the United States at a scale of 1:250,000 by October 31, 1992.

During 1991, the Soil Conservation Service mapped 31.7 million acres and our cooperators mapped 5.8 millions acres. We now have as soil survey on 1.68 billion acres on 73 percent of the United States. Our goal is to complete the mapping of all privately owned land by 2,000.

The Soil Survey Division priorities for 1993 are:

Continue to develop and begin implementation of NASIS

- Data conversion to Informix.
- New data elements.
- Training.
- Generating manuscript tables from tailored MUIR data.

Continue to develop and document Soil Survey standards and procedures

- NCSS Standards Committee, complete networking with committees and work groups.
- Continue development of the NCSS/FGDC Data Dictionary.
- Review and finalize the National Soils Handbook.
- Revise Handbook of Soil Survey Field Investigation Procedures.
- Develop spatial data transfer standard.
- Distribute Guide to Authors of Soil Survey Manuscripts.
- National Soil Taxonomy Handbook revision - approving ICOMID recommendations.
- Develop Soil Survey Field Handbook.
- Distribute Guide for Soil Survey by MLRA.

National data bases, structure, content, implementation

- Implement automated pedon description program (PDP).
- Define & Develop tabular OSED data base.
- Complete STATSGO and develop procedures for generalizing, summarizing, and aggregating digital information to smaller scales.
- Continue cooperation with universities to input data into NCSS Soil Characterization Database.

Support to field operations

Develop a priority list of orthophotography needs.
Participate in NHQ interagency initiative to acquire current ADP capabilities
- Digitizing initiative
- Soil Survey Project Office hardware and software

Complete landform description system.
Develop scheme for electronic data transfer among locations, primarily at the MLRA level.
Develop regional indicators of hydric soil and wetland hydrology.
- Selected states review and comment on soil interpretations rating for selected interpretive guides.

Encourage development of long range soil investigations plans as part of MLRA-wide planning.
Continued development for description, investiqation, and interpretation of deep layers.
Continue the input of Soil-8's.
Continue to emphasize training, and conduct existing courses.
Continue development of interpretive training modules.
Complete 60 soil survey manuscripts for publication.
Maintain laboratory production.

Global climate change activities

- Deveiop and maintain a world soils data base to assist national and international efforts in systems modelling and other uses of soil information.
- Continue soil moisture and soil temperature monitoring.
- Distribute information about project activities, including maps of study locations and descriptions of activities.

International activities

- Assist Lesser Development Countries (LDC) in developing soil survey programs.
- Provide support services to the Agency for International Development (AID), and technology transfer and training to AID country missions, and other international and regional institutions in technical soil services and soils classification.
- Initiate international soil classification committee on soils with permafrost.

Continue preparation for Soil Survey Centennial

Host NCSS national meeting

Vermont, July 1993

complete soil survey marketing plan

Complete draft Strategic Plan for Soil Survey Division

- Solicit information about training, other future needs in field, states, programs, and agencies.
- Expand strategic planning to the whole NCSS, through the national and regional Soil Survey Conferences and existing advisory committees.
- Adjust NSSC services, including participation in Soil Survey Conference Committees, in line with client indications of need.

Develop budget initiatives

- FY94 budget initiatives
  - easy access
  - native American
  - water
- Continue with ?-year state allowance implementation plan.

Develop policy and procedures for support and delivery of technical soil services at all levels

- Coordinate the Hydric Soil Committee.
- Complete electronic generation of hydric soils map unit lists using the State Soil Survey Database.

Role of the Experiment Stations in the National Cooperative Soil Survey

Larry C. Munn
Professor of Soils,
University of Wyoming

June, 1992

As you read this, it will be obvious that I am among the missing. I hope that this will not be my last will and testament, but one *never* knows. A year ago, I talked to Gary Huckel and suggested to him that we should discuss the changing role of the Agricultural Experiment Stations in the National Cooperative Soil Survey. Gary agreed that this would be a topic of concern to everyone, discussed this with Wayne Robbie, and time was allotted in the program.

In the meantime, the Governor of Wyoming (one of the OPEC states) decided that we had a budget crisis. For a couple of weeks, everything that involved spending money was frozen. Then an appeals process was instituted whereby a person could submit requests to travel, purchase equipment and supplies, and fill vacant positions. I have heard estimates that the appeals process, in six months, has cost the University well over $250,000 in administrative expense. This is above our normal bureaucracy, which is considerable. The appeals process will be ended for most state agencies as of June 30, but it may remain in place for the University at the Trusties request. They are upset because the UW administration has not drawn up a RIF (reduction in force) policy for faculty as they were requested to do by the Trusties. So, we are now in unsettled times. I have been denied a $20 request for supplies in the same week I was granted permission to order a $12,000 truck. I have rolls of slide film sitting on my file cabinets waiting the first of July when I will hopefully have money to have them developed. We are looking at level spending for next year which will be great if true, and of course there was no raise money this year. But we didn't take a pay cut either. We have open positions in the department which have been vacant now for four years, with no authorization to search to fill them. One is our Soil Physics position. We are hopeful that we may eventually get to fill that position as a result of an NSF grant related to water quality.

In my department, we are in the process of developing a new undergraduate curriculum (Agroecology) to replace our three traditional B.S. degree programs (Soils, Crops and Entomology). After suffering years of low enrollments, we were getting a strong message to change ourselves, or be "realigned" by the administration. If the new program does not draw enough student interest, I predict that, we (Soils) will be merged into Range Management. We are getting a strong message from our administrators that we <u>are</u> going to become an outstanding institution of undergraduate education. This is a different message than we were getting before perhaps two years ago. Up until then, we were told to develop our research capabilities and become the "Harvard of the West". I am sure faculty at other schools in the region are getting the same message.

Let me spend a few lines going over some history of how we got to where we now are. Before the war (WW II, not Vietnam), college professors were primarily teachers. They taught heavy schedules of undergraduate classes and generally remained atone institution for their entire careers. Pay was low, but there was some prestige associated with the occupation and most considered it a sort of "calling". At that time, relatively few schools had graduate programs. Most of these faculty did conduct some research, but that was because they were scholarly types, and they recognized gaps in our knowledge base. They tended to work on long term projects, in which they were personally interested. Certainly, they were not driven by the "publish or perish" dictum with which all young faculty of today are familiar. I am hard pressed to imagine Hans Jenny embarking on a research project with the comment "Oh well, I suppose there's a paper in it".

Sometime starting in the 1950's, the picture began to change. For what seemed like perfectly logical reasons, we in academia bought into the research oriented agenda which had characterized only a few of the larger institutions in the 1940's. State Colleges became State Universities. Graduate programs proliferated. We were in a technological age and those in the natural sciences strove to keep up with colleagues in the physical sciences. Americans, including college professors became more mobile. Faculty began to build resumes to garner merit raises and new job offers.

In time we came to speak of "research opportunities" and "teaching loads" and the reward for good research was the reduction of one's teaching load. The number of research journals blossomed and faculty in the tenure track were motivated to fill their pages. The prestige of Experiment Station publications declined and faculty developed their resumes by publishing short, experiment oriented articles in peer reviewed journals. If, for example, you look at a current issue of the Soil Science Society of America Journal you will find the papers in S-5 to be considerably different than they were in the 1960's. The cost of page charges alone makes it difficult to publish long articles related to field pedology. The value of a faculty member's program came to be evaluated by two criteria: numbers of journal articles and dollars of grant monies brought in. These were much easier to evaluate than it was to try to determine the actual scientific merit of a faculty member's work, or its value to the scientific community and the public. Cynics have pointed out that much of the current literature is unread, even within the narrow discipline in which it is published. Still, we have bought into this process and at faculty meetings involving decisions of reappointment, tenure and promotion; I hear a lot of counting by my faculty peers and little evaluation of the ultimate quality and value of the work being produced. There has been more money in the professorial profession (until recently at least), but perhaps less prestige.

NOW, with many programs facing low student enrollments for a variety of reasons (demographics, the economy, escalating tuition, no military draft, poor high school preparation, changing career expectations by the students), university administrators are beginning to evaluate the wisdom of attempting to have a degree program for every student and a graduate program in every discipline. At some Land Grant Universities, that most sacred of institutions, the College of Agriculture itself has been questioned. We are taking a second look at curricula that were built on the premise that every new faculty member would want to teach a course in the highly specialized area in which he/ she completed their Ph.D. Many universities have adopted the concept of a common first two year program for all students. Administrators question the need for new low enrollment, upper level courses to teach specialized knowledge at a time when employers complain about the ability of our graduates to write, communicate, and work with others effectively. Traditional programs (Soils, Crops, Forestry) are being redrawn with an "environmental" orientation. Faculty uniformly complain about the poor qualifications and motivation of the few students that they have in their classes.

As the National Cooperative Soil Survey program grew throughout the 1950's and 1960's, participation by soil scientists at the Land Grant Universities varied, but most schools had at least one person involved. Some institutions (North Dakota State University comes to mind) had large programs in which university faculty and staff actually conducted the soil survey of entire counties, training students in the process. Ohio State University had a soil characterization laboratory, totally separate from its soil testing laboratory, which was funded by the state to perform analyses in support of the NCSS. Most schools had designated Experiment Station Representatives to the NCSS who participated in field reviews and correlations, helped prepare manuscripts, etc.

As the expectations for university faculty changed over time, and the criteria by which they were evaluated for tenure narrowed, this participation has generally dropped off. The facts are that today few administrators, or faculty colleagues at reappointment time, will attach much importance to participation in a field review. Research emphasis has shifted to short turn around time projects that will produce papers within a couple of years. State support dollars to faculty have generally declined, in part because of a shift of support by administrators to more glamorous fields like molecular biology. Faculty support is now viewed as "seed money" rather than a commitment of long term program funding. The follow up to "publish or perish" has been "grant or perish".

The federal and state agencies involved in the NCSS have not been static over the last 30 years either and they have had to deal with changing expectations, fluctuations in funding, and a turn over in personnel. Let me finish this paper by suggesting some ways in which the NCSS partnership can continue to be a productive one.

1. I have always considered field reviews to be an important learning experience (for me). This is an opportunity for university faculty to visit with field soil scientists, see new soils and landscapes in their state and see first hand both the successes and problems in the use of Soil Taxonomy in soil survey. These trips

provide ideas for research and a background for teaching in the classroom. Agency people need to be aware that the faculty member's boss will probably not attach any particular value to the activity and the faculty member needs to view the experience as valuable training, which will have long term, if not immediate benefits. There is a limit to the number of field reviews that even a tenured faculty member is well advised to participate in, but I would encourage agency soil scientists to not give up and stop extending the invitation to these events. It is a chance for you to provide some real world exposure to the ivory tower types.

2. University faculty do (hopefully) have some facility to teach, and the agencies should take advantage of this in terms of work shops and other training exercises, both for their soil scientists and for other agency people who use soils information (e.g. silviculturalists and engineers). We (soil scientists) spend a lot of time talking to each other and it is. a wake up call to interact with other disciplines who would like some information about soils, but probably not what we are providing them with now.

3. The advent of CAW (computer assisted writing), which I consider an abomination, has reduced faculty participation in soil survey document development. We should look at advances in desk top publishing and computer data management as opportunities to improve delivery of soils information to NCSS clients.

4. Geographic Information System technology, coupled with satellite positioning capabilities, will revolutionize the way in which we do soil surveys. We in the universities need to help introduce this to the other NCSS cooperators in a non threatening way. I can remember howls of protest and accusations of betrayal when university soil scientists began publishing papers using statistics to document variability in soil mapping unit delineations. No one would now question but that we now have a far more accurate understanding of the spatial variability of soils and the reliability, or predictability of soil mapping units as a result. GIS will greatly improve our ability to store, retrieve and present the spatial attributes of soils. One needs to remember that improvements and development of new methodologies do <u>not</u> negate the value of previous work. But "This is the way we've always done it" is the thinnest excuse for avoiding change.

5. Both those of us from the universities and those in the NCSS agencies need to believe each other when we all plead poverty. In times of limited resources, everything you do is something else that you cannot do. We, in the universities, need to commit ourselves sincerely to investigating research questions that will contribute to the NCSS effort as well as our basic understanding of soil on the landscape. Agency soil scientists need to recognize that we in the universities are ultimately judged by the papers we produce. Hopefully we have a common ground where our needs overlap.

I do not want to present a picture of total doom and gloom. The summer is still relatively new here in Wyoming and I have three graduate students starting their field work. One is working on a conventional soil survey and testing erosion models. The second is evaluating GIS mapping of forest soils in the Snowy Range and the third is evaluating changes in soil morphology and chemistry in old clearcuts. Gene Kelly, my neighbor to the south, and I have a proposal under consideration by NSF that, if funded, will be fun to collaborate on. I was asked to review Paul McDaniel's proposal for a state project in Idaho and believe it to be an example of excellent support of NCSS through basic research. Some contemporary publications (e.g. Alan Busacca's work with paleosols in the Palouse loess, Geoderma 45:105-122) give heart that major contributions are being made to join those of Jenny, Wilding, Gile and Peterson. I'll bet that Jerry Nielsen comes back from his sabbatical full of enthusiasm and ideas. (I'll bet he was that way when he left for it). Several positions which were open at the time we met in Alaska have been filled, and that relieves a major concern that our ranks at the universities were dwindling irreversibly. Perhaps as we attempt to more effectively evaluate undergraduate teaching, we will also develop a better appraisal mechanism for researchthanthe strictly numbers accountingthatwe currently use. I am working on an Introductory Agroecology course and learning new things as I attempt to expand the horizons of my teaching. I regret missing the opportunity to see old friends and to meet the new personalities in the group. Next time !

Western Regional Cooperative Soil Survey Conference
Flagstaff, Arizona
June 22-26, 1992

world Soil Resources: Current and Future Activities

Paul Reich, USDA-SCS, NHQ, Washington, D.C.

World Soil Resources (WSR) is a section within the Soil Survey division of the Soil Conservation Service. Our goal is to assist less developed countries (LDCs) implement policies and commitment to sustainable land management for food and fiber production and conservation of natural resources. Our mission is to assist the U.S. and LDCs to improve the quality of their soil resource inventories to enhance their abilities in attaining a sustainable agriculture and have the capability to address the problems of poverty, hunger, and the environment.

The WSR staff includes the following persons:

Hari Eswaran - National Leader
He is the driving force behind all of the activities we are involved in. His responsibilities involve coordinating WSRs activities to provide services to scs, and domestic and international organizations in the area of evaluation, use, and management of soil resources of the world.

Lorraine Jamison - Secretary

Dave Yost - World Soils Data Specialist
Dave is our liaison to other Federal agencies, private companies and universities among others. He provides technical assistance in helping them use soils data. He is currently working on developing attribute data for a soils database of Africa.

Ben Smallwood - Soil Resource Evaluation Specialist
Ben has been working on creating a map of soil moisture and temperature regimes of North America. He is also working on providing the Economic Research Service with map data layers of soil, physiography, and climate with the purpose of developing productivity indices of the world.

Russel Almarez - GIS specialist
He is a new member on our staff and will start working with us in early August.

Paul Reich - Geographer

I am responsible for maintaining databases and using GIS to create maps for various projects. Some current projects include: using GRASS GIS to create maps to assess constraints to sustainable land management for a watershed area in Java, Indonesia; and using statistical techniques in an analysis of how accurately the Newhall model estimates soil temperature from climatic data.

Everet Van Den Berg - Systems analyst/consultant

Everet is a visiting scientist from the Netherlands. He writes computer programs in PASCAL for data manipulation. Currently, he is working with 4 different global circulation models and the Newhall model to find out how soil climate will be affected by a doubling of carbon dioxide. He is also working on creating maps of the Indian sub continent that will show potentials for sustainable agriculture.

Some of the major activities we are involved in include:

Soil moisture and temperature regime (SMTR) studies,
World soil maps and databases,
Global climate change (GCC) studies,
Sustainable agriculture,
Technical assistance,
Planned meetings,
and Publications.

In our studies of SMTRs of the world we have compiled a database of about 15,000 stations which were processed by the Newhall model which was modified and rewritten in PASCAL by E. Van Den Berg. Some results of the study will include: a world map of SMTR with a database showing their extent, possible modifications to soil taxonomy definitions and tests of scenarios for GCC studies. Preliminary results show that for soil temperature regimes in the continental U.S. 52.6% is classified as mesic, 32% is thermic, 5.6% frigid, 5.8% hyperthermic, and 2.8% cryic with percentages under 1% for the isomesic and isothermic regimes. For the soil moisture regimes in the U.S roughly 56.5% is classified as udic, 18.9% aridic, 13.9% ustic, 9.3% xeric and .6% perudic.

Some of our objectives for GCC studies is to evaluate the magnitude and variability of carbon in the soils of the world and to relate carbon to variables controlling its sequestration. We also have a global database on organic carbon containing about 2,000 pedons from around the world.

A definition of sustainable land management (SLM) was developed by Hari and Dr. Richard Arnold and reads as follows:

Sustainable Land Management is a *system of technologies that aims to integrate ecological and socioeconomic principles in the management of land for agricultural and other uses to achieve intergenerational equity.*

The activities we are performing related to SLM is developing basic concepts, creating an awareness for the role of soils information in SLM, developing and providing soils databases for SLM studies, and assisting in developing techniques to monitor soil degradation.

An important part of what we do is to provide technical assistance to developing countries. Much of the work done for this is under the Soil Management Support Services (SMSS) which is funded by the U.S. Agency for International Development. The major focus with this activity is on SLM, global data bases, geographic information systems, training, and information dissemination.

Organized meetings with other scientists are vital in exchanging new information and the sharing of innovative ideas. Some planned meetings include, a management of forest soils meeting to be held in Taiwan in Nov. '92, and GIS training in Ithaca, NY.

One of our most important activities is in the publishing of information in a format that is most accessible to its users. The main purpose of our publications is for information dissemination to LDCs and to keep SCS staff informed. Examples include, papers submitted by our staff at ISSS Congress meetings, keys to soil taxonomy, and internal reports of WSR. Currently, we are developing a monograph that will describe the processes involved in producing maps using GIS for use in LDCs.

WSR is dedicated to providing the U.S. and LDCs with information and technologies that will improve the management of their natural resources.

I'm not a soils person, I'm really a nosey guy, an inter-loper. I come to learn some things from you. Don't disappoint me by always speaking in a language that I don't understand. My interest is fixing up rangelands. But, Al Amen has helped me a great deal. He forced me to know something of soils so I could understand what is happening out there. The reasons some were stable and some not. So, I owed him one. I want to be provocative and stimulate you because I'm not too sure what the best techniques are in public participation and getting people to buy into my ideas either. I'll give you some ideas but only on condition that you give me some also.

I work with theharshest environments known to man. The marine formations, often clay soils derived from shales, high TDS, high shrink/swell ratios, high pH, low precipitation, and little or no vegetation. Often folks say, "That's a God forsake area!" Help me turn that image around. The areas are great for solitude, quiet, serenity, and rejuvenation of spirit. hfter a week out there your cranky neighbor is more pleasant. These areas always have something intererrsting going on. Pretty delicate flowers which may last only a few hours, the numbers and kinds of animals will surprise you and always cheap but valuable livestock/wildlife forage. Unfortunately they contribute more sediments and salts than they should. How to help them is interesting and challenging.

To challenge each of you, I submit that you have undersold your profession. Soils folks convinced some of us range people that we needed to know soils to identify potential plant communities. But I find we needed more than that. We need to know present soil conditions in most areas and in some the percentage of large rock. You didn't supply it, nor tell us it was important. You short-changed your profession's importance.

Also, you need to change your image. You are not grubby dirt diggers. You are the care-takers of soil, the warm, cuddly home of plants, earthworms, bunny rabbits, and other loveable critters. You have the awesome responsibility of being the conscience of land uses. You should be looked upon as the angelic guides for all improvements but also the saviours where soil conditions are being sacrificed for short term monetary gains. Degraded soils are repulsive and you should champion their cause. The public doesn't know what to look for, nor what it is they are seeing, often until it has gone down too far. Then, it needs capital investment for restoration. Investments often are beyond the capability of private land owners so society as a whole is often stuck with the cost of rejuvenation or they lay idle testifying to past abuses or degradations.

You are involved in sanitary land fills and other hazardous waste problems. But, look at the future! Do we seal off for hundreds of years so future smarter folks can solve? Do we bleed off methane and reduce our heating bills? Hazardous/toxic contamination, water carried dangers, microbes that eat this but not that; life cycles to determine what happens when they die are all part of the answer and no one is smart enough to know all these subjects. What plants can take up and not cause health problems. What are health problems? What things do plants and/or animals concentrate and cause bigger problems. The public's mind set is to seal off any danger. But you must bring reason that at times it is better to use and recycle rather than attempt to seal off. We all must work together to solve todays problems. Public problems which include public lands, riparian areas, salinity, soil degradation areas, etc are no longer the sole province of a single specialty. The best solutions come from the combined brain power of every interested person.

I've talked about your role and image because I believe we must first look inwardly when discussing public participation. And, so let me philosophize. Public participation is often thought about only in relation to those other folks to whom we desire to implant some knowledge or have them buy into our solution. I believe differently. I believe ,we must start with the perceived problem, and all of us grow together. No speciality, no profession has all of the answers. We in any profession owe the public and all players having any interest a clear, explanation of the facts involved in the case. We talk to our own kinds of people but we fail to communicate to others, especially those with conflicting opinions. We often say they just wouldn't understand, soils are too complex to explain in simple terms that all could understand.

When you hear words like that, rest assured that people with that mind set will be dealt out of future involvement or issue. If we can't express ourselves so that all understand, they will not use our expertise. We owe it to them and to our professions to make our concerns understood. Best understood facts are those simple things we can all relate to. Try them out on your children or grandchildren. If they don't understand, work on simpler terms and examples until they do understand. Work on terms and expressions which touch the senses-sight (pictures), hearing, smell, taste, feel. Display a willingness to speak the listeners language. Whatever that language might be. The best message possible isn't worth much if it isn't heard and understood by the target audience.

I have written articles, given speeches explaining how to solve particular problems. And, I have been frustrated that the problem persists. Why? Because, I didn't get my message through all of the filters and other ideas being generated. I think it is best to go to the problems, examine them together. More of the senses get involved, fewer other distractions and more interactions are possible. Everyone buys into the problem and becomes a partner in solving it rather than being told what to do. Oh, I also believe the professionals all take themselves much to seriously. Lighten up, have some humor. Don't get up tight when someone asks you why you play in the dirt! Now some things that can help get your soils messages across: Some great graphics and visual techniques are now available. Soils data can be portrayed in each component of a model (such as RUSLE). The model can then predict sediment yields before and after treatments. This Al did at Sagers Wash in Utah. He then added remote sensing to enhance his soils data even more on the Henry Mountains area in Utah. Soils folks coupled up with GIS, Remote sensing, computer, SLAP and other specialties can create maps in vivid colors and with better accuracy than ever before. We can exhibit soil characteristics, slopes, land uses, soil condition, soil particle size, climate, infiltration, runoff, and a myriad of other data as single entities or in any desired combinations now and after treatments--great stuff. Thanks to the advent to computers, digitizing, remote sensing and other graphic skills, we can make better presentations. And the data that soils folks bring to the decision table is valuable, critical stuff. YOU can graphically display options and predict results, with quanitifiable products. Remember the glitzy graphics may have got you in the door but your communication skills will be tested to keep you there. Otherwise the players will take your maps and still leave you out. Your data isn't all you can contribute. Often the solutions need a different array of the data and without your manipulations a wrong assumption is made of your data. Give them your best, simpliest explanations of what is really significant and leave the nice to know to soils technical functions.

You commonly won't be invited to the decision table unless what you can give is understood and significant. You owe it to the decision makers to give of your talents and make them known. Decision makers can't mystically understand and invite you. Some soils folks are a bit more comfortable with a shovel in the field than they are with publics, other specialists and decision makers. Just remember we all need each other and there is nothing to preclude a soil scientiest from becoming a decision maker or at least part of that team. We all put on our pants one leg at a time. Together we can do a better job of managing salinity, public or private lands and any project or proposal dreamed up by man or woman! Soils folks have a larger part to play that ever before, come right up to the decision tables!

An Introduction to Remote Sensing in Soil Science

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Remote sensing examines soils **from** a perspective foreign to many soil scientists. that of **a** distantly removed, perhaps **spaceborne,** imaging **system**. A **satellite** does not **see** soil profiles or **pedons**. To an imaging sensor system, soil is simply **one** component of the **spectral** response of an entire landscape.. In many areas, **the** soil is essentially invisible to imaging sensor systems, its **spectral** response masked by overlying vegetation How **then,** is **meaningful** information on soils gathered and **analyzed** with remote sensing systems and techniques?

This **paper presents** a general introduction to remote sensing systems and techniques as they apply to soil **science**. Specifically, **multispectral** remote sensing as performed by satellite platforms is examined **Introductions** to common **imaging** satellite systems and the digital data they produce **are** included along with a tabulation of some of the advantages and disadvantages **of** remote sensing techniques. Soil **spectral characteristics** arc **introduced** to **provide** insight into the application of **multispectral** digital imagery to soil mapping. **The** paper concludes with a description of **a** methodology for integrating **multispectral** remote sensing into soil mapping **programs**.

The Electromagnetic Spectmm

The physical response of objects and materials on the earth's **surface** to wavelengths of the electromagnetic **spectrum** is the principal tool of remote sensing. **Our** ability to distinguish vegetation types on panchromatic aerial photography **is** one of the more **common** examples of how spectral response can be applied to **resource** problems.

Only a narrow range of wavelengths composing the **electromagnetic** spectrum is **used** for remote sensing applications (Figure 1). Remote sensing applications begin at about 0.35 micrometers in the ultraviolet **region** of **the** spectrum. **The** region of the spectrum perhaps most used for remote sensing applications encompasses the **realm** of **human** vision, 0.4 to 0.7 micrometers The infrared **(IR) region** of the **spectrum** begins at around 0.7 micrometers and continues to about **300** micrometers. The **IR** region of the **spectrum** is conveniently divided into four wavelength regions. The photographic **IR** from 0.7 to 0.9 micrometers provides a narrow region of the **IR** spectrum where cameras, films, and **filters** are effective. Beyond 0.9 micrometers **IR** is absorbed by glass lenses, and imaging with standard lenses is not possible. The shortwave **IR from** 0.7 to 3.0 **micrometers** is distinctive in that all **IR radiation** in this region is reflected from the earth's surface. The **midwave IR from** 3.0 to 5.0 micrometers is distinguished as being a mixture of reflected and edmitted IR energy. This **midwave IR** region of the spectrum is particularly **useful** for sensing **high** temperature phenomena such as forest fires. The **longwave** IR **from** 5.0 micrometers on to **100** or more micrometers consists predominantly of radiated **IR** energy. The **longwave IR** is used predominantly for sensing thermal emmissions that are close to the earth's ambient temperature; about **27degrees** Centigrade.

Beyond the the IR region of the spectrum lies the microwave region and radar remote sensing (Figure 1). Radar imaging systems are unique in a number of ways. First, they are active remote sensing systems: They illuminate the ground surface with pulses of electromagnetic energy produced by the imaging system. The images recorded by radar systems are built from the reflected pulses. Radar imaging systems (particularly L band systems with wavelengths between 15.0 and 30.0 centimeters) have the ability to penetrate clouds, making them a very useful tool for remote sensing in tropical latitudes. Radar systems am also quite sensitive to changes in surface texture, a significant aid in the analysis of geologic surficial materials. A negative aspect of radar imagery is that it is non-literal; it requires considerable training to use it effectively. Further, it suffers from several inherent forms of distortion

While the visible and JR regions of the electromagnetic spectrum are fairly broad, remote sensing is only performed in a few relatively narrow "windows" where atmospheric interaction with electromagnetic energy is limited (Figure 2). The major windows include 0.3 to about 0.91 micrometers in the ultraviolet through photographic JR regions, 1.55 to 1.75 micrometers, 2.05 to 2.4 micrometers in the near IR, 3.0 to 5.0 and 8.0 to 14.0 microns in the thermal JR, and 7.5 to 11.5 and 20.0 plus millimeters in the microwave region.

Digital Images

Perhaps 90 percent of the remote sensing performed today utilizes aerial photography and/or manual photo interpretation shills. Since the launch of Landsat J in 1972 however, digital imagery, and digital image processing have had an expanding roll in resource analysis. A digital image is composed of thousands, perhaps millions of square elements called pixels (picture elements). The color or grey shade of each pixel in an image is a function of the integrated average spectral reflectance of the portion of ground the pixel represents. In a Landsat Thematic Mapper image for example, each pixel represents a ground area of approximately 900 square meters, or about 1.1 acres. Just as the halftone dots in a newspaper picture appear smooth when viewed at reading distance, the pixels of a digital image also appear as a continuous tone image at viewing distance.

The digital images generated by satellite imaging systems have a number of advantages. First, digital images can be manipulated mathematically in an infinite number of ways to bring out unique details of interest or explore alternative representations. With photographic images, once the negative is fixed, adjustment is extremely limited Digital imagery provides consistant classification results. A scientist knows that if the same algorithim is used to classify 100 digital images, the process will be the same each time. In manual, visual interpretations, each classified map is unique, a function of the experience and mind set of the various interpreters. Digital images from several spectral bands can be analyzed at one time using a computer. Photographic images allow a visual analysis of at best three bands (slices) of the electromagnetic spectrum (color film emulsion). Finally, digital images are cost-effective for large geographic areas, repetitive interpretations, and standard image formats.

The disadvantages of digital images and machine processing can be significant They are expensive for one time interpretations and small area analysis. Start-up costs are high A typical research level digital image processing facility will have at least 250,000 dollars in equipment and imagery. Specialized equipment, also requires specialized staff to operate and maintain it, further increasing costs. Accuracy of digital analyses may be difficult to evaluate, requiring time consuming field work. Finally, almost all digital data requires some form of preprocessing,

Imaging System Characteristics

Remote sensing imaging systems typically collect electromagnetic energy that is either reflected or emitted from the surface of the earth The value of the generated image relative to any specific application is a function of the various resolutions of the sensor system. The word resolution is typically associated with system spatial resolution, loosely assumed to be represented by the smallest object that can be distinguished in the image. This concept is only partly correct: It inadequately defines spatial resolution, and ignores associated spectral. and radiometric resolutions, and temporal parameters that must be considered when assessing image quality or utility for a specific application.

The spatial resolution of an image is a function of the wavelenth band that the sensor collects imagery in, the design of the imaging system, system operating conditions, and target variables, For example, spatial resolution in camera systems is a function of the qualtity of the camera lens, camera body, the type of film chosen, and scene dependent variables such as contrast, shape, and pattern. Camera system resolution is generally measured in terms of Ground Resolved Distance (GRD). GRD does not refer to the smallest object that can be seen in an image. It is measured using using a standard Air Force target, is defined as the distance on the ground that two objects must be separated in order to be seen as separate objects in an image. Because of variations in scene dependent variables, GRD is a somewhat subjective measure used for general comparisons of image quality.

Spatial resolution is measured differently in systems that generate digital imagery. In these systems spatial resolution is a function of the size of the detectors collecting the reflected or emitted electromagnetic energy, the angular field of view of the optical system in the sensor, and the height of the satellite. These factors combine to give each detector an Instantaneous Field of View (IFOV), the area of the ground that each detector sees at a given instant in time. The IFOV, along with the movement of the satellite in space, and the scanning movement of the sensor (in the case of Landsat) determine the Ground Sample Distance (GSD) of the sensor system: A comparative measure of spatial resolution for digital imaging systems.

Radiometric resolution can be simply described as the number of grey levels used to represent the intensity of reflected or emitted electromagnetic energy in imagery collected by a digital imaging system. Imaging sensors with low radiometric resolution generate imagery that does not allow discrimination of objects wbose spectral response in the sensed wavelength varies only slightly. Both Landsat and SPOT, the two commonly used earth resources imaging satellites have sensing systems with 8 bit radiometric resolution, that is, they provide images with 256 possible grey levels per pixel.

Spectral resolution denotes how well an imaging system defines wavelength intervals. Spectral resolution is best presented in terms of how well the spectral response curve of an object or material can be reproduced by an imaging sensor. A spectral response curve depicts the percent reflectance or emittance of a particular material or set of objects at different wavelengths of the electromagnetic spectrum (Figure 3). Well defined spectral response curves improve the ability to discriminate materials or objects of interest in digital imagery.

Spectral resolution is a function of three things, bandwidth, band placement, and the number of bands (wavelength slices of the electromagnetic spectrum) that imagery will be collected in If an imaging system has several broad bands, the spectral response of objects is essentially smoothed: A broad range of reflectance values are reduced to one. On the other hand, bands that are too narrow will not return sufficient energy to the sensor, and produce poor signal to noise ratios. In terms of band placement, if a system has 20 bands, but they are placed in regions of the spectrum where materials of interest have similar spectral responses, imagery will have poor contrast, and discrimination of different vegetation or soils for example, would he difficult. Band placement is critical to detecting and identifying features or materials of interest. The number of bands an imaging system collects determines how well a spectral response curve can be reproduced for a given material. Multispectral imaging systems are those that collect imagery in more than one band of the electromagnetic spectrum. With numerous bands, especially numerous narrow bands correctly located, it is improbable that major distinguishing features of spectral response curves will be missed.

How often imagery of a given target can be acquired is an additional factor important in assessing the value of an imaging system and its products. Landsats (the American imaging satellite series) for example, acquire imagery of any given target about once every 16 days (reacquisition varies with latitude due to convergence of near polar orbits). SPOT's (the French satellite imaging satellite series) orbital parameters are such that nadir reacquisition occurs every 26 days. Off nadir pointing capability reduces reacquisition times for SPOT to about two days, but the imagery is oblique. Generally, imagery can be acquired about once a month accounting for cloud cover. If rapid changes in vegetation phenology are of interest, this time span can be inadequate. Further, in areas of the tropics, it is possible to be "clouded out" for months at a time. Cloud penetrating radars become useful remote sensing tools under tropical conditions

It is obvious that the system resolution characteristics must be traded off by system designers to produce satellite imaging systems that meet the needs of a broad range of scientists. However, in attempting to meet the needs of the many, the needs of those with very specific or unique applications are inherently sacrificed. It is the researchers responsibility to chose the imaging technology that best suits a given application, whether satellite or airborne platforms, or visible, infrared or radar sensors. The consolation is that in the next five to 10 years a wide array of new instruments will become available providing enhanced research opportunities.

Current Imaging Systems

A wide range of imaging technology is currently available to the scientific community. There are in excess of one hundred different aerial camera systems with numerous lens and film combinations. Aircraft can also be fitted with a range of digital imaging systems (radiometers and imaging spectrometers) that cover all the common remote sensing windows. Airborne RADAR systems in several wavelengths and resolutions are also available through numerous contractors and federal agencies such as NASA.

Outside the realms of aerial photography and research, most resource related remote sensing is performed using multispectral imaging systems on spacecraft. There are several satellite platforms from several different nations that are currently vying for the still limited resource imagery market The Japanese launched the Marine Observation Satellite (MOS-1), and the Japanese Earth Resourses Satellite (JERS-I). The European Space Agency (ESA) has launched the ESA Remote Sensing Satellite (ERS-1). Imagery from the Soviet COSMOS series of satellites is being marketed by Soyuzkarta. The French operate the Systeme Probatoire d"Observation de la Terre (SPOT) imaging satellites. The United States, the pioneer in spaceborne imaging systems, has commercialized the Landsat series of earth observation satellites, and also acquires valuable imagery data from the Advanced Very High Resolution Radiometer, a multispectral imaging system on board the TIROS-N series of weather satellites. The most commonly used systems for resource remote sensing are the Landsat satellites, the SPOT satellites, and the AVHRR on the TIROS-N satellites.

The first Landsat satellite was launched in 1972. Imagery is currently acquired from Landsat 4 and 5. Landsat 6 should be launched in late 1992. The current Landsat satellites contain two imaging systems, the Multispectral Scanner (MSS), and the Thematic Mapper (TM). The multispectral scanner is a four band imaging radiometer with a nominal spatial resolution of 79 meters (Table 1). The thematic mapper, a seven band imaging radiometer has a nominal spatial resolution of 30 meters (Table 1). It provides both better spatial and spectral resolution than the MSS, and better spectral resolution than SPOT (Table 1)

SPOT imaging satellites contain two High Resolution Visible (HRV) imaging systems. The SPOT satellite imaging systems are technically more advanced than the Landsat systems. SPOT has better spatial resolution and poorer spectral resolution than Landsat. SPOT can collect imagery in both a 20 meter spatial resolution, 3 band multispectral mode, and a IO meter spatial resolution panchromatic mode (Table 1). SPOT imagery is most commonly used on projects requiring higher spatial resolution. It is possible to combine digitally the IO meter spatial resolution SPOT data with the 30 spatial resolution Landsat data and gain some of the advantages of both systems.

The AVHRR instrument is a five band imaging spectrometer that has proven quite useful for very large area analysis (Table 1). While the spatial resolution of the AVHRR sensor is 1.1 kilometers at nadir, a single image can cover more than a third of the continental United States. Examples of applications using imagery from this broad area sensor system include regional fire fuels analysis, crop forcasting, and desertification studies.

Soil Spectral Characteristics

Remote sensing can be applied to soils using one of two methodologies. The first involves interpretation by proxy. Vegetation, topography, and geomorphology can provide useful clues to soil properties that cannot be studied directly using remote sensing techniques. Remote sensing sensors see the land surface only. Even on bare **soil visible and near infrared radiation penetrate only one or two millimeters in fine textured soils.** Penetration of longer wavelength energy ,radar for example, is a function of frequency, and soil moisture.

The second methodology involves the direct analysis of soils properties based on spectral response. There are a number of properties that effect the spectral response of soils and consequently, their brightness in multispectral imagery acquired by a satellites. Soil properties effecting spectral response include mineral content, organic content, moisture content, and soil structure and texture While each of these properties can be discussed individually, the spectral response of a given soil in the field is a composite of all the properties. Field signatures can be further muddled by the effect of vegetative cover.

Mineral and organic content can have a significant effect on the spectral response of soils to wavelengths in the visible and infrared regions of the electromagnetic spectrum. A comprehensive collection of mineral spectra for particulate materials is available (Hunt and Salisbury , 1970, 1971, 1974) (Hunt et al. 1971, 1972,1973). Spectral analysis indicates that quartz has high reflectance throughout the shortwave infrared region. Other primary minerals are less reflective, and have spectra that contain absorbtion features due either to iron or hydroxal content. Soils with gypsic mineralogy have been found to have the highest spectral reflectance accross the visible and shortwave infrared regions, while montmorillonitic soils had the lowest average spectral response between wavelengths of 0.52 and 1.0 micrometers (Stoner and Baumgardner, 1980). In the same study, kaolinitic soils could be distinguished by an absorbtion band near 0.9 micrometers. Soils typically exhibit lower spectral reflectance as iron oxide content increases. An exhaustive study using over two hundred different soils identified five basic soil spectral response curve forms in the .52 to 2.32 micrometer region of the spectrum associated mainly with the iron and organic content (Stoner and Baumgardner, 1981) (Figure 4).

The effect of variations in organic content are most apparent primarily in the 0.7 to 0.75 micrometer region of the spectrum (P.J. Curran et.al. 1990). Typically though, spectral reflectance over the entire visible and shortwave infrared wavelength regions of the spectrum decreases as organic content rises in the soil. Spectral reflectance of organic soils is a function of decomposition. Poorly decomposed organic material will provide higher spectral reflectance in the 0.6 and 1.4 micrometer wavebands than will soils with highly decomposed organic material (Stoner and Baumgardner, 1981).

Soil moisture content effects both the magnitude of spectra) reflectance, and the shape of the spectral response curves of soils (Figure 5). There is a negative relationship between soil moisture and percent spectral reflectance from soils (Bowers and Hanks, 1965). In addition, as soil moisture content increases, water absorbtion features become more prominent in the spectral response curves. Significant, broad, water absorbtion bands occur at 1.4 and 1.9 micrometers. Moisture in soils has a distinct effect on the spectral response of soils in the thermal infrared wavelengths. While the diurnal surface temperature of dry soils will vary dramatically, soil temperatures of moist soils are moderated as a result of the physical properties of water. Consequently, relative to the radiance of background soils, moist soils appear darker on thermal infrared imagery acquired during daylitght hours, and brighter on imagery acquried near dawn Soil moisture also has a profound impact on remote sensing in the microwave region of the spectrum. Long wavelength radar remote sensing systems have the capability to penetrate extremely dry soils (soil moistures of one percent or less). Studies performed in desert regions have demonstrated penetration of a few meters however, as soil moisture increases beyond 3 percent, penetration decreases to only a few centimeters (Elachi, 1987).

Spectral reflectance increases, and the effect of absorbtion bands decreases as particle size decreases in laboratory settings for transparent soil minerals such as silicates,(Salisbury and Hunt, 1968). For soil constituents that are opaque in the shortwave infrared region, the reverse is true. The spectral response curves of soils with varying textures are typically dominated by the effects of minerology or in the case of clay soils. the effect of aggregation (Figure 6). It is consequently possible for coarser sandy soils to appear brighter than tine textured clay soils in imagery.

Vegetation cover has a signficant effect on the spectral response of soils. Recall that in digital images, the brightness value associated with each pixel is an integrated average of the spectral response of all the materials the pixel contains. Studies have shown that vegetation spectral characteristics can clearly be distinguished at covers exceeding 10 percent (Siegal and Goetz, 1977) (Bentley et. al. 1976) (Short, 1982) (Figure 7). At vegetation covers exceeding 10 percent direct analysis of soil parameters by remote sensing platforms is difficult to impossible.

A wide range of applications in soil science utilize soil and vegetation spectral reflectance and emittance characteristics. Soil scientists have used the relative brightness patterns of vegctaion and soils in aerial photography as an aid in soils mapping for decades. Color and color infrared films have allowed scientists to add color and photographic infrared signatures to the repertoire of mapping tools. Soil unit boundaries generated from coarse spatial resolution Landsat MSS data (80 meters) have been shown to match those of field survey generated maps quite well (May and Petersen 1975). Studies have been performed that correlate soil moisture characteristics with spectral soil classes, allowing soil unit boundaries to be accurately mapped (Seubert et al.. 1979). Similar studies have been performed using the Landsat Thematic Mapper since 1984 (Thompson et.al., 1984) (Seely et al., 1984). Soil spectral response has also been used to examine the effects oferosion in alfisols (Latz et al., 1984). The list of potential examples of remote sensing applications seems endless, requiring hundreds of bibliographic references. A list of general references is provided in the bibliography, and can serve as a starting point for those interested in persuing remote sensing.

Mapping Soils Using Satellite, **Multispectral** Remote Sensing Systems

Remote sensing in the form of air **photo** interpretation, coupled with field work defines **the** most commonly accepted **methodology** for **mapping** soils. Digital, **multispectral** images acquired by satellites are not intended to replace tbis tried and true metbodology. Multispectral satellite imagery is used as an additional tool in the mapping process. Digital image analysis of **multispectral images can** supplement traditional techniques by reducing some of **the** labor intensive **and** variable work performed by tbe **eye-brain** system in air pboto analysis, and some of tbe time and effort expended in performing field work.

Soil unit boundaries derived using satellite, **multispectral** remote sensing systems are delineated using predominantly proxy **evidence** of soil **characteristics**. Proxy **characteristics** include vegetation type, slope, slope aspect, and geologic information. Proxy evidence is most commonly depended on because, **especially** in forests, tbe spectral response of soils are masked by overlying vegetation. A **graduated approach** to soils mapping is adopted **when** digital image processing of **multispectral** imagery is integrated Tbe unit boundaries tbat result from multispectral analysis are refined witb standard pboto interpretation techniques, and assignment of soil series to tbe mapped units will still depend on field work. It is field work, and often tbe professional experience of resource professionals, tbat permit tbe development of relationships between spectral response, ground cover, and soil series that are critical to tbe production of quality maps.

Tbe production of a remotely sensed tbird order soil map follows a straight forward process flow. Tbe process begins **when soil** scientists and remote sensing specialists acquire imagery of an area of interest and ancillary data **such** as digital elevation models, and existing soils, vegetation, and geologic **information.** During this **phase** of tbe mapping operation rbe project team members become familiar **with** tbe study area, and learn as **much** as possible about tbe relationships between tbe spectral responses depicted in tbe imagery, ground cover. and the underlying soils. **Landsat** Thematic Mapper imagery is generally tbe preferred form of imagery for soils and vegetation mapping purposes because it has tbe best spectral resolution of **currently** available sensor systems. **Landsat TM** bands **7, 5, 4,** and 3 tend to be most useful for soils and vegetation mapping projects.

After initial data bas been gathered tbe mapping process continues **with** the generation of an initial soil unit boundary map. Tbe initial map may be **generated** using eitber a supervised or unsupervised classification technique. Tbe supervised technique requires tbe location and documentation of field training areas. The training areas are chosen to represent tbe **variablility** found within vegetation types, habitats, or soils of interest. **The spectral** responses of tbe training areas as seen in the **multispectral** imagery are used to digitally classify tbe entire image. Tbe unsupervised classification approach is essentially tbe reverse of tbe supervised technique. Unsupervised classification uses a cluster analysis **approach** to define spectrally unique classes **within** tbe digital imagery. Tbe classes are mapped, and tbe resulting product is **checked** in tbe field to determine wbat physical features (vegetation **types,** habitats, soils) tbe classes correspond to. Classes are then aggregated, deleted, or split in the process of completing e soil unit map. At this stage it is often useful to integrate ancillary data layers to refine the spectral classification. Ancillary data layers may include slope, slope aspect, temperature, precipitation, and geologic data Ancillary data is generally integrated using a Geographic Information System (GIS).

An accuracy assessment is performed after the initial map is produced not so much to determine how good the map is, but rather, where it fails to match what field investigators see on the ground. The accuracy assessment is performed by drawing e random, or stratified random sample of pixels from the map, and developing an error matrix that compares the classification results for each sampled pixel to what actually appears on the ground. The matrix provides estimates of omission and commission errors by class, allowing investigators to assess which classes and areas require boundary refinement using aerial photography or field reconnassiance: The classification in addition to providing quantifiable mapping units becomes an aid for developing e field sampling strategy, and an aid in survey stratification. This mapping process can be repeated until it becomes apparent that additional refinement will not enhance the interpretation of unit boundaries.

During the mapping process, soil pits are excavated, and soils analyzed using traditional techniques to assign series names to the mapped units. Final map accuracies, as defined in the error matrix will generally fall in a range of 75 to 85 percent. Per hectare cost estimates of soil mapping efforts using multispectral imagery are not available. Cost estimates for old growth forest mapping using a similar technique, however, are about on-third the cost of traditional surveys. (Tepley and Green, 1991).

Forest Service Plans

Integration of remote sensing technology by the Forest Service is driven by the need to provide and utilize increasing volumes of accurate resource information in an increasingly timely manner. The Forest Service remote sensing program in the Southwest is in the early stages of development. An imagery library is being acquired, personnel are being trained, and equipment is being purchased in an effort to fully integrate remote sensing into the resource management process. The Fores! Service Geometronics Group in the Southwest Region is committed to developing vegetation maps for each regional national forest derived from Landsat data. Change detection work using Landsat data will be performed in the fall of 1992 to aid in determining the impact of forest planning in the Zuni Mountains of New Mexico. Finally, in the fall of 1992, multispectral imagery will be integrated into the Terrestrial Ecosystem Survey on the Prescott National Forest. This will be the first attempt by the Forest Service to integrate multispectral imagery into the soil mapping process in the southwest.

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Table

Table 1. A Comparison of Common Spaceborne Remote Sensing Systems

Imaging Instrument	Thematic Mapper (TM): Multispectral Multispectral Scanner (MSS)	2. High Resolution Visible (HRV) Imaging Systems	Advanoed Very High Resolution Radiometer
Bands (Wavelengths in micrometers)	TM 1: 0.45 - 0.52 2: 0.52 - 0.60 3: 063 - 0.69 4: 0.76 - 0.90 5: 1.55 - 1.75 6: 10.4 - 12.5 7: 2.06 - 2.35 MSS: 1: 0.50 - 0.60 2: 0.60 - 0.70 3: 0.70 - 0.60 4: 0.60 - 1.10	Multispectral Mode: 1: 0.50 - 0.59 2: 0.61 - 0.66 3: 0.79 - 0.69 Panchromatic Mode: 1: 0.51 - 0.73	1: 0.58 - 0.68 2: 0.725 - 1.10 3: 3.55 - 3.93 4: 10.3 - 11.3 5: 11.5 - 12.5
Pixel Size	Bands 1 -587: 30 meters Band 6: 120 meters	Multispectral Mode: 20 meters, Panchromatic Mode: 10 Meters	1.1 km at nadir 4.0 km at frame edge
Radiometric Resolution	256 grey levels (6 bit)	256 grey levels (6 bit)	1024 grey levels (9 bit)
Repeat Coverage	16 days	26 days for nadir 2 days for oblique	About 2 days
Image Dimentions	185 km X 170 km	60 km X 60 km	2,700 km swath width, length varies

Figure Captions

Figure 1. The Electromagnetic Spectrum

Figure 2. Atmospheric Windows: Band widths of the electromagnetic spectrum where atomospheric absorbtion by water, carbon dioxide, ozone, and other constituents is minimal

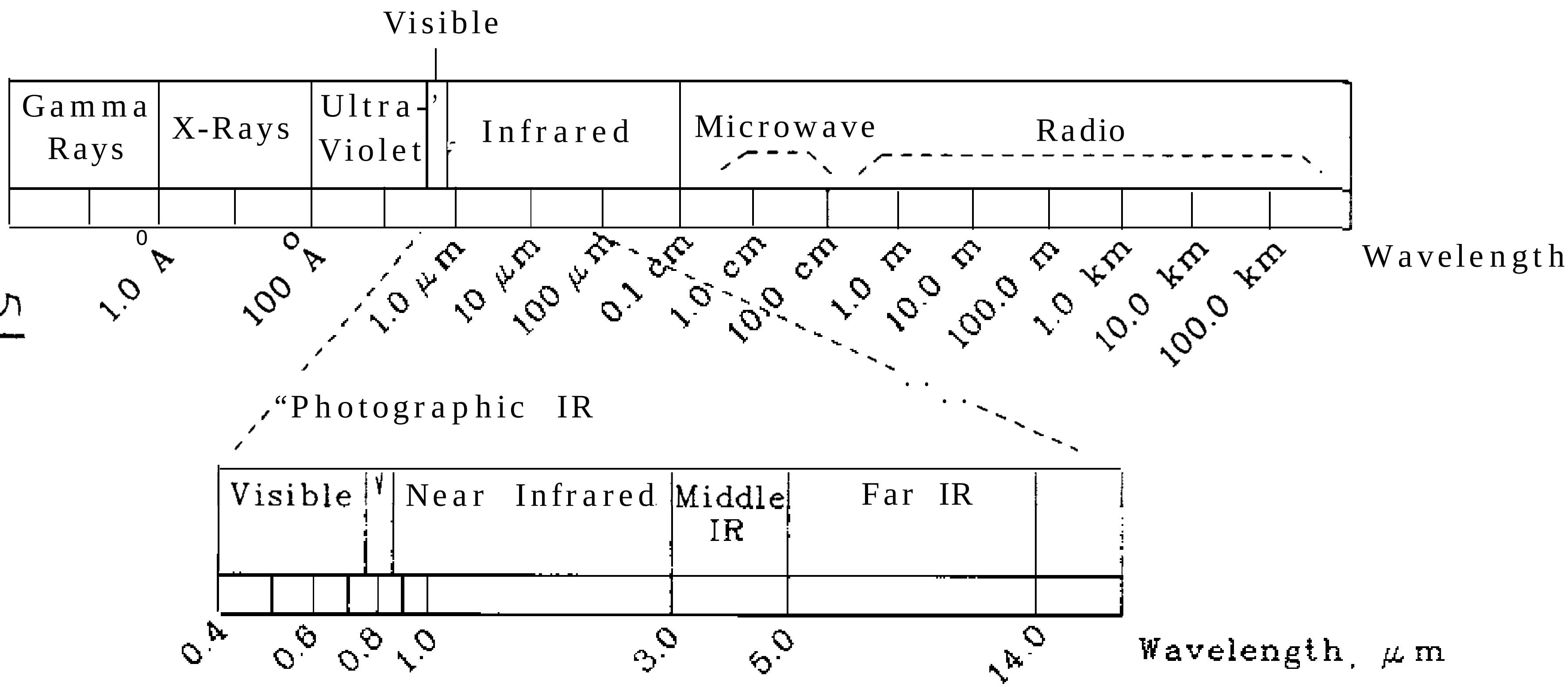
Figure 3. Spectral Response Curves: A spectral response curve graphs percent reflectance against wavelength. The diagram illustrates the average spectral response curves for vegetation, soil, and turbid water.

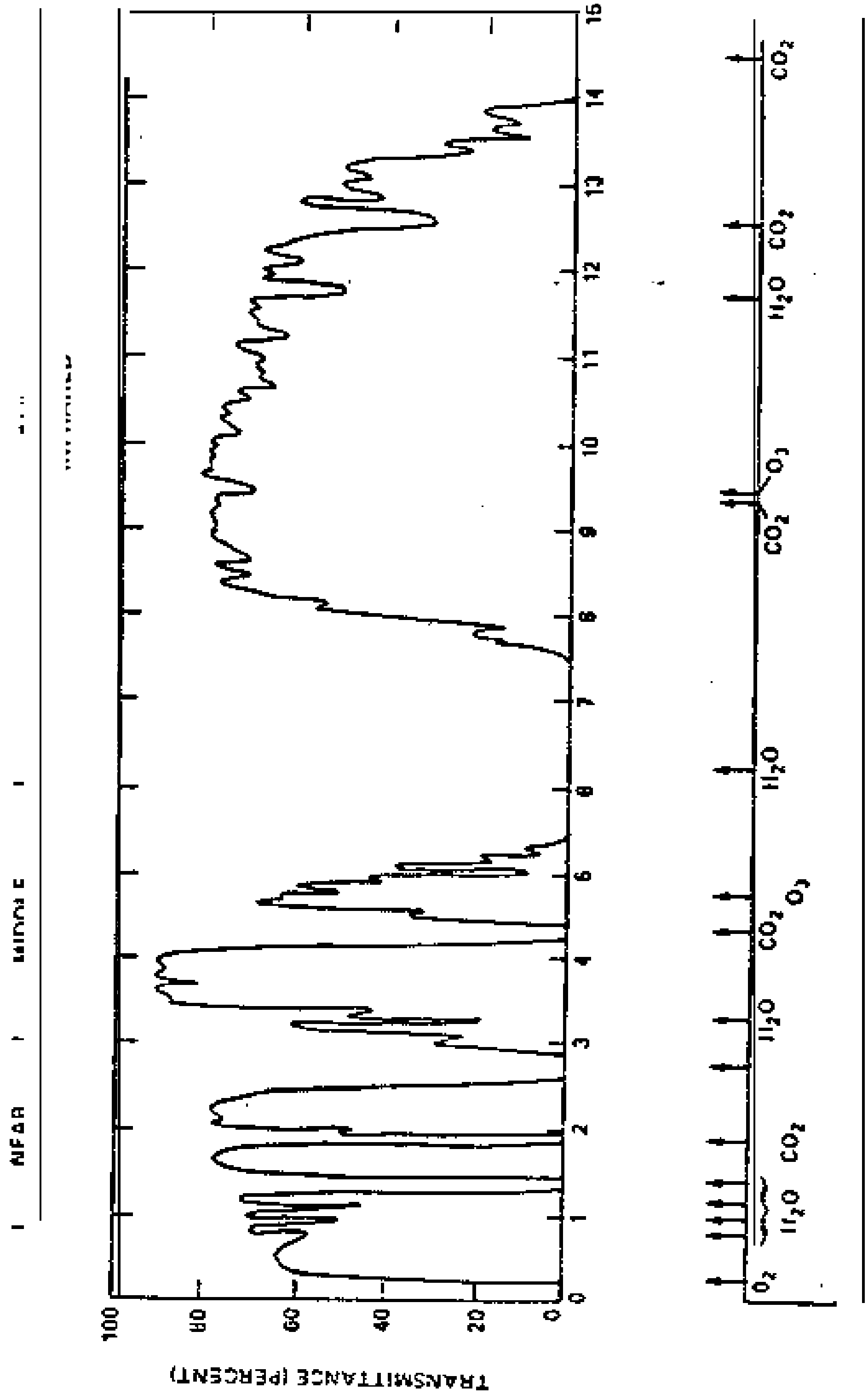
Figure 4. The diagram (after Stoner and Baumgardner, 1981) depicts the five basic forms of soil spectral response curves. Curve 1: Soils having organic matter content in excess of two percent, and tine texture. Curve 2: Soils having organic matter content less than two percent, and iron oxide content less than one percent. Curve 3: Soils having organic content less than two percent, and iron oxide contents between one and four percent. Curve 4: Soils having organic content exceeding two percent., iron oxide contents less than one percent, and medium to coarse texture. Curve 5: Soils having iron oxide content in excess of four percent, and fine texture.

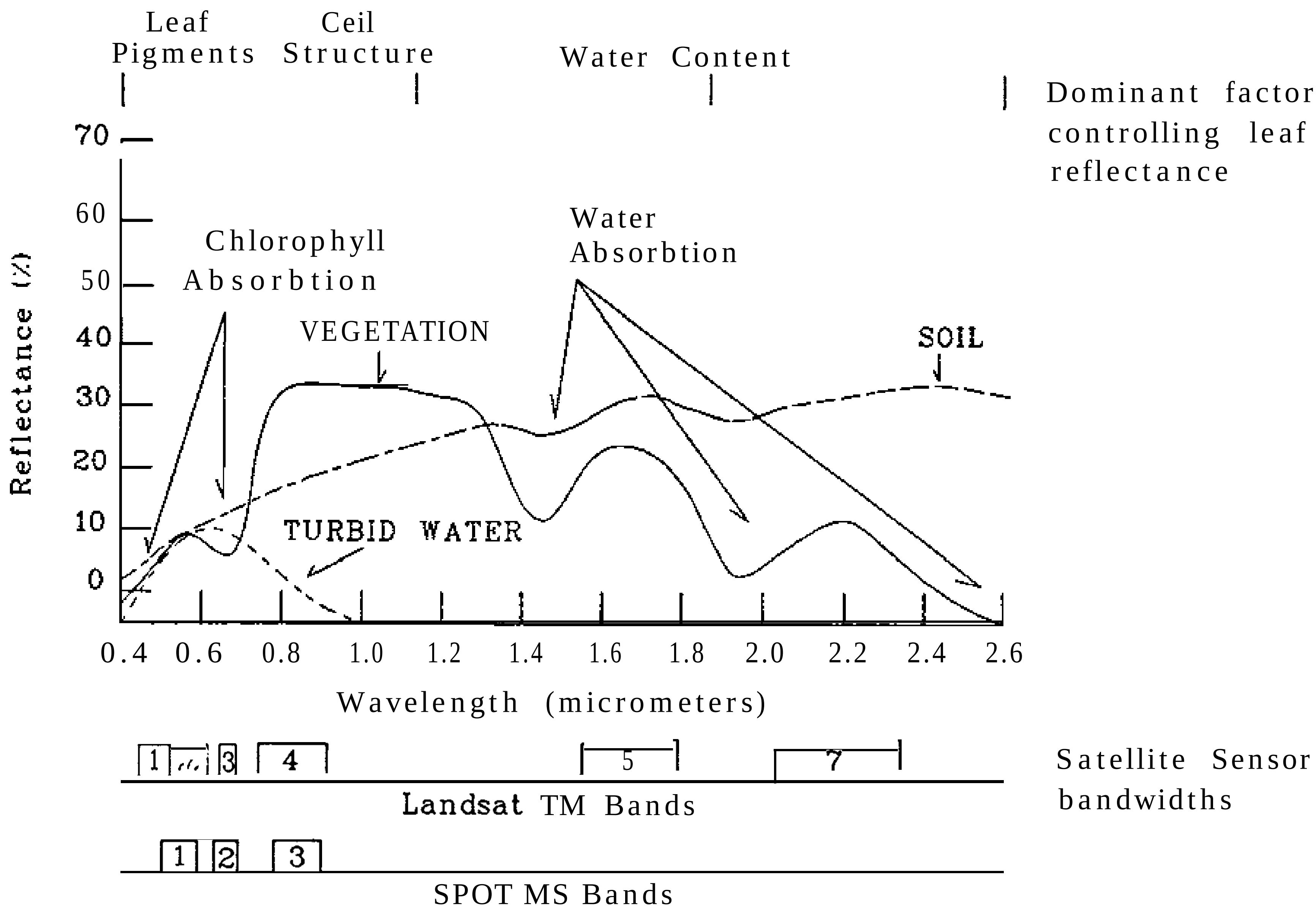
Figure 5. Spectral response curves showing variation in spectral response in Newtonia Silt Loam resulting from increasing soil moisture contents, after Bowers and Hanks, 1965

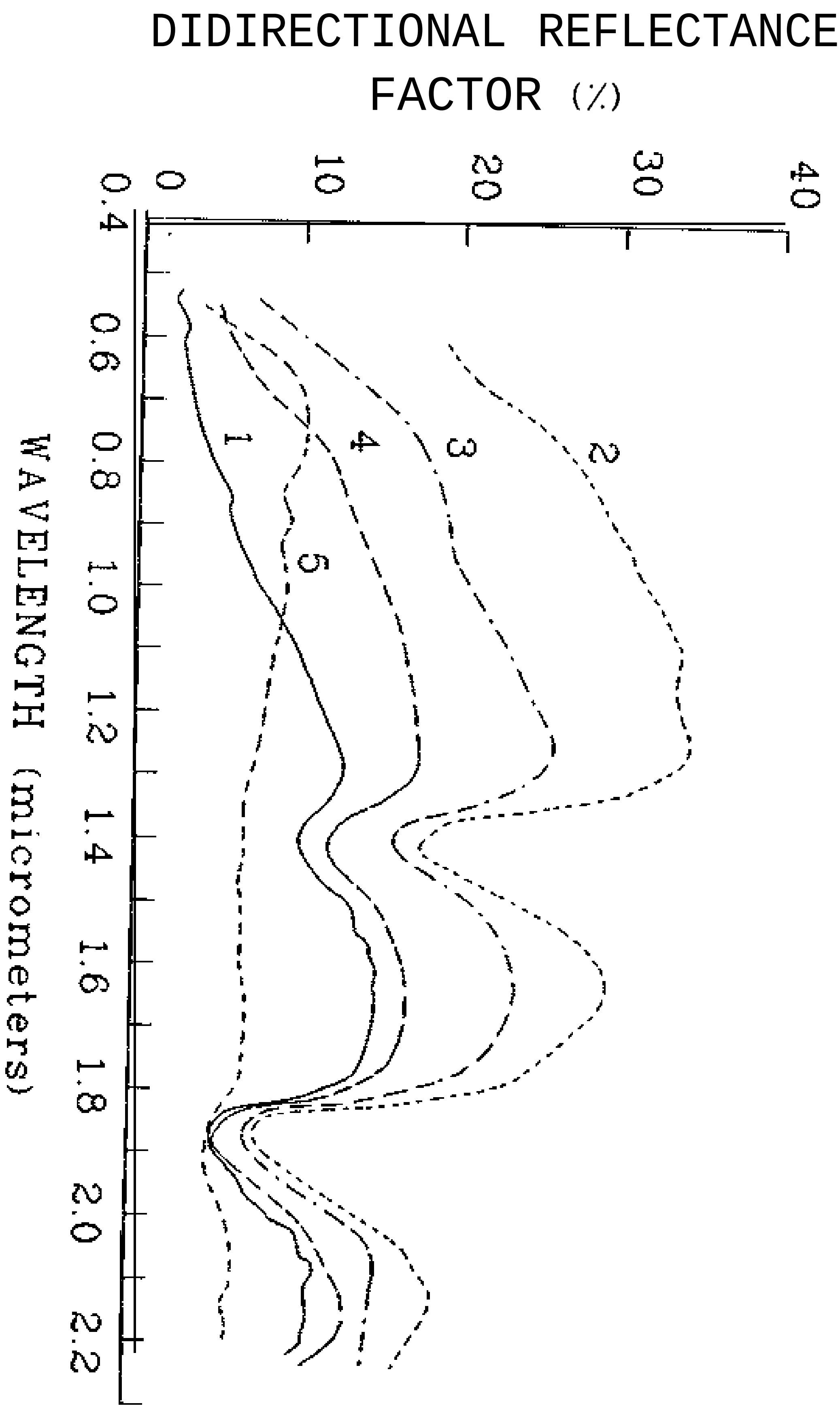
Figure 6. Spectral response curves for sand, clay, and loamy soil textures. Curves reflect the spectral response of differing minerology as much as differing texture.

Figure 7. The graph shows the effect of increasing vegetation cover on spectral response. Note the marked transition from the more or less typical soil spectra1 response curve for vegetation covers of less than 10 percent to the well defined vegetation spectral response curve for vegetation cover greater than IO percent. After Short, 1982.

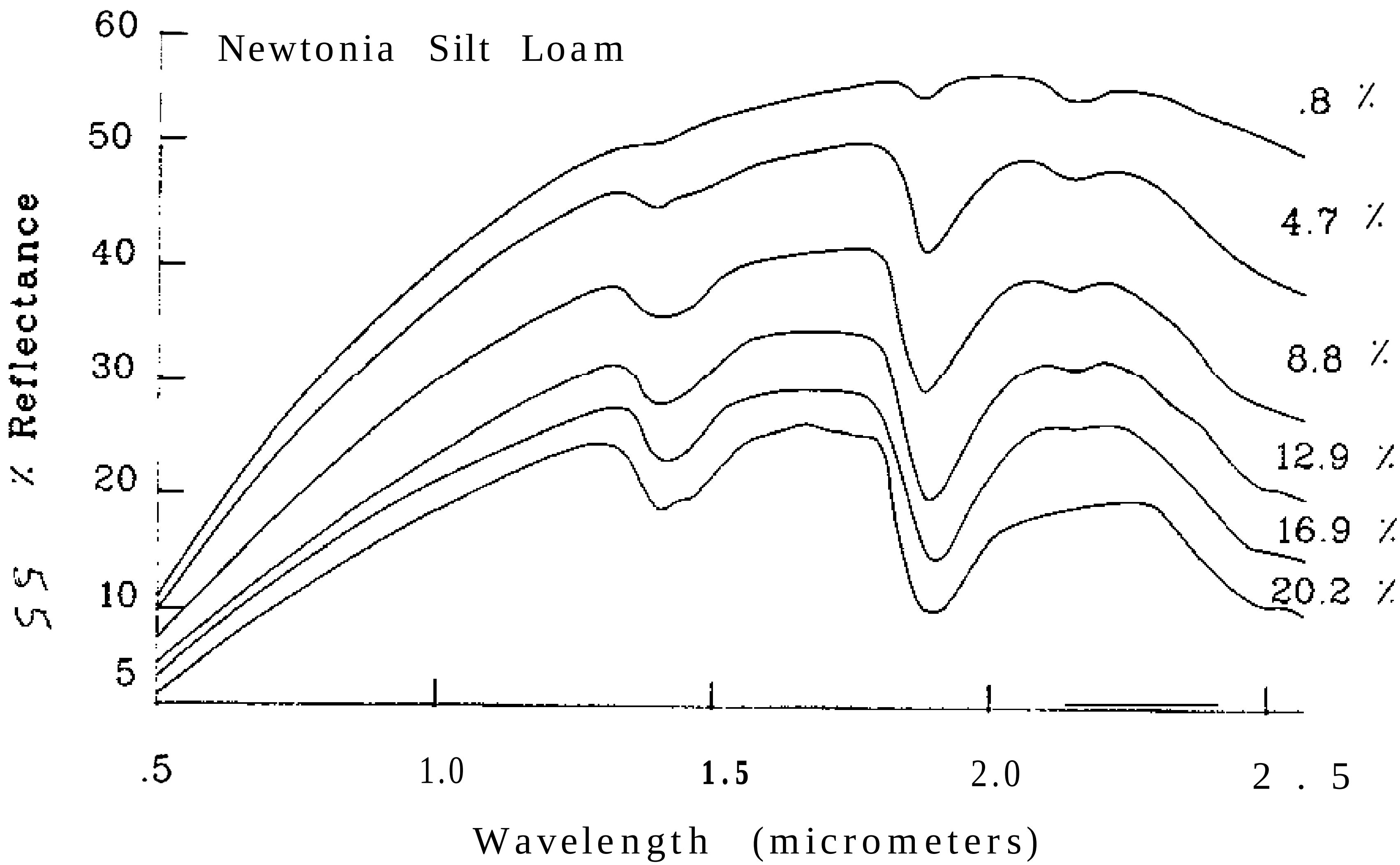

Visible
Gamma Rays
X-Rays
Ultra-Violet
Infrared
Microwave
Radio
1.0 Å
100 Å
1.0 μm
10 μm
100 μm
0.1 cm
1.0 cm
10.0 cm
1.0 m
10.0 m
100.0 m
1.0 km
10.0 km
100.0 km
Wavelength
"Photographic IR
Visible
Near Infrared
Middle IR
Far IR
0.4
0.6
0.8
1.0
3.0
5.0
14.0
Wavelength, μm


NEAR
MIDDLE
TRANSMITTANCE (PERCENT)
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
O_2
H_2O
CO_2
H_2O
CO_2
O_3
H_2O
CO_2
O_3
H_2O
CO_2
CO_2

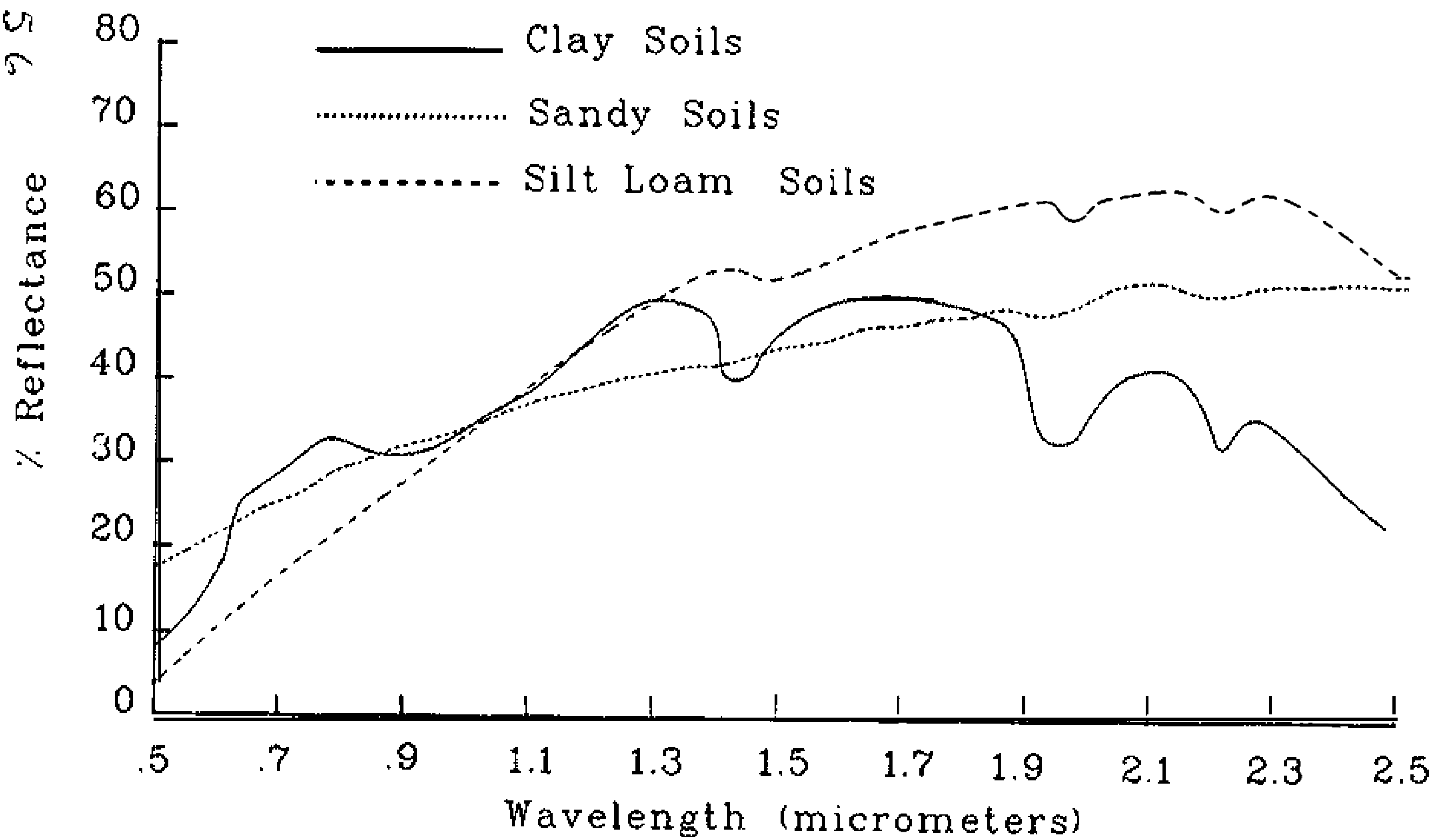

Leaf
Pigments
Ceil
Structure
Water Content
Dominant factor controlling leaf reflectance
Reflectance (%)
70
60
50
40
30
20
10
0
Chlorophyll
Absorbtion
Water
Absorbtion
VEGETATION
SOIL
TURBID WATER
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
Wavelength (micrometers)
1
3
4
5
7
Landsat TM Bands
Satellite Sensor bandwidths
1
2
3
SPOT MS Bands


DIDIRECTIONAL REFLECTANCE
FACTOR (%)
0
10
20
30
40
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
WAVELENGTH (micrometers)
1
2
3
4
5

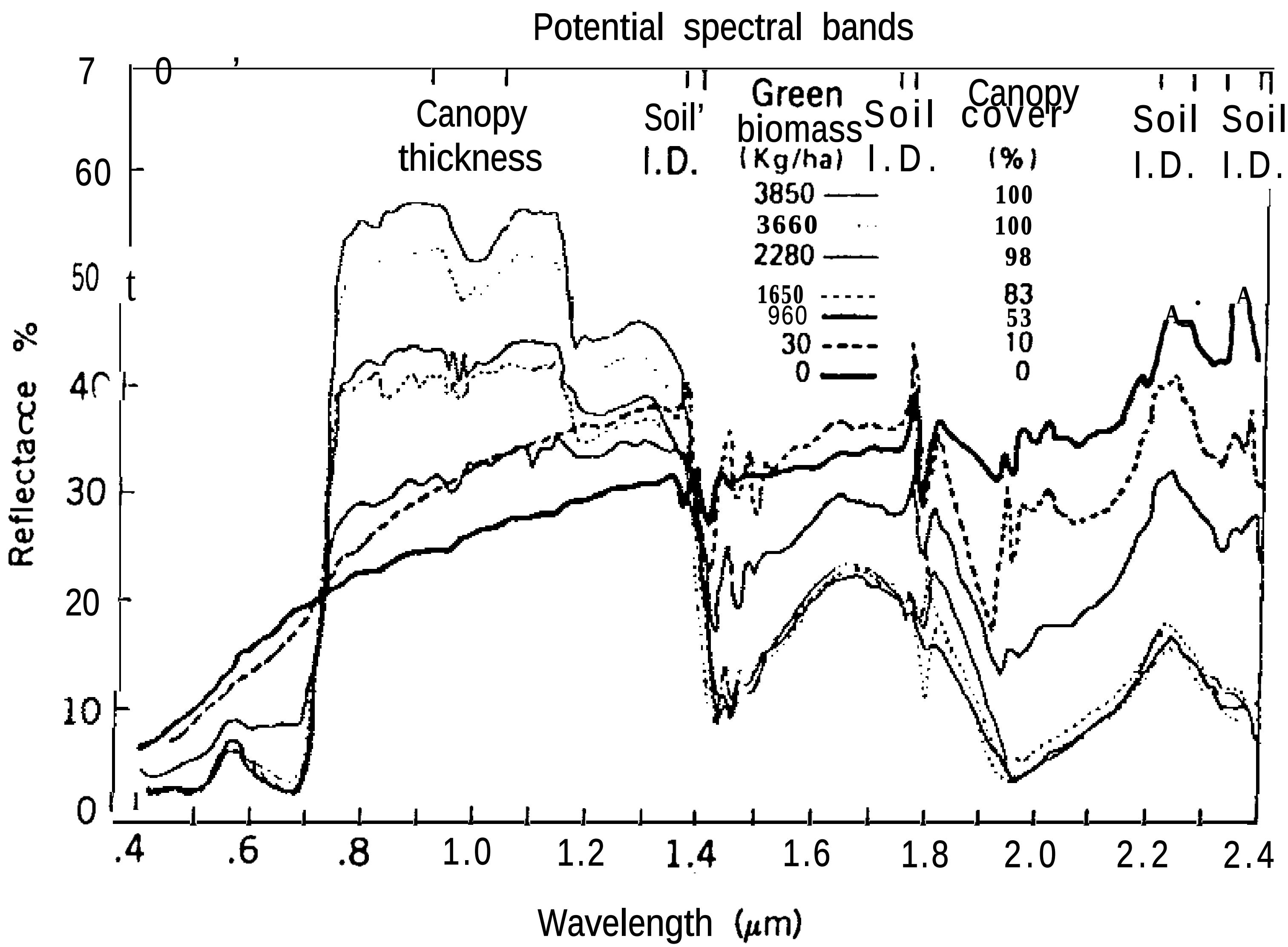
Change in Reflectance with Soil Moisture



Soil Texture and Spectral Response



56



Potential spectral bands
Canopy thickness
Soil' I.D.
Green biomass (Kg/ha)
Soil I.D.
Canopy cover (%)
Soil I.D.
Soil I.D.
3850 100
3660 100
2280 98
1650 83
960 53
30 10
0 0
Reflectance %
Wavelength (μm)

RECENT DEVELOPMENTS IN SOIL TAXONOMY
Soil Classification Staff
June, 1992
Bob Ahrens, SCS

During the past year the chairs from 3 international committees; ICOMAQ, ICOMOD, and ICOMERT; submitted their recommendations to Dr. John Witty, National Leader for Soil classification. The charges and summary of the major changes from each committee are outlined below.

ICOMAQ

The International committee on Aguic Moisture Regime (ICOWAQ) was established in 1982 and chaired initially by Frank Moormann, then by Johan Bouma (since 1985). The main classification problems which the committee undertook to solve vere the inadequate definition of the term aguic soil moisture regime, the lack of distinction betveen soils with perched and ground watertables, and the question of wetness induced by rice culture (paddy soils).

The following is a summary of the major changes in terminology proposed by ICOWAQ that will be implemented by the soon to be released amendment, NSTH issue 16:

1. The concept of aguic conditions will replace that of the aguic moisture regime. Aguic conditions in a soil *or* horizon require saturation, reduction, and redoximorphic features. The new term aguic conditions has a wider range of application than the term aguic moisture regime and will be used extensively in Soil Taxonomy.

2. Use of the term mottles that have chroma of 2 or less will be discontinued, and so is the use of the term mottles, with few exceptions: The following terms are introduced as replacements:

   a.' Redoximorphic features, which essentially includes all wetness mottles:

   b. Redox concentrations, which are concentrations of Fe and Mn and include the high-chroma wetness mottles:

   c. Redox depletions, which represent low-chroma wetness mottles (mottles vith a chroma of 2 or less) where *Fe* and Mn have moved out: and

   d. Reduced matrix, which represents reduced soil materials that change in color when exposed to air.

3. The new term endosaturation *means* the saturation of a soil with water in all layers from the upper boundary of

saturation to a depth of 200 cm or more from the mineral soil surface.

4. Episaturation means a saturation with water of one or more layers above a depth of 200 cm from the mineral soil surface in a soil that also has one or more unsaturated layers below the saturated layer.

5. The term anthric saturation characterizes a variant of episaturation which is associated with controlled flooding, e.g., of rice paddies.

Also included are changes in criteria for acid sulfate soils. Although ICOMAQ has not emphasized the revision of acid sulfate soils, Circular Letter No. 4 presented an update following the third International Symposium on Acid Sulfate Soils held in Senegal in January of 1986. The revisions included in this amendment were reviewed by the International Symposium on Acid Sulfate Soils held in Ho Chi Minh City, Vietnam, in February of 1992, and included in a paper "Fanning, D.S., and J.E. Witty. 1992. Revisions of Soil Taxonomy for acid sulfate soils," which was presented by Fanning at that symposium.

ICOMOD

The International Committee on Spodosols (ICOMOD) was established in 1981 and chaired initially by F. Ted Miller, then by Robert V. Rourke (since 1986). The committee's mandate was to:

1. Evaluate chemical criteria for defining spodic horizons:

2. Evaluate thickness requirements;

3. Improve the classification of Aquods;

4. Propose criteria that would adequately distinguish Spodosols from Andepts (Andisols); and

5. Recommend changes in the classification of Spodosols and define appropriate taxa as well as the diagnostic properties required for their definition.

The following is a summary of the changes proposed by the committee that will appear in the next National Soil Taxonomy Handbook issue.

1. The new criteria adds emphasis to the spodic morphology. Most soils presently classified as Spodosols will meet the new morphology, pH, and organic carbon requirements.

2. The albic horizon is used to separate most Spodosols from Andisols.

3. Spodic materials are introduced to allow more flexibility in defining the spodic horizon.

4. Iron and aluminum extracted by ammonium-oxalate rather than pyrophosphate and dithionate-citrate are used for the chemical criterion.

5. The "Al" great groups of Aguods and Orthods are added to capture the soils with low ammonium-oxalate-extractable iron contents.

6. The suborder of Cryods is added and "Trop" great groups are deleted.

ICOMERT

The International Committee on Vertisols (ICOMERT) was established in 1980, with Juan Comer-ma serving as chair. The objectives cf the committee were to:

1. Identify those criteria in the classification of Vertisols that have resulted in taxa with misleading or vague definitions or very few identifiable soils;

2. Propose improvements in the classification of Vertisols, considering both genetic and practical implications: and

3. Test the proposals and submit recommendations to the Soil Conservation Service for improving the classification of Vertisols in Soil Taxonomy.

The following i a summary of the major changes proposed by ICOMERT and that will appear in the next amendment to Soil Taxonomy:

1. Establishment of two new suborders, Aguerts and Cryerts, and their respective great groups and subgroups:

2. Introduction of new great-group and subgroup criteria to provide better interpretive groupings:

3. Elimination of the pell and chrom great groups because of the questionable value of the resulting classes: and

4. Redefinition of the vertic subgroup criteria to include more soils with high shrink-swell potential.

In addition to the changes mentioned above, the 5th edition of "The Keys to Soil Taxonomy" has had an English edit and should be easier to use. The 5th edition should be available in the fall.

other Committees

The International Committee on Aridisols (ICOMID) has submitted their recommendations to John Witty. The Soil Classification Staff will evaluate these recommendations later this summer and early this fall. The International Committee on Families (ICOMFAW) made excellent progress this spring and should have their final recommendations available in about a year. The International Committee on Soil Moisture and Temperature Regimes (ICOMMOTR) has one of the biggest challenges and has made good progress. However, this committee will need a couple years to complete their task.

Status of Policy on Hydric soils and Wetlands

Prepared by
Maurice J. Mausbach

Presented by
Lawson D. Spivey, Jr.

to the West Regional Cooperative Soil Survey Conference
June 25, 1992

Introduction: I find myself repeating things when reporting on hydric soil and wetland issues. One of the things I keep saying is that the hydric soil definition and criteria are a continuing issue especially with respect to the public comment on the Federal Manual for Identifying and Delineating Jurisdictional Wetlands. Special interest groups on both sides of the wetlands fence are keenly interested in how we in the National Cooperative Soil Survey (NCSS) manage and control the quality of the hydric soil lists. Some groups just plain do not trust us. Other groups are very interested in the scientific basis for the hydric soil definition and criteria and will perhaps challenge the National Technical Committee for Hydric Soils (NTCHS). In this report, I will discuss a brief history, organization, and activities of the NTCHS, some current issues concerning hydric soils, and some issues on the Federal Wetlands Manual and our agency's National Food Security Act Manual.

Background: The Soil Conservation Service (SCS) began work on a hydric soil definition in 1977 at the request of the Fish and Wildlife Service (FWS). Blake Parker, a soil scientist, was working with FWS to develop a definition of hydric soils. Keith Young was assigned the task to work with Blake on developing a definition of hydric soils and a list of hydric soils for use in the FWS National Wetlands Inventory. From 1977 to 1981 definitions were developed and tested in field studies. In 1981 the NTCHS began as an ad hoc group with the charge to develop a definition and criteria for hydric soils and a list of hydric soils. Dr. Guthrie chaired the group which consisted of Keith Young, Blake Parker, Keith Schmude, Carl Thomas, Arville touchet, Paul Johnson, and Del Fanning. In October of 1981 the first national list of hydric soils was distributed far state and NTC review. This list generated many comments both from SCS and the Land Grant Universities.

In early 1985 the present National Technical Committee for Hydric Soils was organized by the SCS Deputy Chief for Technology and the Corps of Engineers (CE): Environmental Protection Agency (EPA), and FWS were invited to assign permanent members to the committee. Dr. Guthrie also invited experts from the university community to join the committee. Keith Young replace Dr. Guthrie as chair of the NTCHS shortly after the committee was formed. It was under his leadership that the criteria were developed. In 1985, I replaced Keith as chair.

In 1985 congress passed the Food Security Act (FSA) which cited the hydric soil criteria as part of the definition of wetlands as part of Swampbuster legislation. Also in 1985, the committee published the first edition of Hydric Soils of the United States. The NTCHS published the second edition in 1987 and the third edition in 1991. The 1987 wetland manuals of the CE and EPA also required the use of hydric soil lists.

National Technical Committee for Hydric Soils: The NTCHS is an interagency, interdisciplinary committee. Its functions are to:

- Develop and improve hydric soil definition and criteria
- Publish a national list of hydric soils
- Respond to comments on hydric soil criteria
- Provide technical consultation on hydric soils to other technical groups
- Investigate new technology for defining hydric soils

The committee representation includes 7 from the Soil Conservation Service (SCS), 5 from universities, and one each from EPA, FWS, CE, Bureau of Land Management (BLM), Forest Service (FS), and a private consultant. Of the 18 total members we have 13 soil scientists, 4 biologists, and 1 engineer. The SCS members include:

- Maurice Mausbach (Chairperson)
- Ray Miles (West representative)
- C. L. Girdner (Midwest representative)
- De Wayne Williams (South representative)
- H. Chris Smith (Northeast representative)
  (State soil scientist representative)
- Billy Teels (National Biologist)

The other members are:

- D. Fanning, University of Maryland
- Richard Guthrie, Auburn University
- W. Patrick, Jr., Louisiana State University
- R. W. Skaggs, North Carolina State University
- J. Richardson, North Dakota State University
- P. Reed, FWS
- R. Theriot, CE
- W. Sipple, EPA
- C. Voigt, BLM
- P. Avers, Forest Service
- W. Blake Parker, private consultant

The committee is chaired by SCS. Committee membership has gradually grown to the present 18. Avers, Voigt, and Richardson have been added in the past year.

The committee usually meets once a year to review comments on the hydric soil definition and criteria. They often meet in an area to study hydric soil issues in the field. The next meeting is scheduled for Fargo, North Dakota in August. The committee will tour the hydric soil research sites in the pothole area.

Hydric soils: The most recent changes in the hydric soil criteria added frequency to the saturation criterion to require frequent saturation (more than 5 out of 10 years). This change matches frequency criteria for flooded and ponded soils. Duration for saturation was increased to more than two weeks during the growing season. This change reflects current research that shows, on average anaerobic conditions occurring after 10 to 20 days of continuous saturation. These changes do not affect the list of hydric soils as our soil property record is not specific enough to distinguish between 1 or two weeks of saturation. The NCSS definition of a seasonal high water table is:

> "A zone of saturation at the highest average depth during the wettest season. It is at least 6 inches thick, persists in the soil for more than a few weeks, and is within 6 feet of the soil surface."

The NTCHS revised the criterion for depth of water table in sandy soils to occur above 0.5 feet instead of 1.0 feet. Sandy soils have sand, coarse sand, or fine sand textures in the upper 20 inches. This requires the water table at the surface for these sandy soils. This change is supported by the thickness of the capillary fringe in these soils. The major affect of this change is for sandy soils on the lower Atlantic Coastal Plain.

The current hydric soil definition and criteria are given in the appendix. The SCS publishes a national list of hydric soils for the United States. The list is computer generated by matching the criteria to soil properties on the Soil Interpretations Record (SIR). Soils are added and deleted from the national list only buy changing the estimated properties on the SIR. The national list contains taxa at the series level of Soil Taxonomy. The third edition was published in June 1991. This publication is in high demand by wetland delineators and other users of the information. This national list is maintained on computer file and can be subdivided by state.

The local or field office lists of hydric soils are the most specific for use in wetland determinations. They are generated using the specific information in the state soil survey database for the soil survey area by matching the criteria with soil properties of the map unit components. The software also allows for adding information about included soils. The lists contain information on the landscape position of the hydric component of the map unit. It is extremely important that the soil property records for components of map units are of the highest technical quality because these lists are coming under extreme scrutiny.

Hydric soil issues: The major issue for hydric soils is our quality control and quality assurance procedures on the soil properties used in the hydric soil criteria as they reflect changes in the hydric soil lists. I emphasize that we must document any changes that affect a soil either being added or deleted from the list of hydric soil map units or hydric soil series. The NTCHS has a subcommittee drafting proposals for the kind and amount of documentation. I know that Florida has already developed a system to track and document changes in hydric soils. I believe the South National Technical Center has circulated this system to all states for comment. Other National Technical Centers (NTC's) are doing the same. We have been asked by outside groups to monitor these changes at the National level, but have been able to respond that our NTC's and National Soil Survey Center Quality Assurance staffs are performing this function.

Some individuals are suggesting that the NTCHS publish changes in hydric soil criteria in the Federal Register for public comment. We presently file notice of change. We have been able to thwart these suggestions but the pressure remains. These same individuals think we should publish for public comment changes to the lists of hydric soils. It is extremely doubtful that this will happen, but if it did it would impact most of what we do in soil survey. Because of these issues, we must be extremely attentive to our quality assurance of the soil property record and of changes to the hydric soil lists.

The NTCHS continues to review our understanding of soil processes in wet soils. The period of saturation, flooding and pondinq necessary for a soil to become anaerobic is a crucial issue. In this respect, I am working with Dr. Jimmy Richardson, North Dakota State University, to review the literature on the biogeochemical processes in wet soils. One of my goals is to develop a generalized kinetics framework from which to deal with time needed to develop anaerobic conditions. Major factors are organic matter content, soil temperature, soil wetness characteristics, pH, and the kind of organic matter available to the microorganisms.

Depth to water table and saturation in the capillary fringe are continuing issues with the hydric soil criteria. Saturation in the capillary fringe is part of the current water table definition. The criteria now read that water tables are less than a certain depth such as 1.5 feet. By our database convention, this in fact means that the water table is at 1.0 feet, because we only record water table depths by 0.5 foot increments. There is a difference of opinion as to the capillary fringe and development of anaerobic conditions. There are some reports in the literature of reducing conditions in the wetter part of the capillary fringe.

In an effort to resolve some of the issues, the SCS in conjunction with the CE has extended the wet soils research projects.

In addition to the sites in Louisiana and Texas, we are contracting with Dr. Richardson, North Dakota State University: Dr. Huddleston, Oregon State University: Dr. Ping, University of Alaska: Dr. Franzmeier, Purdue University; and Dr. Veneman, University of Massachusetts to study water tables, oxidation reduction potentials, and other soil processes. The information. will help in understanding soil processes in these wet soils, help to support or refine hydric soil criteria, and assist in defining aquic conditions in soils. The study in Alaska will also help refine biological zero in cold soils.

Federal Wetlands Manual: The first edition of the Federal Manual for Identifying and Delineating Jurisdictional Wetlands was published in 1989. During 1990 the CE and EPA held a series of public hearings on the manual. The interagency committee responsible for the manual has redrafted the manual addressing the concerns of the public and wetland delineators. The revised manual was then revised by the National Council for Competitiveness which is chaired by the Vice President. These revisions were then published in the Federal Register for public comment. We received over 80,000 comments, which the EPA is now summarizing. The interagency technical committee is reviewing the technical comments and are making technical recommendations to the Vice Presidents committee on the Federal Manual. The soils section of the Federal Manual needs major revisions regardless how the hydrology criterion develops.

Changes in the 1989 manual include:

- The hydrology criterion is separate from hydric soils and requires 15 days of inundation to the surface and/or 21 days of saturation at the surface.

- The growing season for hydrology is the interval between 3 weeks before average date of last killing frost in spring to 3 weeks after average date of first killing frost in fall.

- Specifies the use of hydric soils criteria and minimizes the use of hydric soil (morphological) indicators but requires field verification of hydric soils.

- Emphasizes that all three criteria must be met for an area to qualify as wetland.

- Allows for the use of wetland hydrology indicators to determine hydrology under certain circumstances.

The hydrology criterion remains the major stumbling block and it is anybody's guess at what it will be. I can guarantee you that it will be different from what we are presently using in the National Food Security Act Manual (NFSAM).

The wetland delineation community has asked us to develop wetland hydrology (hydric soil) indicators for saturated soils. Hydrology from saturation is the most difficult criterion to measure and evaluate in the field. Measurements must be made over a multiyear period when weather is close to normal. Therefore,. soil characteristics that correlate to wetland hydrology are extremely important in identifying wetlands in the field. We started out by trying to have a national list of indicators, but have now decided to develop lists of indicators on a regional or perhaps a state basis with the NTC's monitoring their development and approving the use of the indicators. Florida has set develop an excellent set of indicators which may work in other states. One of the key problems in developing indicators is that non soil scientists use and sometimes misuse of them. Most of the indicators are very technical and require a soil scientist's expertise. It is my believe that one of the main problems with the 1989 Federal Wetlands manual was the misuse of the hydric soil indicators.

summary: Hydric soil and wetland issues are at the forefront, politically and scientifically. We in the National Cooperative Soil Survey are being asked to better quantify are information on soil saturation, flooding and ponding and to further develop our knowledge on genetic soil processes in wet soils. We must develop documentation to support our technical decisions to change soil properties that impact the hydric soil status of a soil series or map unit delineation. We must also have quality assurance and quality control procedures in place and operating to be able to respond to public question on the changes in the lists.

APPENDIX
DEFINITION OF HYDRIC SOIL

A hydric soil is a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. The following criteria reflect those soils that meet this definition.

CRITERIA FOR HYDRIC SOILS

1. All Histosols except Folists, or

2. Soils in Aquic suborder, Aquic subgroups, Albolls suborder, Salorthids great group, Pell great groups of Vertisols, Pachic subgroups, or Cumulic subgroups that are:

a. Somewhat poorly drained and have a frequently occurring water table at less than 0.5 ft from the surface for a significant period (usually more than 2 weeks) during the growing season, or

b. poorly drained or very poorly drained and have either:

(1) a frequently occurring water table at less than 0.5 ft from the surface for a significant period (usually more than 2 weeks) during the growing season if textures are coarse sand, sand, or fine sand in all layers within 20 in , or for other soils

(2) a frequently occurring water table at less than 1.0 ft from the surface for a significant period (usually more than 2 weeks) during the growing season if permeability is equal to or greater than 6.0 in/h in all layers within 20 in, or

(3) a frequently occurring water table at less than 1.5 ft from the surface for a significant period (usually more than 2 weeks) during the growing season if permeability is less than 6.0 in/h in any layer within 20 in, or

3. Soils that are frequently ponded for long duration or very long duration during the growing season, or

4. Soils that are frequently flooded for long duration or very long duration during the growing season.

Revised NTCHS 9/27/90

GLOBAL CHANGE

by
Deborah Ulinski Potter, M.S
USDA Forest Service

Most people associate global change with climate change. Or perhaps others think of ozone layer depletion in the stratosphere. The scope of global change, however, is much broader. Current trends such as decreasing biodiversity, continuing acid deposition, deforestation, population growth, soil and coastal erosion, waste generation and disposal, and desertification are all aspects of global change. The cumulative and synergistic effects of these changes on ecosystems, however, are poorly understood.

GLOBAL CHANGE RESEARCH PROGRAMS

It is essential to study global change at various scales (i.e., local, regional and global) in order to understand potential impacts to ecosystems and human interactions. Global concerns are currently being addressed primarily at the international and national levels. Although global predictions vary in reliability, the uncertainty of regional effects is high due to a lack of refined models or other predictive methods.

International Efforts

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United Nations Environmental Program and the World Meteorological Organization. A recent report summarized the state of knowledge regarding global change (Houghton et al. 1990). The United States National Academy of Sciences, Committee on Global Change, is part of a program called the International Geosphere-Biosphere Program (IGBP). The IGBP was established in 1986 by the International Council of Scientific Unions to study the biogeochemical processes of the biosphere, and is the primary coordinating organization at the international level (Committee on Earth Sciences 1989). Additional international efforts are through the World Climate Research Program of the World Meteorological Organization and other intergovernmental bodies (ibid).

The recent "Earth Summit," formally known as the United Nations Conference on Environment and Development (UNCED), addressed several aspects of global change. One product was the endorsement of 27 principles known as "The Rio Declaration." An environmental action plan, "Agenda 21," specifies ways to promote energy efficiency and sustainable economic development. Another product was two treaties: the Biodiversity Convention to protect indigenous species; and the Climate Convention of policies to control carbon dioxide emissions.

The United States was the only nation to refuse to sign the Biodiversity Convention, and demanded the removal of all goals and timetables to stabilize, but not reduce, carbon dioxide emissions before signing the Climate Convention. On a more positive note, the President announced an international and cooperative "Forests for the Future Initiative" to conserve and sustain forest resources. It is primarily a program of financial assistance and voluntary partnerships to stop global deforestation in the next few decades.

There was no discussion of problems directly associated with population growth at the Earth Summit, despite the fact that over five billion people have occupied the earth since 1987. Scientists such as Paul Ehrlich postulate that the planet has already approached or exceeded its carrying capacity. Population is projected to increase to approximately 10 to 14 billion by the middle of the next century.

US Efforts

The U.S. Global Change Research Program involves many government agencies, academic institutions and the private sector, and is coordinated by the President's Office of Science and Technology Policy. The main committee of the Federal Coordinating Council on Science, Engineering and Technology (FCCSET) responsible for global change planning and coordination is the Committee on Earth Sciences. The research objective is to monitor, understand, and predict global change so that resulting information can be used as the basis for policy decisions (Committee on Earth Sciences 1989).

The Sustainable Biosphere Initiative of the Ecological Society of America was announced in 1991. It focuses on the ecological aspects of global change and sustainability. Three principle concerns are global change, biological diversity, and sustainable ecological systems (Lubchenco et al. 1991).

Regional Effort6

Global change results in varying regional effects and priorities. However. little information is currently available on the regional impacts of global change. An interdisciplinary group known as the Rio Grande Basin Consortium was organized through the University of New Mexico Department of Biology in 1990 to provide a network for sharing information and to develop the Rio Grande basin as a regional study site for global change. It is postulated that the effect of climate change would be detectable early since four biomes meet within the basin and form ecotonal edges that are highly sensitive to change. These biomes are the Chihuahua" Desert, Mountain Conifer Woodland, Great Plains Grassland, and Great Basin Shrub Steppe (Risser 1990).

Several hypotheses of the effects of climate change on the Rio Grande Basin have been presented (Rio Grande Basin Consortium 1990, unpublished comm.):

1. different stream precipitation quantity and temporal distribution;
2. changes in stream flow quantity and quality;
3. changes in water availability that will affect water supply, laws and both interstate and international compacts;
4. effects on demographics, land use patterns, and other social factors;
5. economic impacts; and
6. a northward shift in the distribution of the four biomes of New Mexico.

A study by the National Academy of Sciences showed that a two degree Celsius temperature increase and a 10% decrease in precipitation in the Rio Grande Basin may result in a 76% decline in runoff (National Academy of Sciences 1983; Thomson and Thompson 1991.1 Such change would not only affect ecosystems, but impart political, economic, institutional and social consequences. The Rio Grande is also unique in that it divide6 an industrialized and developing nation. Thus, understanding the human dimension of climate change is an important aspect of the Consortium.

The Consortium sponsored an upper basic conference in June 1990, and is supporting a combined conference with Mexico's El Colegio de la Fronterna Norte (COLEF), the Lower- Rio Grande Research Project of the Houston Advanced Research Center, the University of Texas at El Paso's Binational Water Policy Institute. and the University of New Mexico. The purpose of the meeting is to discuss how global change will affect the Rio Grande/Rio Bravo basin and to identify innovative processes for sustainable development. The Consortium also hopes to participate in a new project of the Scientific Committee for Problems on the Environment (SCOPE) that is being initiated at seven regional workshops.

Forest Service Global Change Program

The Forest Service Global Change Research Program views global change as a resource issue. The fundamental research goal is to understand, monitor and predict the impacts of atmospheric change on forest ecosystems. The program is divided into four geographic regions to develop and implement detailed plans for monitoring and modeling: the Northern, the Southern, the Interior West and the Pacific Coastal Region.

At the National level, the Forest Service Global Change Program has four program elements. These are: atmosphere/biosphere interaction; disturbance ecology; ecosystem dynamics; and human interactions with natural resources.

The Interior West Global Change Program, headed by Douglas Fox, Rocky Mountain Forest and Range Experiment Station, has identified their areas of concern, as follows:

1. 'Terrestrial vegetation, life histories and distributions and community compositions;
2. Water quality and quantity, erosion and sedimentation;
3. Energy and biogeochemical cycles;
4. Aquatic ecosystems and wetlands;
5. Insects, pathogens, and microbes;
6. Fire severity and occurrence; and
7. Wildlife and domestic species" (USDA Forest Service 1990).

The program includes cooperative research that integrates effects of global change at various scales through an interagency laboratory for Terrestrial Ecosystem Regional Research and Analysis (TERRA). The objectives of the TERRA lab are to "establish an inter-agency land processes laboratory; improve the description of land processes in General Circulation Models; understand the role of terrestrial processes in climate change; assess land changes at the regional level; and employ an interdisciplinary systems analysis approach" (Watts 1991).

The Rocky Mountain Forest and Range Experiment Station also conducts research at the Glacier Lakes Ecosystem Experiments Site (GLEES) in Wyoming to evaluate how alpine and subalpine ecosystems may respond to climate change (Musselman and Fox 1991a).

SCIENTIFIC FINDINGS

Information from the international and national global change programs, and findings from academic institutions are rapidly becoming available. Broad scientific findings for sir global change issues identified in the introduction are discussed below.

Atmospheric Concentration of Greenhouse Gases

Other than water vapor, the most important atmospheric gases that affect the Earth's surface temperature are as follows: carbon dioxide (49%); methane, a mote effective greenhouse gas than CO_2 for global warming (19%); chlorofluorocarbons (14%); nitrous oxide (6%); and various trace gases such as nitrogen oxides (13% total) (NASF 1990). Activities that contribute to global warming include energy use and production (57%), release of CFCs (17%), agricultural practices (14%), and land use modification (9%) (ibid).

It is widely accepted by the scientific community that the atmospheric carbon dioxide concentration will double from 300 to 600 ppm within the next century due to fossil fuel combustion, industrial and agricultural activities (Schneider 1989; Godish 1993). Many studies indicate that the anthropogenic inputs of these gases may have already caused significant atmospheric changes since the industrial revolution. The current estimate is that carbon dioxide levels have increased 25% since 1850 to over 350 ppm, and the rate of increase has accelerated over the last thirty years (U.S. EPA 1988, Council on Environmental Quality 1989; Godish 1991). Similarly, methane concentrations have doubled since the early 19th century to approximately 1.70 ppm (Godish 1991).

Ice cores from Greenland's ice caps contain trapped air bubbles that have been analyzed for carbon dioxide concentrations. These stacked ice layers contain a record of the atmosphere for 160,000 years. An analysis of the Vostock ice core shows increasing carbon dioxide concentrations from less than 280 ppm in the 1700's to 350 ppm today (NASF 1990; Barnola et al. 1987). Actual measurements over the last century show an increase in carbon dioxide, nitrogen oxides, methane and CPC concentrations, global temperatures, and deforestation (NASF 1990, Council on Environmental Quality 1989).

Global Climate Change

Climate change reflects the combined effect of natural and athropogenic factors. Natural factors that influence climate include volcanic eruptions and the El Nina-Southern Oscillation (ENSO) events. The eruption of volcanoes such as Mt. Pinatubo or Mt. St. Helens generates a cooling effect on climate because particles ejected into the atmosphere scatter light and impede incoming solar radiation. Conversely, the El Nina-Southern Oscillation generates a climate warming effect due to increased ocean temperatures. Although the El Nino corresponds to some warm years in the 1980's, 1990 was a normal year yet higher than average temperatures still occurred.

El Nino events are driven by the weakening of trade winds and dominance by the Westerlies that move warm water from the Western Pacific toward the Eastern Pacific, causing surface temperatures to increase across the ocean. These warm currents are detected along the coast of Peru around Christmas time. In a normal year, the trade winds force warm waters toward the Western Pacific Ocean, and maintain cooler surface temperatures in the cental and eastern Pacific. The Southern Oscillation is characterized by fluctuating barometric pressure over the Pacific Ocean, During El Nino events, barometric pressure falls. When opposite conditions occur, i.e., unusually cold surface waters in the middle of the Pacific Ocean end a corresponding rise in barometric pressure, this is called a La Nina year (Molles and Dahm 1990).

In the southwest, increased precipitation volume and changes in precipitation quality are associated with El Nino-Southern Oscillation (ENSO) events; The southwest experiences a wet spring end fall during en El Nino year, while the consequence for the Pacific Northwest is drought. Areas within the southwest that are affected include the Rio Grande Valley, the Gila River Basin, end southeastern Arizona. High precipitation El Nino years also bring greater acid precipitation inputs end less dry deposition of alkaline duet. Conversely, La Nina episodes may bring less moisture, winter-spring drought and a higher incidence of forest fires to affected areas of the southwest. During El Nino years spring runoff in the Gila and Pecos Rivers is two to three times higher then average, end six to seven times higher then during La Nina years (Molles end Dahm 1990).

The anthropogenic contribution to global warming is known as the enhanced greenhouse effect, or increased absorption of infrared radiation emitted by the earth's surface. In this context, global warming is the predicted result of activities such as fossil fuel combustion end deforestation which produce greenhouse gases. Accordingly, the lower stratosphere will become cooler as the troposphere (lower atmosphere) warms. Greenhouse warming is one of several factors concerning global climate change. Related climate changes include variations in the timing end distribution of precipitation, as well as variations in humidity, soil moisture, cloud cover and evaporation.

Global temperatures have been estimated by at least four methods. These include: 1) lend-based surface temperatures of the Earth "sing thermometers, 2) extrapolations that include both land end ocean surface temperatures, 3) satellite measurements of the troposphere end stratosphere using radiometers, end 4) balloon measurements of temperatures in the troposphere. A current warming trend based on data from the earth's surface is demonstrated by six of the seven warmest years in the 140 year record occurring between 1980 end 1990 (Monastersky 1991). Currently, 1990 is the hottest year on record, and 1991 had the second warmest (land-based) global average surface temperature. This represents a 0.5C warming in the lest century (Monastersky 1991). Subsequent drought end crop failure brought national attention to the global warming issue (NASF 1990). Initially 1991 was very warm but cooled during the second half of the year, partially due to the eruption of Mt. Pinatubo in the Philippines that June. In addition, the highest tropospheric temperatures have been recorded in 1988 end 1990 "sing balloon measurements at 63 sites while 1991 is the fourth warmest year (Monastersky 1991, 1992a). Calculations that include ocean surface temperatures in addition to land-based measurements show a record 0.39C temperature rise above normal in 1990 (Kerr 1991).

Not all scientific estimates of global temperature support global warming. Satellite data for the mid-troposphere end lower stratosphere has been collected since 1979 "sing radiometers (Spencer and Christy 1990). Preliminary analyses indicated that no long-term warming trend was detectable, but the data were skewed by the short record length and the 1983 end 1987 ENSO events.

Although climatologists can not conclusively link the indications of global warming to greenhouse gases (Kerr 1991), "international scientific opinion strongly supports the reality of this enhanced greenhouse effect" based on both land and sea-surface temperatures (Monastersky 1991, 1992b).

Perhaps the most frequently cited response to rising temperature is a sea level rise due to thermal expansion and glacial melting. It is estimated that the rate of sea level rise will be at least 0.5 to 2.0 m by 2100 (Smith and Tirpak 1988). Very recent signs of global warming have been found in the rapid shrinking of high-mountain glaciers in the tropics and temperate areas (Table 1). A study of oxygen isotopes representing a five hundred year record for the Quelccaya Ice Cap in Peru shows that 1990 had the most melting on record. Similar results are reported for ice caps in China and Kirghizia and glaciers in east Africa. For example, the World Meteorological Organization reports that glaciers on Mt. Kenya receded by 40% from 1963 to 1987, in part due to atmospheric warming (Hastenrath and Kruss 1992). Satellite images and aerial photography show rapid disintegration of the Wordie Ice Shelf in Antarctica since 1966, which is also attributed to a progressive warming trend (Splettstoesser 1992).

General Circulation Models (GCMs). GCMs have been used to predict global temperatures under a doubling of greenhouse gas levels over the preindustrial concentration, which is expected to occur by the year 2050. Although all the models predict global warming, the magnitude of the temperature increase varies. The predicted global temperature increase is roughly 3 to 5C (Joyce, Forsberg and Comanor 1990). The greatest climate change will likely be at the poles and middle latitudes and only a one degree change may be detected at the equator (ibid). It is also predicted that the Northern Hemisphere will experience greater warming than the Southern Hemisphere (Lal and Jain 1989).

Uncertainty in the models is due to poor representation of clouds and the deep ocean, the complexity of positive and negative feedback mechanisms, and coarse spatial resolution (Joyce et al. 1990). Inconsistent predictions among various models also needs to be resolved. Indirect effects in the models do not always weaken global warming, however, and some climatologists contend that the positive feedback mechanisms that enhance global warming are largely underestimated (Kellogg 1991).

For example, cloud behavior is poorly simulated by the existing models, and clouds provide both positive and negative feedback to global warming. Although rising temperatures would increase cloud formation and distribution, and thereby block incoming solar radiation, clouds also efficiently trap infrared radiation (Godish 1991). Some negative biological feedback mechanisms such as enhanced photosynthesis would be relatively short-term, and enhanced microbial decomposition would concurrently release carbon dioxide to the atmosphere (Musselman and Fox 1991; Joyce et al. 1990). Another positive feedback mechanism that magnifies the warming trend is reduced snow-covered area that results in less reflection and larger dark surface areas to absorb heat.

global Carbon Budget. Understanding the global carbon budget is crucial for predicting climate changes and the relative contribution of factors such as

Table 1. Observed glacier melting due to warming. Anthropogenic contributions are undetermined. Splettstoesser 1992; Hastenrath snd Kruss 1992; Monastersky 1992.

- Antarctica -- Wordie Ice Shelf
  shrank from 2000 sq. km in 1966 to 700 sq. km 1989
- China ice caps -- 50 year warming trend*
- Peru -- Quelccaya Ice Cap
  1991 most melting in 500 yrs.*
- Kirghizia (formerly USSR) -- 50 year warming trend*
- East Africa -- Uganda and Kenya
  Ruwenzori Mtn. glacier receded > 150 m from 1977 - 1990
  Mt. Kenya 40% surface loss 1963-1987

* Based on oxygen isotopes.

fossil fuel combustion and deforestation. The largest carbon reservoir is the oceans (Table 2). However, in addition to knowing where carbon is stored, it is also important to know the capacity for uptake and release, or carbon flux. Since only half of the carbon dioxide emissions remain in the atmosphere, it was often thought that the remainder is largely absorbed by the ocean, and a smaller fraction is absorbed by land vegetation and soils. The net rate of uptake by the oceans is less than one Gt per year (Tans et al. 1990; Musselman and Fox 1991b). Thus, the magnitude of carbon flux of the oceans is now considered less than the terrestrial exchange (Musselman and Fox 1991b).

In 1967, the National Academy of Sciences reported that a doubling in atmospheric carbon dioxide concentration would foster the following global changes:

> "large stratospheric cooling (virtually certain)
> global mean surface warming (very probable)
> global mean precipitation increase (very probable)
> reduction of sea ice (very probable)
> polar winter surface warming (very probable)
> summer continental dryness (likely in the long run)
> high latitude precipitation increase (probable); and
> rise in global mean sea level (probable)" (U.S. BPA 1988).

Effects of Global Change on Forests

Kellogg has compared predictions for soil moisture changes by season. He notes that three or more models agree that soil moisture will increase during the winter throughout much of the United States. Similarly, three or more models predict that soil moisture will decrease throughout most of North America in the summer (Kellogg 1991).

Global warming could affect the location, abundance, and health of tree species. Rapid changes in environmental variables such as soil moisture, and subsequent disturbances such as periodic &ought CM severely stress forest ecosystems. Excessive stress then generates pest infestation and other indications of forest decline.

Using data from a GCM, Leverenz and Lev (1987) predicted that Douglas fir would move to higher elevation and also decreases in abundance on the east slope of the Rocky Mountains and in the southernmost portion of its range (Joyce, et al. 1990). Ponderosa pine in the southern Rocky Mountains was predicted to decrease substantially in response to spring water deficits and high summer temperatures. However, the range of ponderosa pins would expand in California and Oregon due to summer drought along the coast. Ponderosa pine would also migrate upslope in Washington, Montana. Idaho and in the middle and southern Rocky Mountains (ibid). Similar predictions have been made for hemlock, sugar maple and lodgepole pine. In general, a temperature increase of one degree centigrade can move the southern boundary of a plant's distribution 100-160 km northward. Forest health may decline as soil moisture levels fall. symptoms of decline are predicted to be evident in about 30 to 60 years in response to a 1C warming (Smith and Tirpak 1988).

Table 2. Carbon storage in the biosphere. A gigaton (Gt) is equal to one billion metric tons. (from Joyce, Forsberg and Comanor 1990)

PLACE STORED	Gt CARBON
VEGETATION	617
SOILS	1662
OCEAN	39660
ATMOSPHERE	740

Biogeochemical cycles would also be affected by climate change. For example, nutrient cycling may be affected by changes in soil moisture and temperature, with either positive or negative results on forest productivity in a given area, depending on the change in soil mineralization rates.

Deforestation

Deforestation is occurring at a rapid rate. For example, tropical forests are lost at a rate exceeding 17 million hectares per year (White House press release 1992). In addition to the loss of carbon uptake through photosynthesis, carbon dioxide is released into the atmosphere though burning and the decomposition of debris. Deforestation currently contributes about 0.5 to 2.5 billion tons of carbon each year, or approximately 20-40% of the carbon emitted from fossil fuel combustion (Musselman and Fox 1991b).

Some estimates have been made regarding the feasibility of mitigating global warming through intensive tree-planting efforts. An effective program would require planting 300 to 800 million hectares at an expense exceeding 186 billion dollars or $400 per hectare, excluding any land acquisition costs (Sedjo 1999; Dixon 1991; Musselman and Pox 1991b).

Biodiversity

It is estimated that the Earth has approximately 30,000,000 species (Scott et al. 1989) and more than half reside within the world's forests (White House press release 1992). Although speciation and extinction are natural processes, human activities have accelerated the rate of extinction. For example, the extinction of warm-blooded vertebrate species has increased by a factor of seven compared to the late Pleistocene, a period of great environmental change, to the current rate of over 100 species lost per 100 years (Council on Environmental Quality 1989). Yet, biodiversity refers not only to species diversity, but to habitat and genetic variability of the gene pool (Westman 1990).

Both the amount and rate of change determine the natural ability of species and ecological communities to adapt to change and to survive new or rapidly changing conditions. One consequence of global warming and changing precipitation patterns is the inability of populations to live within their present ranges because species tend to shift locations toward their climatic optima. Physiological and competitive stresses as well as the availability of suitable habitat would affect the viability of some populations as new associations are formed (Peters 1988). Human populations would also migrate in response to climate change due to changing agricultural conditions etc.

In addition to climate change, biodiversity is affected by land use and landscape fragmentation. The disruption or elimination of critical habitat is a primary mechanism of species loss. Global changes in environmental chemistry and biogeochemical cycles will also impact populations and species. Finally, since the days of Rachel Carson and her book "Silent Spring," we have recognized the detrimental effect of biocides and other environmental contaminants on biodivereity.

Acid Deposition

The precursors for acid deposition can be transported for hundreds of kilometers (Godish 1991) and this long-range transport affects the entire world (Bowersox et al. 1990; Committee on Barth Sciences 1989; NAPAP 1991.) Acid deposition was first observed in Manchester, England in 1852, (Bowersox et al. 19901 and more notably in Sweden in the mid 1960's (Godish 1991). It is currently widespread throughout the northern hemisphere (Committee on Earth Sciences 1989).

In 1990 National Acid Precipitation Assessment Program (NAPAP) published the results of vet deposition monitoring data collected over 10 years. This network contains approximately 200 sites within the United States and territories that are sampled each week. Although only 4% of lakes sampled during the National Surface Water Survey are acidified (i.e., have no acid neutralizing capacity), approximately one-third of the loss in fish populations of Andirondack lakes has been attributed to acidification (NAPAP 1990). Lakes in the western U.S. often have low acid neutralizing capacity, and are therefore particularly vulnerable to acidification. Additional biotic changes throughout the aquatic food web have been documented using lake acidification experiments.

Dramatic damage to silver fir and Norway spruce in the Black Forest of Germany is attributed to a combination of air pollutants, primarily acid rain and fog and ozone. This has resulted in needle loss, magnesium deficiency and root damage due to aluminum mobilization in acidified soils. In the United States, acid deposition may be damaging high elevation red spruce in the northern Apalachian Mountains (NAPAP 1990). Forest decline has also occurred since 1960 in the Green Mountains of Vermont and the White Mountains of New Hampshire, which may be attributable to air pollution (Mohnen 1988).

Overall, atmospheric pollutant emissions in the United States have declined and stabilized after a peak in the 1970's (NAPAP 1992). Although declines are predicted to continue in the eastern United States, nitrogen oxide emissions will probably be increasing throughout the West (NAPAP 1990). For example, the region bounded by Washington, Oregon and Idaho CM anticipate a 70% increase in sulfur dioxide and a 2021 increase in nitrogen oxides from the years 1980 to 2030 (NAPAP 1991).

Title IV of the 1990 Clean Air Act Amendments regulates acid deposition in the midwestern and eastern state8 through an emissions allowance trading program. Phase I will be implemented in 1995 for 110 coal-fired electric generating stations. Phase II will start in the year 2000 to stabilize sulfur dioxide emissions in the United States at 8.95 million tons per year (NAPAP 1992).

Depletion of the Stratospheric Ozone Layer

The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer was issued to address the issue of stratospheric ozone depletion and subsequent increases in incoming ultraviolet radiation. Despite this international effort, the problem of ozone destruction continues. High concentrations of chlorine and bromine monoxide in the stratosphere are associated with ozone loss. Ozone depletion has been detected by NASA over Antarctica, the Arctic, and the middle latitudes of the northern hemisphere (Table 3). An annual ozone hole as observed over Antarctica is anticipated to form over the Arctic within 10 years (Monastersky 1992b). Chlorine monoxide concentrations in the stratosphere over northern New England and Canada were measured in January 1992 at a high of 1.5 ppm, exceeding all observations within the Antarctic ozone hole.

Table 3. History of ozone layer depletion.
Monastersky 1991, 1992; Godish 1991.

- Antarctic - hole each spring for 57 weeks

- Arctic - 10% loss winter 1992*
  hole expected in 10 years

- Mid-latitudes, N. hemisphere -
  Canada, N. New England*
  February 1992 shows 13 yr. record loss or
  10-15% below normal;
  ClO of 1.5 ppb exceeds Antarctic [ClO]

- Tropics - no loss

- based on stratospheric ClO (NASA).

Ozone loss at the poles is primarily attributed to chemical destruction by chlorine in the presence of sunlight but depletion at middle latitudes is the combined effect of natural chemical reactions and air movement, sulfur from Mt. Pinatubo, and chlorine pollution.

One important function of the stratospheric ozone layer is to absorb ultraviolet radiation that causes human sunburn and skin cancer (Godish 1991). Normally, the ozone layer absorbs most wavelengths shorter than 320 nm such as W-B radiation (Godish 1991). Plants, including ocean phytoplankton, are also adversely affected by increases in W-B radiation (i.e., 290-320 nm). The biotic response varies, however. and individual organisms may be able to adapt or tolerate some increase in ultraviolet radiation.

CONCLUSIONS

While some policy-makers focus on the uncertainties in understanding and predicting global change, human-induced change is undeniably occurring now (Committee on Earth Sciences 1989) with an unprecedented detrimental effect on the biosphere (Lubchenco et al. 1991). The relative contribution of anthropogenic impacts vs. natural change is the focus of ongoing debate, yet the cumulative impact of global changes could have substantial consequences in the next century. For example, stratospheric ozone depletion increases the amount of incoming ultraviolet radiation that in torn produces tsoposheric warming. The increased W-B radiation can also impede ocean phytoplankton productivity, and thereby lessen the ocean's capacity to absorb carbon dioxide. These are merely examples of how various global changes may interact.

Potential responses to global change range from cautious inaction, to adaptation, mitigation and prevention (Godish 1991). While natural changes may be unavoidable, most nations believe that we have a responsibility to prevent or mitigate the consequences of human-caused global change. Solutions to challenges posed by global change are not mysterious or unknown. Among the actions most likely to be effective are to decrease the rate of emission of air pollutants and other environmental contaminants, substantially increase energy conservation, aggressive reforestation, and reduce world-wide population growth. Inaction, or failure to implement sound policy decisions, could impede our ability to effectively respond to global change. Productive policy solutions, implemented through international solidarity among industrialized and developing countries, are required to meet our global challenges.

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Table 1. Observed glacier melting due to warming. Anthropogenic contributions are undetermined. Splettstoesser 1992; Hastenrath and Kruss 1992; Monastersky 1992.

- Antarctica -- Wordie Ice Shelf
  shrank from 2000 sq. km in 1 966 to 700 sq. km 1 989
- China ice caps -- 50 year warming trend*
- Peru -- Quelccaya Ice Cap
  1 991 most melting in 500 yrs.*
- Kirghizia (formerly USSR) -- 50 year warming trend*
- East Africa -- Uganda and Kenya
  Ruwenzori Mtn. glacier receded > 150 m from 1977 - 1990
  Mt. Kenya 40% surface loss 1 963-1987
- Based on oxygen isotopes.

Table 2. Carbon storage h the biosphere. A gigaton (Gt) b equal to one billion metric tons. (from Joyce, Forsberg and Comanor 1990)

PLACE STORED	Gt CARBON
VEGETATION	617
SOILS	1652
OCEAN	39660
ATMOSPHERE	740

ALTERATION OF SOIL AND HYDROLOGIC PROPERTIES IN RANGELAND TREATED WITH MUNICIPAL SEWAGE SLUDGE

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Abstract

Municipal sewage sludge has been applied to Southwestern rangelands to determine the effects of sludge on soil and vegetation properties and assess changes in surface hydrology resulting from the treatment. In a preliminary study, dried, anaerobically digested sewage sludge was surface-applied to a degraded rangeland site in north-central New Mexico at 22.5, 45, and 90 Mg ha^{-1} (10, 20, and 40 tons/acre). The results of this study showed that sludge applied at rates between 10 and 20 tons/acre will maintain the most favorable nutrient levels coupled with significant improvements in forage production. In an ongoing study, treated municipal sewage sludge has been surface-applied (20 tons/acre rate) on research plots in central New Mexico rangeland to assess treatment effects on water and sediment yields. Runoff occurring from natural and simulated rainfall is being collected at the base of plots established on moderately sloping (6%) and strongly sloping (10-11%) hillslope components to evaluate the sludge's effect on runoff yield and surface water quality. Increased resistance to surface flow created by the sludge significantly reduced runoff during the first year following the treatment. Water absorption by the sludge also played a minor role in reducing runoff and water loss from the sludge-amended plots. The direct changes resulting from the sludge amendments were increased nutrient contents, somewhat increased trace metal contents, and increased ground surface roughness. Indirect changes resulting from the treatment included increased infiltration and reduced surface runoff.

INTRODUCTION

Approximately 6 million metric tons of municipal sewage sludge are produced annually in the United States alone (U.S. Environmental Protection Agency, 1990). Disposal of this waste product is becoming a major problem for large metropolitan areas, particularly those in the heavily populated eastern seaboard. In many large urban areas of the Southwest, including the City of Albuquerque, New Mexico, liquid waste is processed in a sewage treatment plant. This process greatly improves the quality of effluent leaving the plant, but disposal of the solid sewage sludge remains a problem. Presently, Albuquerque's sewage sludge is applied over large acreages of rangeland set aside specifically for disposal purposes and tilled into the subsoil. Safe, economically feasible disposal of the sludge, not rehabilitation of the rangeland affected, is the City's primary objective. Innovative ways of beneficially utilizing sewage sludges must be continually developed, and the use of sludge for rehabilitation of degraded rangeland represents an alterative to disposal of sludge for the sole purpose of elimination.

A primary concern limiting the use of sludge as a soil amendment is the potential introduction of contaminants into the environment, including surface and groundwater resources. However, sewage sludge has been successfully used as a fertilizer and mulch for agricultural purposes (Berglund et al., 1984; Catroux et al., 1981) and in mined land reclamation efforts (Sopper and Kerr, 1979). Recently, a pioneering study has shown that degraded rangeland responds favorably to the application of sewage sludge as a fertilizer and organic matter amendment (Fresquez et al., 1990a). Dried municipal sewage sludge was applied to a degraded rangesite within the Rio Puerco Watershed Resource Area at 10, 20, and 40 tons/acre (22.5, 45, and 90 Mg ha-‘). The Rio Puerco area, comprised largely of public lands managed by the USDI Bureau of Land Management, has had a long history of heavy livestock grazing. The results of this preliminary study showed that a one-time surface application of 22.5 to 45.0 Mg ha^{-1} (10-20 tons/acre) of anaerobically digested sewage sludge improved forage quality and total production, increased total plant density, and significantly reduced broom snakeweed *(Gutierrezia sarothrae)*. Soil and plant tissue analyses showed that the treatment did not lead to undesirable levels of heavy metals or other contaminants in soil or plant tissue (Fresquez et al., 1990b and Fresquez et al., 1991).

Any successful attempt at increasing vegetative cover (canopy cover, canopy height, and residue or litter cover) in semiarid rangeland should lead to reduced runoff and sediment yields. Runoff and erosion on hillslopes increase with decreasing vegetation cover and increasing slope gradient. Both factors are recognized as important parameters in existing erosion prediction equations and models (Wischmeier and Smith, 1978; Alberts et al., 1989; Hernandez et al., 1989). Vegetative cover disrupts overland flow on hillslopes and promotes greater infiltration while reducing runoff. Much of the Southwestern rangelands experienced heavy livestock grazing over the past century, leading to a substantial reduction in total plant cover and density (Dortignac, 1956). Therefore, barring the introduction of sludge-borne contaminants to surface and groundwater, improved rangeland condition brought about by the sludge treatment should, in turn, lead to improved surface water quality.

This paper reports the changes in semiarid rangeland hydrology treated with sewage sludge during the initial growing season following sludge application. Differences in runoff yield and runoff quality generated from plots treated with sewage sludge are compared to those from untreated (control) plots. Continued research will assess the changes in vegetation induced by the sludge treatment and the subsequent effects these changes have on rangeland hydrology.

Study Site Description

The hydrologic study was established within the Sevilleta National Wildlife Refuge (Fig. 1). The refuge, managed by the U.S. Department of Interior's Fish and Wildlife Service, provides an excellent opportunity to compare rangeland treatment effects because the area is completely fenced off. Public access is also restricted and livestock grazing is prohibited. Climate at the Sevilleta National Wildlife Refuge is arid to semiarid with mean annual precipitation ranging from 200 to 250 mm (Moore, 1991). Summers are relatively hot and winters are cool. Vegetation in the refuge is dominated by semiarid grassland and shrubland at low elevations in the Rio Grande Valley. Pinyon/juniper stands dominate the vegetation at high elevations.

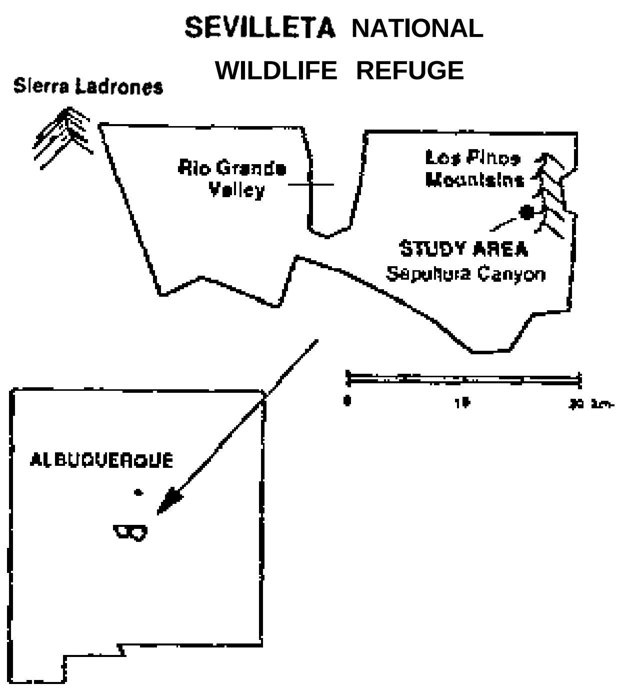

Figure 1. Location of the study area, Sevilleta National Wildlife Refuge, New Mexico.

Study Design

A blue grama/hairy grama (*Bouteloua gracilis/B. hirsuta*) dominated community was selected for study on both moderately sloping (6%) and strongly sloping (10%-11%) components of a stable alluvial fan within the refuge. The soils at the site are mapped as the Harvey-Dean Association (1-9% slopes) (USDA Soil Conservation Service, 1988). The Harvey soil is classified as fine-loamy, mixed, mesic Ustollic Calciorthid and the Dean soil is classified as fine-loamy, carbonatic, mesic Ustollic Calciorthid. The soils are formed from alluvium derived primarily from limestone and eolian material and are deep and well drained. Permeability ranges from moderate for the Harvey soil to moderately slow for the Dean soil. Runoff is medium and the hazard of water erosion is moderate for both soils.

Three pairs of runoff plots, each consisting of a treated (sludge-amended) and a control (no sludge) plot were established within each of the two slope gradient classes. Individual runoff plot dimensions (3 X 10 m) are identical to those used by USDA-ARS researchers involved in the Water Erosion Prediction Project (WEPP). Therefore, data and results obtained through this study might be applied to WEPP models for larger scale predictions on runoff and sediment yield on semiarid grasslands.

The sludge was applied in early spring, 1991. The treatment consisted of a one-time application of 45 Mg ha^{-1} (20 t acre-‘) dried municipal sewage sludge provided by the City of Albuquerque. The loading rates of various sludge constituents are listed in Table 1. All soil and vegetation samples are being collected from ten plots (5 control and 5 treated, dimensions 10 X 10 m) that have been established on soil/vegetation assemblages similar to those of the runoff plots. These plots are also being used for experiments that might otherwise influence the surface hydrology of the runoff plots. The sludge amendment on these plots was identical to the treatment on the runoff plots.

Table 1. Elemental analysis of municipal sewage sludge, Albuquerque, New Mexico (estimates of sludge content (g ha-‘) are based on a *one-time application* of 45 Mg ha-‘).

	Sludge content	
	(mg kg^{-1})	(g ha^{-1})
Potential Contaminants		
Cadmium (Cd)	a.27	372
Copper (Cu)	575.90	25,915
Lead (Pb)	205.00	9,225
Zinc (Zn)	828.60	37,287
Nutrient Elements		
Total Nitrogen (TKN)	38,300.00	1,723,500
Phosphorus (P)	20,200.00	909,000
Organic Carbon (Org C)	198,460.00	8,930,700

Analytical tests for soil, water and vegetation parameters, including soil organic matter, total nitrogen, nitrate-N, ammonium-N, pH, electrical conductivity, etc., will followed standard procedures as outlined in Agronomy #9, Methods of Soil Analysis - Part II (Page, 1982) and U.S. Department of Agriculture Handbook No. 60 (Richards, 1969).

Water Quality Assessment

The experimental runoff plots were bordered by metal flashing to prevent external water from entering the plots. The borders direct internal surface runoff to the base of the plots where it is channeled to and collected in sample reservoirs during natural and simulated rainfall events. Representative samples of the runoff water, obtained by manually stirring the contents in the collection reservoirs, were analyzed for trace element contaminants. Total precipitation that occurred during summer storms was measured with two standard rain gauges (rainfall collection buckets). Additionally, a self-activating recording rain gauge was installed at the site on August 1, 1991, allowing measurements of storm intensity (mm hi') for subsequent events.

The runoff plots were subjected to simulated rainfall in September 1991 after the vegetation had an entire growing season to respond to the sludge treatment. A large area rainfall simulator was used to test the hydrologic response of the rangeland to high-intensity rainfall under controlled conditions. The rainfall simulator consisted of 15 sprinklers mounted on 3-m standpipes that distributed water simultaneously to each plot in a pair so infiltration and runoff yield could be observed and recorded on the two plots (control and treatment) concurrently. The simulated rain was equivalent to a high intensity summer thunderstorm common in the region (10-16 cm hr^{-1}, approximately 4-6 inches/hr).

RESULTS

Pre-treatment soil characterization established uniformity in both textural characteristics and chemical properties between control plots and those plots subsequently treated with sludge (Table 2). We are confident that any future significant differences in soil properties observed between treated and control plots will be a result of the sludge treatment. No significant differences in vegetative cover or in plant tissue chemistry were found among the study plots prior to sludge application. Analysis of post-application vegetation transects currently are in progress.

First-year runoff measurements taken after natural storms that produced runoff (Fig. 2) showed that surface application of treated municipal sewage sludge significantly reduced runoff on our plots. Runoff yields were greatest during high-intensity storm events. Runoff yields from the control plots increased progressively with increased precipitation and storm duration. In contrast, a similar pattern was not observed in the sludge-amended plots, wherein the proportion of total precipitation lost from the plots as runoff remained under 2% of the input regardless of total precipitation and storm duration,

Table 2. Mean textural and chemical properties of soils from all study plots (control versus treated) prior to sludge application. Soils were sampled at three depths: A = O-5 cm, B = 5-10 cm, and C = 10-15 cm. (means are based on five composite samples taken from each of the five control and treated large sample plots)

	Control			Treated		
	A	B	C	A	B	C
Textural Class	SL[1]	SL	SL	SL	SL	SL
Org C (%)	0.71	0.81	0.98	0.86	1.03	1.19
pH	7.57	7.60	7.68	7.54	7.60	7.53
EC (mmhos/cm)	0.61	0.37	0.39	0.58	0.39	0.36
Nutrient Elements (ppm):						
TKN	710	950	989	701	840	1076
NO_3^-	7.6	7.2	9.2	7.5	7.1	9.2
NH_4^+	3.9	3.4	4.0	3.6	3.6	3.6
P	6.5	2.6	1.7	6.4	3.1	1.3
Heavy Metals (ppm):						
Cd	0.07	0.04	0.04	0.07	0.05	0.04
Cu	1.78	1.72	2.52	1.12	1.58	2.25
Pb	1.11	0.72	0.60	1.13	0.82	0.70
Zn	0.65	0.41	0.36	0.65	0.41	0.35

[1]SL = Sandy Loam

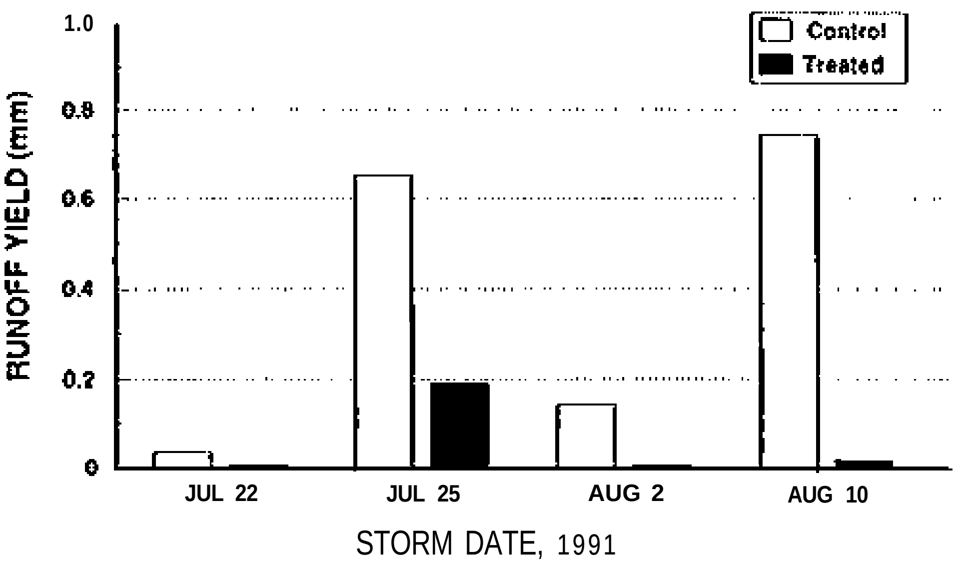

Figure 2. Runoff from treated (*n* = 6) versus control plots (n = 6) during four natural storm events, 1991. Runoff from control plots was significantly different from treated plots at $p < 0.05$ for all storms except on July 22, wherein $p = 0.09$).

In September 1991 rainfall simulation experiments were conducted on the pairs of experimental plots. The sludge's effectiveness in reducing runoff from the treated plots is evident (Fig. 3).

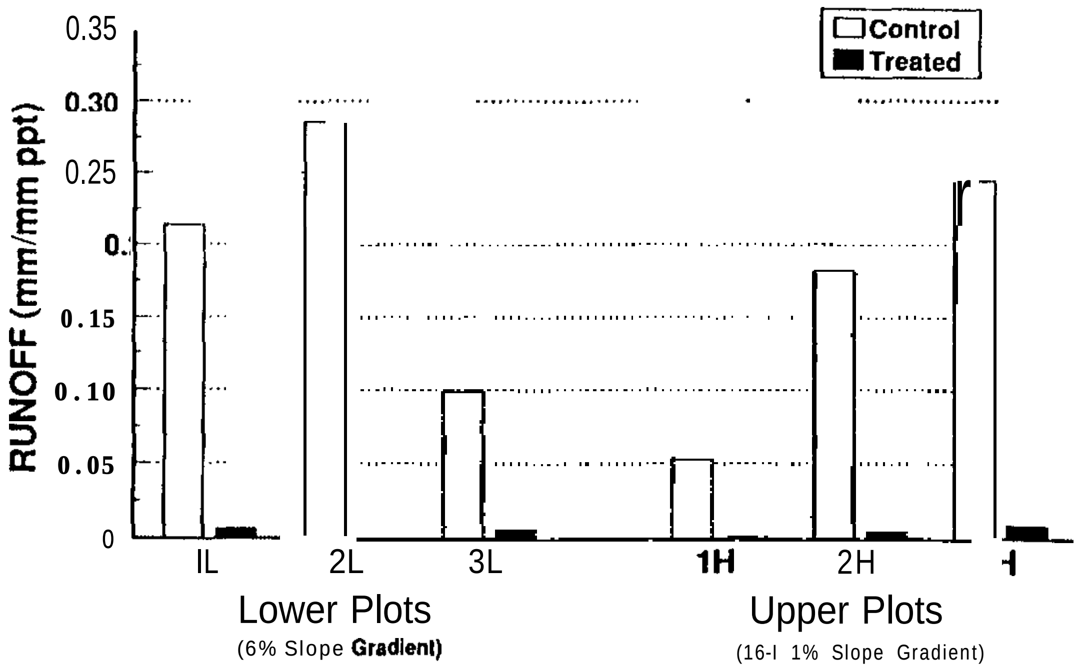

Figure 3. Runoff yield from sludge-amended (treated) and unamended (control) plots during rainfall simulation experiments. Expression of runoff yield as runoff per millimeter of precipitation standardizes the runoff for comparison because there were differences in precipitation input among and between plot pairs. (Note: difference in total runoff yield between treated ($n=6$) and control (n = 6) plots was highly significant at $p < 0.05$.)

Other indications of the lack of runoff generation from the sludge plots is the rate at which water first appears on the surface of the plot (i.e., the time to ponding on the ground surface, thus signifying that rainfall rate and infiltration rate are equal at this location) and the time needed to drain the plot after rainfall has ceased. Table 3 lists the recorded time to ponding and time of runoff cessation for the 12 plots. In general, ponding occurred about three times faster on the control plots than on the sludge-amended plots. The only differences in cessation times recorded were between the lower and upper control plots. Runoff ended about 2.9 times faster on the steeper, upper plots than on the lower plots. The three lower plot pairs have an average slope of 6.1% and the three upper plot pairs have slightly steeper slopes (10.2%). Differences in runoff cessation rates are attributed to the slope steepness at this time. However, samples of bulk soil (including coarse fragments) will be collected during Summer 1992 to determine if differences in coarse fragment content in the soil surface horizon might be producing differences in infiltration, and thus be partly responsible for the hydrological differences observed between the upper and lower plot pairs.

Table 3. Time to ponding and runoff cessation during rainfall simulation experiments on sludge-amended (T) versus unamended control (C) plots. Time to ponding was measured from the beginning of the rainfall application, while the time to runoff cessation was measured from the moment the rainfall was terminated.

Plot ID	Time to ponding (min:sec)	Time to runoff cessation (min:sec)
1L-C	1:34	4:46
1 L-T	4:32	0:00
2L-C	0:46	5:40
2L-T	2:19	0:00
3L-C[1]	1:26	
3L-T	4:37	0.00
1 H-C	2:03	2:38
1H-T	5:39	0:00
2H-C	2:09	1:59
2H-T	5:11	0:00
3H-C	0:59	1:40
3H-T	6:28	0:00

[1] Time to cessation of runoff was not measured due to unexpected problems with runoff tank and plot boundary contact.

Levels of nitrate (NO,.), copper (Cu), cadmium (Cd), and lead (Pb) in runoff water collected after both natural and simulated rainfall events are listed in Table 4. New Mexico standards regard ≥10 mg l^{-1} nitrate, ≥0.01 mg l^{-1} Cd, and ≥1.0 mg l^{-1} Cu concentrations in surface and groundwater as unacceptable (New Mexico Water Quality Control Commission, 1991a). Current state standards for livestock and wildlife watering prohibit ≥0.05 mg l^{-1} Cd and ≥0.5 mg l^{-1} Cu (New Mexico Water Quality Control Commission, 1991b). Nitrate, Cu, and Cd concentrations in the runoff water collected from our plots, both during natural and simulated rainfall, were well below these established standards and we found no statistical differences in these potentially toxic constituents between the treated and control plots.

Although we did detect Pb concentrations exceeding current New Mexico standards for groundwater (0.05 mg l^{-1}) and livestock and wildlife watering (0.1 mg l^{-1}) after some storms, we found no significant differences between the mean Pb concentrations in runoff from treated plots and control plots. The elevated Pb concentrations in the runoff water may be due to elevated Pb concentrations in the soils or Pb solubilization from the galvanized steel tanks we used as runoff collection reservoirs. We did, in fact, detect somewhat elevated soil Pb contents (0.84 to 1.54 mg kg-‘) in both control and treated plots during pretreatment soil analysis.

Table 4. Concentrations (mg l^{-1}) of NO;, Cd, Cu, and Pb in runoff collected from sludge-amended (T) and untreated (C) plots at the Sevilleta Wildlife Refuge, 1991. Mean Pb concentrations between treated *(n=6)* and control *(n=6)* plots were not significantly different at $p < 0.10$ for any one of the precipitation events, including rainfall simulation.

PLOT	NO;	Cd	CU	Pb	NO_3^-	Cd	Cu	Pb
	July 25 Storm				August 2 Storm			
1L-C	0.018	<0.005	<0.02	0.31	0.004	<0.005	co.02	0.11
1L-T	0.046	<0.005	co.02	0.36	0.008	co.005	co.02	0.25
2L-C	0.026	<0.005	<0.02	0.21	0.004	co.005	co.02	co.05
2L-T	0.026	<0.005	<0.02	0.26	0.004	co.005	co.02	co.05
3L-C	0.019	<0.005	<0.02	0.19	0.006	co.005	co.02	co.05
3L-T	0.023	<0.005	<0.02	0.48	0.007	<0.005	<0.02	co.05
1H-C	0.062	co.005	0.02	0.47	0.007	co.005	co.02	0.09
1H-T	0.023	<0.005	co.02	0.23	0.086	co.005	co.02	0.24
2H-C	0.002	<0.005	<0.02	0.66	0.004	co.005	<0.02	0.10
2H-T	0.006	<0.005	<0.02	0.82	0.009	co.005	co.02	co.05
3H-C	0.072	<0.005	<0.02	0.34	0.059	co.005	co.02	0.07
3H-T	0.018	<0.005	<0.02	0.37	0.068	co.005	co.02	0.25
	August 10 Storm				September Rainfall Simulation			
1L-C	0.005	<0.005	<0.02	0.13	0.295	co.005	co.02	co.05
1L-T	0.004	<0.005	<0.02	0.20	0.396	co.005	co.02	0.13
2L-C	0.095	<0.005	<0.02	0.21	0.620	<0.005	co.02	0.40
2L-T	0.094	<0.005	0.52	2.52	0.552	co.005	co.02	0.11
3L-C	0.027	<0.005	<0.02	0.16	0.284	co.005	co.02	0.11
3L-T	0.094	<0.005	co.02	0.05	0.209	co.005	co.02	0.17
1H-C	0.008	<0.005	<0.02	0.10	0.343	co.005	co.02	0.13
1H-T	0.007	<0.005	10.02	0.39	0.595	co.005	co.02	0.13
2H-C	0.008	<0.005	<0.02	0.16	0.383	co.005	co.02	0.12
2H-T	0.007	<0.005	<0.02	0.14	1.037	co.005	co.02	0.21
3H-C	0.006	<0.005	<0.02	0.16	0.000	<0.005	co.02	<0.05
3H-T	0.007	<0.005	<0.02	0.46	0.253	co.005	co.02	<0.05

SUMMARY AND CONCLUSIONS

Surface application of treated municipal sewage sludge significantly alters soil and hydrologic characteristics of semiarid rangeland. Surface soil organic matter, nutrients, and ground surface roughness are increased by the treatment. Upon surface application of the sludge, surface water flow is immediately impeded and this, in turn, significantly reduces runoff yield. We anticipate that future changes in vegetation cover and composition will also affect the surface hydrology of the rangeland.

Our observations support the use of sludge for reducing runoff from hillslopes in semiarid rangeland. Runoff and infiltration rates observed on our control plots are comparable to rates observed for semiarid rangeland in studies conducted elsewhere in New Mexico and Arizona (Ward and Bolton, 1991). Therefore, the differences in hydrologic properties we observed between our sludge-amended and control plots can be attributed to the sludge and to differences in the plots prior to sludge application. However, the long-term effects of the sludge on the runoff, particularly after the sludge has weathered and decayed, are not yet known. The goals of our second-year rainfall simulation experiments are to determine those effects.

Results from the first year rainfall simulation experiments can be summarized as follows, The sludge, as tested, is an effective treatment for preventing runoff from hillslopes in semiarid rangeland. The two factors we considered most important for the reduction in runoff yield on treated plots were increased ground surface roughness and water absorption by the dry sludge. Five samples of sludge at field moisture conditions were collected before and after the simulated rainfall on plots 2H-T and 1 H-T to quantify the amount of water absorbed by the sludge. The portion of total plot precipitation absorbed by the sludge during the two rainfall simulation trials was 13% for plot 2H-T and 25% for plot 1 H-T (Aguilar and Loftin, 1992). These observations indicate absorption of a greater portion of precipitation by sludge during smaller rainfall events, since the total amount of precipitation added to plots 2H-T and 1H-T during their respective rainfall simulation runs was 50 mm and 18 mm, respectively. The sludge should decompose through time and have less influence on water absorption. However, due to the sludge's nutritional benefits, increased plant productivity and ground cover should sustain reduced runoff yields from the sludge-amended plots.

Potential contamination of surface water by sludge-borne contaminants, including heavy metals, does not appear to be a problem for a one-time application of 22.5 to 45 Mg ha^{-1} (10-20 tons/acre) city of Albuquerque sludge. Sludge application on semiarid rangelands has the potential for being environmentally and economically beneficial if these applications are based on sound guidelines developed through continuing research.

ACKNOWLEDGEMENTS

Portions of this research were conducted in cooperation with the USDI Bureau of Land Management. The hydrology study was funded by the 1991 New Mexico Water Resources Research Institute (WRRI)- Chino Mines Company Grant Fund. Continued funding is being provided through the 1992 WRRI General Grant Program. We thank the city of Albuquerque for providing the sludge and transporting it to study sites. We also express gratitude to Tim Ward and Susan Bolton, New Mexico State University, for assistance with the rainfall simulation experiments.

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MANKIND WILL NEVER MASTER THE ART OF COMMUNICATION.
ABSURD!
NONSENSE
ROT!
HOGWASH
OK---WHAT'S THIS?
GROUND
SOIL!
EARTH
DIRT!
THE PROSECUTION RESTS.

CURRENT STATUS OF THE SOIL SCIENCE PRACTICE ACT

John R. Munn

Western Regional Cooperative Soil Survey Conference

Flagstaff, Arizona

June 26, 1992

The purpose of this presentation is to describe the current status of the Soil Science Practice Act that has been sponsored by the Soil Science Society of America (SSSA). Although the Act is still in draft form, I can give you an idea of its content and approach.

First, I want to emphasize that the proposed Act is intended to be a model for use by soil scientists seeking registration at the state level. It is not supposed to be a rigid document, and changes to adapt to local conditions are expected.

Major subject areas covered by the Act include:

- Definition of terms for the purpose of regulation, including - soil science, soil scientist, and the practice of soil science.
- Provisions for regulation of the practice of soil science.
- Requirements and qualifications for registration as a soil scientist and soil science specialties.

The intent section of the Act:

- Recognizes the importance of soil resources.
- Identifies the need for qualified soil scientists.
- Establishes a state policy of prudent and responsible soil management.
- And declares the state's intent to regulate the practice of soil science.

Following is some background on the Act's development and why anyone would be so presumptuous as to undertake this task.

John R. Munn, Soil Erosion Studies Project Leader, California Department of Forestry and Fire Protection, P.O. Box 944246, Sacramento, California 94244-2460.

In recent years, there has been steady increase in demand for soil science skills to address environmental problems, development projects, and the needs of intensive agriculture. This has promoted the application of soil science by untrained and inexperienced individuals, while soil scientists have been excluded from independent practice in some areas by state and local regulations that require the use of other, registered professions in an attempt to identify "qualified" individuals. As a result, soil scientists are often overlooked or treated as second class citizens in the earth sciences, both in research and private practice.

This problem has been clearly recognized by SSSA Past President Fred Miller and by the current SSSA President Bill McFee. In response, the SSSA called together interested soil scientists at the 1991 Annual Meeting in Denver. The participants at this meeting agreed that a model practice act was a necessary step toward improving the practice and recognition of soil science, and a Soil Science Practice Act Committee was formed. I was appointed Chairman, and the Committee has now grown to include 23 members with representation from a wide variety of work experience and locations.

The Committee began its work by reviewing current and proposed soil science practice acts from states such as Maine, Alabama, Virginia, and South Dakota. Committee members then focussed their attention on a first draft of the Act prepared by SSSA staff from a wide variety of requirements in the acts of other professions. Based on comments from Committee members, a second draft was prepared and circulated for review in April. Then a smaller, writing subcommittee was convened in May to go over the Act in detail and prepare a draft for final review by the full Committee and SSSA legal staff.

The final version of the Act is scheduled to be presented to the SSSA Executive Committee in August and should be available to the public at, or prior to, the SSSA Annual Meeting in early November.

At the present time, the major, incomplete section of the Act is an alternative administrative structure that would provide for a national organization to undertake the routine administrative activities of a registration board. These activities could include processing and reviewing of applications, developing and administering tests, and handling renewals. State level commissions or committees would then have an oversight role on applications and disciplinary actions.

An important advantage of a national approach would be the spreading of administrative costs, which could be overwhelming in states with few soil scientists. It could also provide for easier recognition of credentials among participating states.

Disadvantages of a national option might include:

- o A real or perceived loss of local control.
- o Lack of state level staff for administering disciplinary actions.
- o Finding a national organization willing to undertake the program (which would require some up-front work on the presumption that states will sign on).

It is easily apparent that registration of soil scientists is not going to be an easy task. So why bother? Here, I am going to go out on a limb and predict the consequences of continuing under the present conditions.

First, the practice of soil science in the private sector will be increasingly conducted by members of other professions, such as geology and engineering, as the demand for services and the money involved increases. Where these other professions are registered, they will increasingly claim the more lucrative aspects of soil science as part of their respective areas of practice, thereby excluding soil scientists from independent practice. Both of these trends are already happening in California.

Second, soil science research and teaching are not exempt from losses in private practice. As private sector professionals in other disciplines become involved in areas of traditional soil science practice, the colleges and universities training students in these disciplines will add coursework and research programs to meet the needs of their graduates. This will lead to an overall loss of identity and demand for soil science graduates, which will eventually result in a loss of support for soil science teaching and research programs. This also may have started in California, and could be accelerated by pending state budget problems.

Third, government employees also have a stake in soil scientist registration, because private sector salaries are one factor in setting federal wage rates, and registration would allow soil scientists to compete more effectively with other, higher paying earth science professions. And where might federal and other government soil scientists seek work after retirement, or in the event of agency layoffs, other than in the private sector?

The changes I am predicting will occur at a slow, but steady, pace. In fact, these aren't really predictions, but are a recognition of trends that are already underway and are now becoming apparent. Although history tells us that change is inevitable, we can help to direct it and keep from being left behind.

Finally, I believe that it is important for each of us to work toward improving our chosen profession, which has provided our livelihood and supported our careers. Recognition and registration has not occurred overnight for any of the earth science professions. Rather, it is earned by the time and efforts of a profession's members, including support from field, agency, and academic quarters.

COMMITTEE REPORTS

Report of the 1992 Western Regional Cooperative Soil Survey Conference
Wetland and Riparian Area Task Force

This work group (Table 1) "as assigned the task of discussing how soil surveys should be conducted to meet management needs of wetland and riparian areas. The following items were addressed by the group:

A. Identify and evaluate the existing soil classification and map unit design procedures relative to the identification and description of riparian and wetland areas.

   1. Address existing soil survey procedures and evaluate the effectiveness of these procedures to provide an adequate information base for interpretation and decision-making.

   2. Recommend new soil survey procedures to identify and describe riparian and wetland areas as a significant component of the landscape.

B. Assess existing cartographic procedures and criteria for the delineation and spatially locating riparian and wetland areas

   1. Identify current cartographic criteria and mapping standards that are not conducive to delineating these areas as soil map units.

   2. Recommend new ways and mechanisms to identify riparian areas and wetlands in conjunction with map unit design which would allow for the information to be incorporated in a permanent database.

Given the short time period available for us to meet, the work group elected to concentrate on outlining new methodologies which might be appropriate for wetland and riparian mapping. Consensus concerning the opinions and recommendations reflected in this report were not reached. Consequently, the material which follows is tentative and should be reviewed and modified by future task forces.

The work group acknowledged that the diversity of issues relevant to wetland and riparian areas necessitated that new approaches to soil/landscape mapping be developed. The abbreviated listing of riparian and wetland issues developed by the group (Table 2) illustrates the complexity of knowledge required to manage such environments. Accordingly, soil surveys should be designed to address as many of these issues as appropriate to local user needs.

Table 3 describes the types of items which should be considered in the design and description of riparian/wetland mapping units to address the issues listed in Table 2. Taxonomic components other than soils may be required to describe riparian/wetland mapping units in future soil surveys (BLM 1990). stream type (Rosgen 1985) and potential natural community classifications (Pfister and Arno 1980. RISC 1983) are available to many survey areas and should be utilized in map unit characterization. Similar classifications should be developed for areas where they are currently lacking. Successional plant community pathway descriptions (Arno et al. 1985, Jensen et al. 1993) may also be required in future survey work to assist quantification of "desired plant community" in land management planning. Differentiae for map unit design will increasingly require non-soil criteria to meet user interpretation needs for multiple scale riparian maps. Hierarchical landscape based approaches to map unit design offer promising alternatives to traditional soil survey methods (Wertz and Arnold 1972, Jensen et al. 1989, Jensen et al. 1992).

Specific recommendations concerning new soil survey procedures to be used in riparian/wetland mapping were developed (Table 4). The work group felt that riparian/wetland areas need to be mapped at multiple scales using non-soil differentiae to meet various survey objectives and interpretation needs. This is especially true for agency personnel who utilize landscape ecology principles (Urban et al. 1987, Noss 1990, Hunter 1991) as their foundation for biodiversity and ecosystem management. The group also felt that minimum data requirements for site, soil, potential vegetation, and stream type descriptions should be developed for National Cooperative Soil Survey efforts.

Cartographic procedures currently used in traditional soil survey are often inadequate to meet riparian/wetland mapping needs. Consequently, the group identified new procedures which should be considered (Table 5). The recommendations presented in Table 5 follow those outlined by George Staidl in his draft technical note dated 3/8/91 (SCS 1991).

The recommendations presented in this report are tentative. The riparian/wetland work group suggests that additional effort needs to be addressing the items presented. We believe the ideas developed by our group will prove beneficial to future riparian/wetland work groups.

Table 1: List of Participants in the Wetland and Riparian Area Work Group

Name	Address
Mark Jensen (Team Leader)	USDA, Forest Service, Northern Region, P.O. Box 7669, Missoula, MT 59807
Bruce E. Frazier	Crop and Soil Sciences Department, Washington State University. Pullman, WA 99164-6420
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Table 1 (Continued1

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John Nesser	USDA, Forest Service, Northern Region, P.O. Box 7669, Missoula, MT 59807

Table 2: Abbreviated Listing of Riparian and Wetland Issues

Issue	Description
Water Quality	Includes water chemistry, temperature, sediment.
Water Quantity	Includes amount and timing of flow, sustaining maximum and minimum base flows for channel maintenance and consumptive water uses.
wildlife Habitat	Includes forage production, security and thermal cover, nesting habitat.
T&E Species	Identification of riparian dependent species and their habitat requirements.
Riodiversity	Includes maintenance of species habitats and corridors for species movement. Identification of natural variability ranges for riparian ecosystem components to implement coarse-filter strategy for biodiversity management.
vegetation Management	Includes maintenance of unique riparian plant communities for wildlife habitat, water quality/quantity, recreation, and other management needs (e.g., old-growth).
Multiple Use Impacts	Includes effects of grazing, logging, recreation, mining, etc., on riparian/wetland ecosystem function and composition.
Wetlands	Includes identification, delineation, restoration and compensation.
Analysis Process	Need to improve our analysis process for riparian/wetland assessment (e.g., utilize multiple scales, quantify desired future condition).

Table 3: Listing of Items Which Should Be Considered in the Design and Description of Riparian/Wetland Mapping Units

Issue	Item
Water- Quality and Quantity	Soil properties (e.g., depth, texture) Watershed climate (e.g., precip. timing and amount) Watershed morphology (e.g., landform, geology. drainage density) Valley bottom morphology (e.g., gradient, width) Stream morphology (e.g., bankfull flow gradient, width/depth ratio) - Stream channel substrate - Stream type/watershed flow characteristics (i.e., unit hydrograph) Stream type composition Stream channel adjustments following natural and management-induced disturbance
Wildlife Habitat T&E Species, Vegetation Management, Biodiversity	Vegetation composition (foliar cover, biomass by plant species) and structure (layer size class relationships) of potential natural communities (i.e., ecological sites, range sites, ecological types) Potential natural community composition Historic composition and patter" of successional plant communities in riparian/wetland settings Historic processes which maintained riparian/wetland ecosystems (e.g., magnitude and frequency of fire, flood events, mass wasting) Successional plant community pathways following natural and management-induced disturbances
Multiple-Use Impacts	Describe composition (as appropriate) of soil types (family or series), potential natural plant communities, and stream types in ecological mapping units Contrast current conditions of a site (e.g., vegetation. erosion) to its potential (as determined from the ecological mapping unit) - Deviations from potential are attributable to the impact(s) present at a site, and should be described during the mapping process
Wetlands	Describe hydric soil properties Identify hydric plant species (existing and potential Identify site hydrologic properties (e.g., water table dynamics, flooding and ponding frequency and duration1

Table 3 (continued)

Issue	Item
Analysis Process	- Develop multiple scale maps of riparian ecosystems to facilitate appropriate analysis of issues (e.g., coarse scale for regional fisheries viability analysis, detailed for project level assessments of water quality) Need to consider natural variability range, plant succession, hydrologic function, etc., in the description of "desired future condition" for riparian/wetland areas

Table 4: Recommendations for New Soil Survey Procedures to be Used in Riparian/Wetland Mapping

Item	Recommendation
Map Scale	Allow for multiple scales dependent on survey objectives and interpretation needs (i.e., mapping may be coarser or finer than a 1:12,000 or 1:24,000 scale).
Map Unit Differentiae	Allow for non-soil differentiae in map unit design (e.g., landform, geology, climate, topography, stream types, potential vegetation).
Components	Allow for more than three named components in certain instances (i.e., highly variable units)
Taxa	Allow for description of other taxa besides soils (i.e., potential plant communities, stream types).
	Allow for description of soils at series, family or subgroup level dependent on survey needs.
Data	Develop minimum list of data required for site, soil, potential vegetation, and stream type description.

Table 5: Recommendations for New Cartographic Procedures to be Used in Riparian/Wetland Mapping

Item	Recommendation
Acreage	Dependent on survey needs, riparian and wetland areas should be delineated as unique mapping units. The minimum number of acres to include such delineations in a survey report should be smaller than that used for woodland, rangeland, or cropland map units.
Cartographic Techniques	Identify techniques for unique delineations and spot symbols that will represent map units and their acreage but do not meet present cartographic requirements.
Line Segments	Allow for line segment map unit delineations to denote riparian areas (i.e., follow drainage spot symbols to minimize map clutter).
	Assign width groping codes to the end of line segment map symbols to assist determination of acreage (e.g., w = l-50 ft., x = 50-100 ft., y = 100-150 ft., z = 150-200 ft.). Areas greater than 200 ft. width will typically be located by an enclosed line polygon.
spot Symbols	Allow for adhoc symbols or a dot to denote a wetland map unit.
	Assign acreage grouping codes to the end of wetland map spot symbols (e.g., x = Cl acre; y = 1-2 acres). Areas greater than 5 acres will typically be located by an enclosed line polygon.
Map Scale	Allow for presentation of riparian or wetland delineations on base maps of different scale than those commonly used in traditional soil mapping (i.e., 1:24,000, 1:12,000). Use a GIS to produce riparian or wetland maps independent of upland soil maps.

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Report from the Committee
"Soil Survey Information Management*@
Flagstaff, Arizona
June 22 to 26, 1992

Committee Members:

Allan Amen, Bureau of Land Management, Denver, CO
Richard Dierking, Soil Conservation Service, Portland, OR
William Dollarhide, Soil Conservation Service, Reno, NV
Scott Davis, Bureau of Land Management, Lakewood, CO
Wally Miller, University of Nevada, Reno, NV
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Colin Voight, Bureau of Land Management, Washington, DC
Bill Johnson, Soil Conservation Service, Phoenix, AZ
Jim Glade, Bureau of Indian Affairs, Phoenix, AZ
Bill Bishop, Bureau of Indian Affairs, Billings, MT
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Earl Lockridge, Soil Conservation Service, Lincoln, NE
David L. Richmond, Soil Conservation Service, Phoenix, A2

Objectives:

To provide recommendations concerning "Soil Survey Information Management."

Sunmarv of Discussions:

1. A National Data Base is needed.

2. A National Soil Survey Dictionary is needed.

3. A standard format is needed for laboratory data.

4. A standard format is needed for soil site data--especially the core data set.

5. Data should be identified as follows:

   a. Measured
   b. Observed
   c. Estimated

6. A basic core of data should be established for:

   a. National data bases
   b. State data bases
   c. Local data bases

7. Soil Survey data needed for analyses is moving faster than the data can be collected with the present staffing of Soil Scientists. There is a need to implement scanning devices and electronic clip-boards.

8. Each agency should be involved in developing the Soil Survey Dictionary.

9. Each agency should be involved in developing the data base.

10. Each agency should be involved in developing the minimal or basic core of data that needs to be completed for the representative site data.

11. Workshops should be held to promote multi-agencies input to complete the Soil Survey Dictionary and the core data set for both field and laboratory data.

Recommendations of the Committee:

1. A national data base should be established with cataloged data available to field, national staffs, and local users. The data base should be established with input from field staffs (all agencies and universities).

2. The development of the Soil Survey Dictionary and core data set for both laboratory and field data should receive priority. Workshops should be used to promote a multi-agency effort to establish the dictionary and core data sets.

3. Data collected should be identified as follows:

   a. Measured
   b. Observed
   c. Derived
   d. Estimated

4. Scanning devices and electronic clip-board (field data recorders) are needed. The devices should be researched thoroughly before implementation.

5. Information concerning geologic surfaces is needed for managing water quality.

6. The committee recommends the establishment of a, communication system that will:

   a. Keep the field informed of available procedures
   b. Promote feedback from the field
   c. Promote suggestions for improvement

7. User friendly programs are essential.

General Discussions that Led to the Recommendations:

There is a concensus that a national soil survey dictionary and data base should be developed.

There is a need to develop standard formats for laboratory and field data.

The standard form for collection field data is needed to promote the compilation of all elements in the core data set.

Some comments made in the session indicated that the lack of uniformity in the format of laboratory data are causing considerable difficulty in analyses at the university level.

Comments from the national staff indicated that requests could be made for arrangements of columns in the data requested. Other comments indicated that few field people were aware that specific formats could be requested. This suggests that more efficient communication lines are needed.

Requests were made for establishing standard formats for collection field data. The standard format is essential to a complete data set: it is especially important to have a complete set of core data. Many times analyses are limited by the lack of complete data. A standard format for both laboratory and field data could solve this problem. The national soils staff thought that "windows" in the computer entry could solve the problem. It was further discussed that the standard format would allow for data entry by technicians.

Data collection should be identified as measured, observed, and estimated.

Algorithms would be used for generating interpolated data. There should be a minimal or core data set at the national, state, and agency levels.

Data needs and analyses are moving faster than the present staff of soil scientists can provide the data. There is a need for scanning devices or clip-boards to speed data entry.

A national dictionary is needed by all agencies and should receive high priority in being established.

Workshops that would promote multi-agency input for the development of core data and the Soil Survey Data Dictionary are needed.

The BLM staff promotes definitions and interpretations for geological surfaces. These data are especially important to manage water quality.

1992 WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE
Flagstaff, Arizona
June 22-26, 1992

Identification and Understanding of Customer Requirements

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Identification and Understanding of Customer Requirements
6-23-92

Concensus of the committee was primarily to create and use a questionnaire in conjunction with public participation meetings to assess customer requirements. Some ideas presented by participants are as follows:

- Participate in local community fairs with demonstrations and handouts as an educational process.
- Earth Day demonstrations at Malls
- Conduct public meeting during the design of the survey, during the survey and post publication.
- Issue public service announcements.
- Public meetings can be organized, publicized and sponsored by Soil and Water Conservation Districts, Soil and Water Conservation Society, Extension Service, etc. These meetings can be used as public forums for gaining an understanding of customer requirements.
- There is a need to create more interaction with other specialists within our own agency and other agencies.
- Need to involve local units of government in long range planning.
- Should use Soil Potential studies as an educational tool.
- Questionnaire could be placed on an electronic bulletin board.
- Questionnaire could be inserted in the soil survey.
- SCS sociologists and public affairs specialists could be used for the design of a questionnaire (lengthy and wordy questionnaires are virtually ineffective - need good design.)
- Public affairs specialists could be utilized to prepare articles for publication in major newspapers to accompany a Status of Soil Surveys map.

The committee felt that a distinct recommendation should be made as a result of this meeting with follow-through to assure that their efforts would not be just another exercise.

Identification and Understanding of Use Requirements
b-25-92

Personal contacts and interviews may be much more effective than questionnaires.

New customers require an education process.

Target new and specialized users.

Work with community higher education centers.

Develop guidelines for use by local, state, regional or national levels on processes involved in determining customer needs including:

- marketing - informing potential new users
- public participation meetings
- questionnaires
- follow-up interviews

One view: Each agency must make their own decisions about their cutomers.

Counter: Guidelines could be set, then agencies could tailor them for their own applications.

Suggestions to mail our information to explain what, how, why we are doing what we are doing.

Agreed to form a continuing/follow-up committee consisting of Dennis, Tommie Parham, Dave Richmond, Jerry Latshaw, Steve Strenger, Clif Fanning, WNTC, and Cooperative Extension.

2. Soil Survey Program, Background Questionnaire; by Tommie L. Parham, June, 1992.

C. Program Evaluation Reports

1. Report of the Task Force for the Review of Procedures for Publishing Soil Surveys; William L. Vaught, USDA-SCS, June 25, 1973.

D. Literature

1. Popenoe, J. H., Collecting and Using Soil Survey Information in Park Management: Examples from Redwood National Park. Redwood National Park, P.O. Box 7, Orick, CA 95555.

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PART I. CHARGES

1. Identification and Understanding of Customer Requirements

A. Recommend ways to reach the customer(s) to determine what they need in the way of soil survey information - content, interpretations, format.

1. Evaluate all methods and ways that have been used to reach customers to find their needs. Identify those methods that provide the most response and highlight those that have been the most successful.

2. Evaluate and identify potential new ways to reach customer(s) for their input, i.e., public participation process, telephone polls, newsletters, questionnaires.

B. Develop procedures to query the customer(s) to determine their needs and/or uses of soil survey information.

1. Evaluate items such as interpretations needed; publication format desired; parts of the report that are never used, seldom used, frequently used or very frequently used; suggestions to improve the report; other interpretations needed for inclusion in the sample form.

C. Identify customers.

PART II. INTRODUCTION

Meeting user needs is the basic premise of soil survey. As Soil Scientists, we should pride ourselves for our conscientious and continued efforts to meet customer needs. In every aspect of Soil Survey, we apply scientific principles to meet customer needs. We define the scope and content of new survey projects on the basis of anticipated land uses and soil information needs. We tailor map unit design decisions according to interpretation needs. We have a taxonomy system with class limits defined on the basis of known responses to use and management or predicted soil behavior. We make correlation decisions with an over-riding concern for interpretations.

We continually ask our customers, the soil survey users, what their needs are. And then we challenge ourselves to develop ways to meet those needs. We know that we can meet some needs, but not others. We also know that we can't meet all needs and will have to make choices. To provide for some customers, will require that we do business differently. For example, water quality concerns relate to both the near surface soil the the underlying vadose zone. If we choose to address this zone that is below the primary depth of biological activity, new methods of examining, characterizing, predicting and interpreting deep soil properties will need to be developed. The challenges are there, and we will meet them as we always have.

Changes in the way we do business are a part of business for us. One specific change this committee has undertaken is to replace the word "user" with "customer." Customer is a user-friendly word that reinforces the relationship between ourselves as producers, and those who we serve.

PART III. DISCUSSION AND FINDINGS

A. Recommend ways to reach the customer(s) to determine what they need in the way of soil survey information - content, interpretations, format.

1. Evaluate all methods and ways that have been used to reach customers to find their needs. Identify those methods that provide the most response and highlight those that have been the most successful.

2. Evaluate and identify potential new ways to reach customer(s) for their input, i.e., public participation process, telephone polls, newsletters, questionnaires.

A.l. <u>Methods to reach customers</u>

The following are methods that have been used to reach customers:

a) questionnaires
b) open forum/meetings
c) meetings for specific soil management problem
d) marketing and follow-up
e) personal contacts with professional organizations
f) personal involvement in non-soils programs within agencies
g) through partners such as extension service, planning, boards, RCD/SWCD's
h) public service announcements for customer needs meetings
i) local media/articles for new surveys or meetings
j) mailings
k) telephone polls to specific professional groups or industries
1) MOU development meetings
m) 1st acre/last acre ceremony
n) testing process during survey project
o) soil potential studies
p) field reviews
q) programs for service clubs/scouts, etc.
r) community colleges/higher education center
s) through public affairs staff
t) training exercises for specialized customers
u) SWCS public forum
v) computer bulletin boards
w) tours
x) fair booths
y) long range plan development

A.2. Evaluation of methods

a) <u>Questionnaires</u>: Questionnaires have been used to evaluate the soil survey program's effectiveness in meeting customer needs. They have also been used to query customers that work outside of the program or agency about their needs. They are commonly distributed at meetings or through the mail by agencies and Resource Conservation Districts.

Questionnaires are the best way to gather information from large groups of people, if used appropriately. However, they have limitations because they are often structured in a way that influences the customer to tell us what are already know or want to hear. In many cases, customers don't know enough about soils or the kinds of services soil scientists can provide to identify their needs using a questionnaire.

The Vaught Study Group (1973) was successful in bringing about significant changes to the soil survey report format and content. A copy of the questionnaires used by this group have not been obtained. The report is attached.

Questionnaires provided by this committee are listed in the Table of Contents. A copy of each will be attached to the final report of this committee.

b) Meetings/ open forum/ public participation. This was the method most frequently discussed by committee members. The most common type of meeting discussed was for an individual soil survey. These meetings were held to initiate the soil survey and determine local user needs. This method was determined successful, however good publicity provided by cooperators such as Extension Service, RCD's/SWCD's or planning departments was vital for success. Initial identification of customers targeted for invitation to these meeting is a part of this process.

Another meeting approach included quarterly meetings open to anyone interested in soil survey. This was productive in generating ideas, but there was not enough time to carry out the ideas. The benefit of these meeting was the generation of interest by agency and local county officials.

A third kind of meeting was with a group of people who had a specific soil problem. The purpose of the meeting was to discuss how to solve the problem. This was an effective method of meeting customer needs.

c) Public service announcements, local media coverage. These methods were used primarily to inform customers of upcoming user needs meetings.

d) Personal contacts with special interest groups (professional groups, industry). This was recommended as effective follow-up to meetings that were designed to inform and train people on the use of the soil survey. Personal discussions with individuals who aggressively used soil survey information were also described as effective if we listened to the customer's requests, no matter how non-traditional they were.

e) Literature search on "using soil survey information". Conduct a literature search of published articles to locate information on customer needs. An example of a article discussing this subject is "Collecting and Using Soil Survey Information in Park Management: Examples from Redwood National Park by James H. Popenoe, Redwood National Park. (See attached article)

f) Long range plan development. Involve local and state governments in the development of long range plans.

B. Develop procedures to query the customer(s) to determine their needs and/or uses of soil survey information.

1. Evaluate items such as interpretations needed; publication format desired; parts of the report that are never used, seldom used, frequently used or very frequently used; suggestions to improve the report; other interpretations needed for inclusion in the sample form.

B.l. <u>Procedure to determine customer needs</u>

a) A proposal which numerous committee members discused and supported was a combination approach of Marketing-Meetings-Questionnaires-Followup. This was considered the most successful approach because all vital steps were a part of the process. Marketing is the step in which customers are aggressively sought out to insure the greatest number and variety are contacted. <u>Meetinss</u> are designed to train the customers and potential customers on how to use the soil survey. This gives them an informed background with which to respond to questionnaires. Questionnaires are provided after the meeting to get input from meeting attendants. Content of the questionnaires will vary depending on the objective. A common objective is to determine local interpretation needs for a new soil survey. Another objective is to determine soil survey information needs of state government. Personal follow-up meetings, interviews, visits or phone calls are necessary to stimulate discussion and reveal specific needs of individual customer groups (engineers, planners, farmers, etc).

Each meeting situation will require its own set of questions, depending on the objectives. Key people in the target audience should be assembled to discuss and help develop the questionnaire. This will enhance credibility and support for the process. Objectives should be clearly defined **before a questionnaire is developed. Potential issues to address** for customer needs questionnaires are:

- -sources of soil information used
- -business/occupation of customer
- -section of soil survey report used
- -interpretations used and needed
- -soil data elements used and ***needed***
- -frequency of use
- -publication format desired
- -need for electronic text files
- -need for electronic soil attribute files (databases)
- -need for electronic spatial data files (GIS)
- -suggestions to improve report, maps or database.
- -quality/availability of assistance from soil specialists.

Information from these meetings should be compiled and passed on to the next higher agency level for incorporation in program development activities.

The amount of time required to follow the comprehensive Marketing-Meetings-Questionnaires-Follow-up method will be determined primarily by the size of the target audience and the complexity of the questionnaires.

b) An evaluation sheet included in each published soil survey report (or other product deliveries) is another suggested method of gathering information from customers. A set of questions similar to those in the US Army Ballistic Research Publication could be developed. (See appendix)

C. Identify customers.

1. One committee member suggested we define a "non-typical client group." This is an appropriate consideration. A non-typical customer in one soil survey area or agency may be typical in another. Consequently, we have listed examples of customers. Each agency should define their own internal and external customers.

- -Ourselves (SCS/FS/BLM/NPS/BIA)
- -Agriculture - farmers, ranchers, crop management companies, fertilizer companies, water managers, irrigation/drainage districts
- -Forestry - foresters, logging companies
- -Home buyers
- -Developers, realtors
- -Planners
- -Land assessors
- -Sanitarians
- -Environmental engineers
- -Geologists
- -Hazardous waste management industry

-Private consultants
-Educators
-Legislators
-Environmental groups
-City dwellers (landscaping)
-City dwellers (education)
-Local units of government
-State/federal agencies (EPA, Water Quality, Water Resources, Air Quality, Transportation, Fish and Wildlife, Solid Waste, Forestry, Agriculture, Natural Resources, Geology and Mining
-Military bases
-State/federal prisons
-Schools
-Universities
-Extension service
-Bankers, lending institutions
-Environmental scientists

2. Ways to contact them include all items listed in the discussion of methods in item A.l. Aggressive support by Extension Service or a leading state agency is very helpful and insures better success.

PART IV. RECOMMENDATIONS

A.1 Public participation and interview activites should be the primary methods for determining customer needs because of their effectiveness in capturing the needs of new customers. Questionnaires have a value as a secondary method in some but not all situations.

B.l Encourage soil scientists to become involved in activities with other specialists and in agency programs other than soil survey.

8.2 Develop guidelines for use by local, state, regional or national levels on processes involved in determining customer needs including:

- -marketing
- -public participation meeting
- -questionnaires
- -follow-up interviews.

(Include "how-to" information for publicity, facilitating discussions, developing questionnaires, conducting follow-up interviews and summarizing input.)

Continue committee:

Tommie Parham
Davie Richmond
Gerald Latshaw
Steve Strenger
Clif Fanning
Arlene Tugel
Extension Service
WNTC
NO-Tech Services

B.3 Provide a locally developed customer evaluation questionnaire with each soil survey product that is distributed.

PART V. ATTACHMENTS

See attached.

Participating Task Group Members:

Hugh Alcon
Bill Broderson
Gordon Decker
Cameron Loerch
Gerald Latshaw
Bob Meurisse
Tommie Parham
Therman Sanders
Ray Sinclair
Arlene Tugel, Chair
Clif Fanning
Davie Richmond

USE OF SOIL SURVEYS FOR ENVIRONMENTAL ISSUES AND CONCERNS:

Committee Chair - Eugene F. Kelly

Committee Secretary - Carol Wettstein

Committee Members -

Earl Alexander	Larry Munn
Otto Baumer	Bob Nielsen
Mark Blakeslee	Gerry Nielsen
Joseph Chiartti	Ron Paetzold
Edwin Cowley	Tom Remington
Phil Derr	Chris Smith
Bob Drew	Randy Southard
Herb Huddleston	Bill Ypsilanti6
Chien Lu Ping	John MacDonald
Paul McDaniel	Tom McKay

The task force addressed the charges set forth by the steering committee which relate to the use of Soil Survey's and Soil Survey information in addressing current environmental concerns. The following is a summary of the committee's discussions and recommendations.

The charges were stated as follows:

A. Evaluating existing criteria for rating soil properties with regard to the retention, movement and degradation of pesticides/herbicides, industrial, municipal, hazardous, nuclear wastes and susceptibility to acid deposition.

B. Assess the use of soil surveys in studies of global climatic change.

1. evaluate the use of higher order (small scale) original soil surveys and soil association maps and other generalized soil maps compiled form original soil surveys.

2. develop a minimum data set of soil characteristics necessary for evaluating the effect of climate change on forestry, range and non-irrigated crop production.

A. Evaluating existing criteria for rating soil properties with regard to the retention, movement and degradation of pesticides/herbicides, industrial, municipal, hazardous and nuclear wastes.

Discussion centered on the following major points

1) No existing criteria for hazardous and nuclear wastes. Information may exist regarding some of these materials, however it is not in a form that would be considered usable.

2) Efforts directed towards appropriate characterization of soils with the goal being the development of such criteria.

a) Spatial and temporal problems:

Evaluation of site suitability with regard to retention, movement, and degradation of hazardous and nuclear wastes goes beyond the scale (temporal and spatial) that soil survey has traditionally dealt with. We generally are concerned with the surface 5 feet of material this is generally inadequate for site evaluations.

b) Types of measurements: in situ vs. ex situ

1) In Situ: Knowledge of the transport and retention of materials for municipal waste disposal and in the event of accidental spills.. Also evaluate sites for engineering purposes.

a. Hydrological: (retention and movement)

Textural parameters

Macro pore flow (will affect compounds that shown to be immobile)

Permeability of the soil (in/hr) to at least 2 meters.

Presence of a seasonal high water table within l-10 meter(s)of the soil surface.

Presence of bedrock or other root-limiting layers.

Additional information gray area between soil and geologic material.

Specific attention to fractured or un-fractured character. Permeability of root-limiting layers as related to fractures and joints.

How deep will we interpret geological materials?

Soil moisture as related to the seasonal occurrence (or lack of) gravitational water

capable of moving hazardous substances.
saturated flow

b. Chemical, biological and physical properties:

Rate for potential in bioremediation processes

The cation exchange capacity (CEC) of the surfacehorizon and/or horizons in the upper 24 (?) inchesof the soils

Special analysis could be conducted by experimental station cooperators expertise.

Chemical nature and content of soil organic material.

Reaction (pH) of the soil.

Heavy metal content (background)

Mineralogical Composition
(dcb fe)

2) Ex situ: Knowledge of the remediation potential (Biological or chemical) of soil. Requires physical and chemical characterization of both soil and waste material.

a. Characterization of soils:

Sorptive capabilities of soil materials may be utilized effectively in some cases (remediation of chemical spills etc.) and we may want to work closely with biochemists in developing interpretations for these types of uses.

b. Source material for construction

potential for land fills

potential for liners

don't know how suitable they will be for hazardous and nuclear wastes

c. Characterization of foreign materials:

Reactivity (Not sure we have any real idea of what is going on biologically or chemically with these materials).

B. Assess the use of soil surveys in studies of global climate change (climate change, land use etc..).

1. Evaluate the use of higher order (small scale) original soil surveys and soil association maps and other generalized soil maps compiled form original soil surveys.

Use soil survey information to identify key zones(perhaps climatic regimes that would be sensitive. Monitor 'soil properties in these sensitive zones. This can give us a geographical base line reference for on-going monitoring of soil temperature and soil moisture in selected sensitive zones to check on significant climatic change.

Assessment of soil organic carbon (SOC) storage and trend in the soils of selected regions.

Assist in modeling of future vegetation shifts as a result of climate change.

2. Develop a minimum data set of soil characteristics necessary for evaluating the effect of climate change on forestry, range and non-irrigated crop production.

Consider the same soil characteristics for evaluating productivity regardless of our interest in the effects of climate change. It is important to rate systems for resilience (buffer capacity) and base this key soil properties (perhaps Organic C or N, weatherable minerals). The normal fluctuations often to thirty year cycles we've experienced over the past few hundred years are not well reflected in soil characteristics unless accompanied by poor or unsound management practices.

Primary characteristics that may be important:

Soil moisture

Soil Organic carbon

Weatherable minerals

Soil reaction (pH) of the surface horizon

Base saturation of the surface horizon

Concentration of cations (in meq/100g) of exchangeable calcium (Ca), magnesium (Mg), aluminum(Al) and hydrogen (H)

Concentration of anions (in meq/l) of sulfate and carbonate

Content of toxic metals (in ppm) of lead and cadmium

Effective soil depth

Committee Summary and General Recommendations:

General -

1. It was agreed that a discussion regarding the use of Soil Surveys for current environmental applications and global change initiatives be continued on at the national level.

Charge A - Regarding Soils for the Retention/Movement of Hazardous Materials

1. Specific attention should be made to those measurements not made to support current Soil Survey Laboratory Characterization. In cases some of this characterization of soils (in situ vs ex situ or variations in depth of sampling for example) may be better conducted by Experiment Station Cooperators.

Charge B - Regarding Global Climate Change

1. The Soil Survey should provide the overall guidance for selecting sites and quantifying the spatial relationships (at many scales) in global climate change investigations.

2. This area could be modified to incorporate Global Change Issues and not specifically tied to Global Climate Change. This would incorporate changes caused by varying land use, natural disasters and the degradation of soil ecosystems

3. Focus on defining Soil Degradation Potential.

4. Recognition that anthropogenic influences may in fact cause climatic change but will also magnify a change in soils brought about by climatic variations.

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

Sponsored by
Arizona Chapter of the Soil and Water Conservation Society

FIELD TOUR GUIDE

by

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University of Arizona

and

Greg Miller
USDA Forest Service

June 24, 1992
Flagstaff, Arizona

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Acknowledgement

The following people have contributed to the information contained in this guide:

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and

Debbie Prevost -- USDA Soil Conservation Service

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INTRODUCTION

The tour encompasses an area around Flagstaff on the Coconino National Forest. The purpose of the tour is to observe the geology, vegetation and a few selected soils in the area. The tour will mostly be restricted to the San Francisco volcanic field which contains rocks ranging in age from late Miocene to Holocene and in composition from basalt to rhyolite. The tour will pass through five of the vegetation life zones in the area of Merriam6 (1890) classical ecological study. Mean annual precipitation of the tour area ranges from 35 cm (14 inches) to 76 cm (30 inches) or more and mean annual air temperature from approximately 1' Celsius (34' Fahrenheit) to 10' Celsius (50' Fahrenheit). The first stop will be at Sunset Crater National Monument where the nature of the geology resulting from the most recent volcanism of the San Francisco volcanic field will be described. At the second stop, a Mollic Durustand will be observed, The distinctive feature of this soil is the strongly developed duripan. The third stop will be at the Fort Valley Experimental Forest where some of the research being carried out by the Rocky Mountain Forest and Range Experiment Station of the U.S. Forest Service will be described. The fourth stop which includes a Pachic Cryoboroll below Agassiz Peak on San Francisco Mountain, is an example of higher elevation forest soils. A hlollic or Vitric Haplustand will be observed at the fifth stop in Kendrick Park.

Geology

The tour is located in north-central Arizona on the Colorado Plateau. one of two physiographic provinces in Arizona (see Figure 1). Unlike the Basin and Ranee Province to the south and west and the other physlo-graphic provinces in the western United States. the Colorado Plateau is only moderately structurally deformed. The Colorado Plateau relief is more the result of deep canyons cut into moderately flat terrain than of mountains and valleys created mostly by deformation as in the Basin and Range Province. Volcanic mountalns exist within the province, but block-fault structural mountain ranges do not. Hunt (1967) described the general structure as being analogous to a stack of saucers. tllted toward the northeast Into Utah and Colorado where the plateau meets the Rocky Mountains.

The southwestern part of the Colorado Plateau Is referred to as the Grand Canyon Section, the highest part of the province (Fenneman, 1931). The most notable feature of this section is the Grand Canyon, a classical geological feature, which exposes completely deformed Precambrian formations and about 1.200 to 1,600 m of Paleozoic formations. The dominant surficial rocks In the Grand Canyon Section include the Permlan Kalbab and lesser amounts of the Triassic Moenkopi and other formations except where covered by volcanic rocks.

The main geologic feature of the tour area is the San Francisco Volcanic Field, the largest of several volcanic fields in the Grand Canyon Section, covering more than 5.000 so. km. Basaltic lava flows dominate the eruptive products of the volcanic field. More than 600 volcanoes. ranging from basaltic through Intermediate to rhyolitic In composition, have been identified. Most of the volcanoes are basaltic scoria cones that are scattered throughout the field.

The geochronology of the San Francisco volcanic field has been studied fairly extensively beginning with Robinson (1913) who divided the rocks In three perlods of eruption: (1) basaltic volcanics, probably of the late Pliocene, (2) rhyolitic to andesitic volcanoes, probably of the early Pleistocene, and (39) basaltic volcanism, probably of the latter parr of the Quaternary. Cotton (1937, 1967) divided the basalts of the field Into five stages based on weathering and erosion of the cinder cones and flows. Cooley (1962) expanded Cotton's (1937) classification by relating the basaltic stages to eroslonal surfaces and alluvial deposits in the Little Colorado drainage basin adjacent and to the east of the field. More recently Moore. Ulrich and Wolfe (1974) and Moore, Wolfe and Ulrich (1976) defined five episodes of basaltic volcanism based primarily on: (1) stratigraphic and physiographic relations. (2) weathering and erosion, (3) potassium-argon and tree ring age determinations. and. in part, (4) chemical and (5) petrographic data. The different subdivisions of the San Francisco volcanic field are compared In Table 1.

San Francisco Mountain (also referred to as the San Francisco Peaks) rising to an elevation of 3.850 m is the most prominent geomorphic and volcanic structure In the San Francisco volcanic field. San Francisco Mountain consists of individual remnants of a compound composite volcano that predates the Inner Basin. a large bowl-shaped valley (caldera) that occupies the central part of the mountain. The growth and development of the mountain occurred during the late Pliocene and Pleistocene by the eruption of approximately 110 km^3 of lava and pyroclastic material. Estimated volumes of the lithologic types in the central volcano are andesite (99 km^3), dacite (13 km^3) and rhyolite (1 km^3) (Holm, 1987). An additional estimated 8 km^3 have been removed by erosion (Holm, 1987). The volcanic history of the mountain as summarized by Holm (1986. 1987) consisted of four magmatic cycles. each beginning with silicic eruptions which contributed to 5 stages of volcanism during a time span of approximately 2.5 Ma.

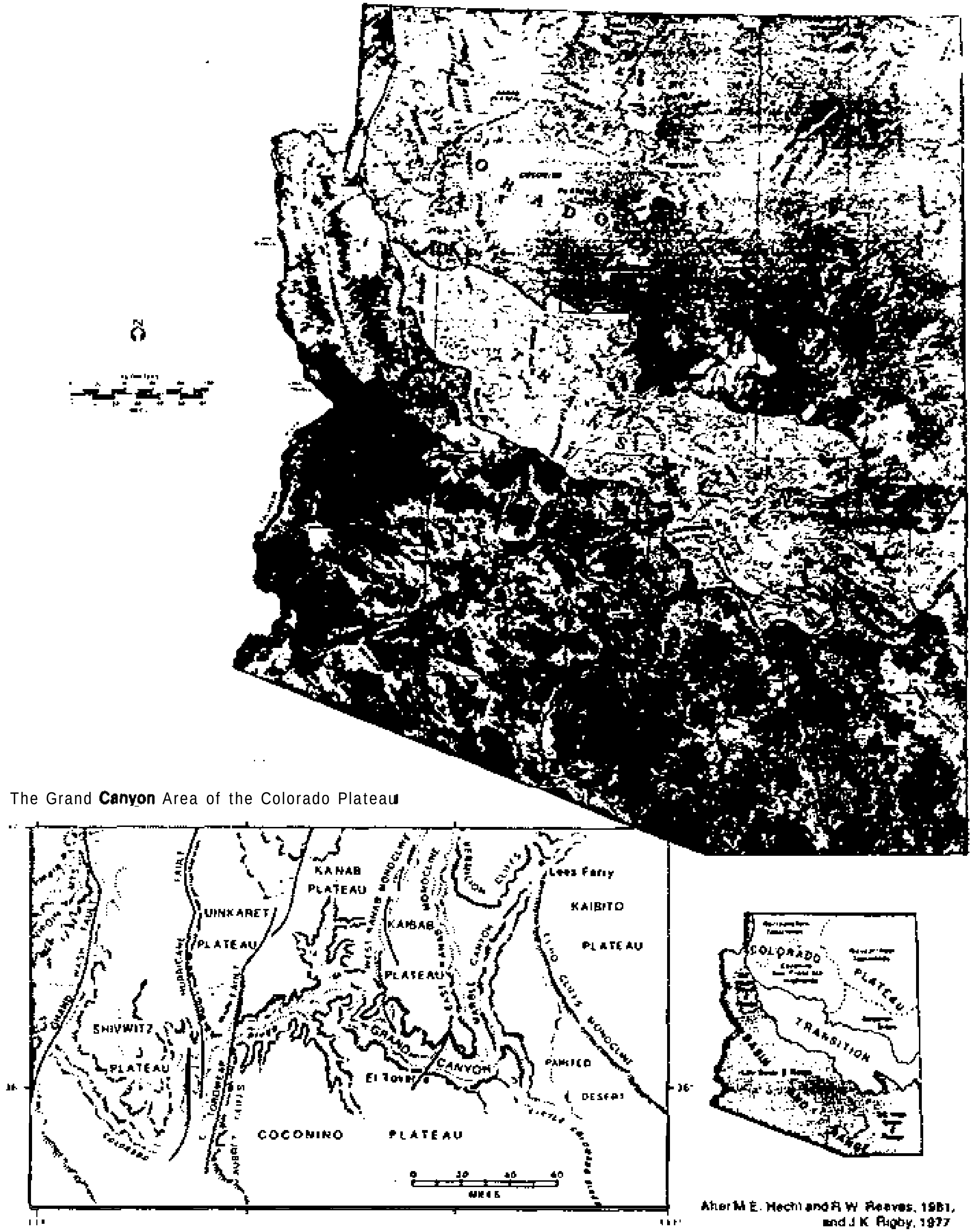


Figure 1. **Landform** Features and Physiographic Provinces in **Arizona** (Taken **from** Hendricks, 1985).

TABLE 1.
Comparison of San Francisco Volcanic Field Subdivisions

Age		Million Years	Colton (1937, 1967)	Cooley (1962)		Moore et al (1974)
Quaternary	Holocene		Stage V	Younger Basalts	Stage V	Sunset Age Group
		0.01	Stage IV		Stage IV	Merriam Age Group
	Pleistocene	0.20	Stage III		Stage III	Tappan Age Group
			Stage II		Stage II	
		1.00			Stage IA	Woodhouse Age Group
		2.00	Stage I		Stage IB	
Tertiary	Pliocene			Transition Basalts		Basalt of Cedar Ranch Age Group
				Older Basalts		

Climate

A unique feature of the climate in Arizona is the two periods of precipitation; one season is from December through March and the other during July, August. and September. The proportion of winter precipitation decreases from west to east and the summer precipitation decreases from south to north. The biseasonal precipitation pattern appears to reach equality in the Flagstaff-Prescott area with the same average annual moisture falling during each period (Jameson, 1969).

Winter preclpltatlon results from storms associated with large-scale mid-latitude cyclonic disturbances which provldes the strong winter maximum moisture In California. The greatest winter rainfall In Arizona comes from storms moving eastward or northeastward from southern Callfornla. As these storms move inland across Arizona, they drop most of their moisture on the mountains of the southwestern and central part of the state. These storms are particularly noticeable along the Mogollon Rim (escarpment forming the southwestern and southern edge of the Colorado Plateau) of central Arizona with the maximum moisture falling on the central portion of the rim including the western part of the tour area. Downwind from the rim there Is a dlstlnct rain shadow which is especially pronounced in the Llttle Colorado Basln east of the tour area.

Summer rainfall has a tropical orlgln. The influx of warm moist air masses from the Gulf of Mexico begins about July 1 and lasts untll the end of August. The unstable air advances into Arizona from the southeast over strongly heated land surfaces and yields moderate to heavy afternoon or evenlng thundershowers. There is no rain shadow effect associated with the summer ralns since the "monsoon" alr masses do not show dlstlnct frontal characteristics. Because much of the summer preclpltatlon falls as a result of convection storms, high preclpltatlon coincides with points of abrupt topography. Precipitation Is highest In summer at about the same location as It Is In winter in the central Mogollon Rim.

There is a dlstlnct vertical zonation of climates in the tour area. For each 300m increase In elevation there is a corresponding decrease In temperature of approximately 3°C (Smith, 1956). Accompanying this increase In precipitation Is a decrease in potentlal evapotranspiration and a pattern of **increasing precipitation**, distribution of which depends on exposure, **prevailing** winds and distance from mountains.

The data presented in Figures 2, 3, and 4 are for Fort Valley, Sunset Crater National Monument and **Leupp** which represent the **climatic conditions** and soil moisture budgets for most of the tour area. Climatic data are not available for San Francisco Mountain above Fort Valley and Flagstaff although **Péwé** and **Updike (1976)** state that the **precipitation** in the upper **Interior** Valley is nearly twice that of Flagstaff. The data presented in Figures 2, 3, and 4 were **compiled** by the USDA **Soil** Conservation Service (Unpublished data). The values for the potential evapotranspiration were **determined by the Newhall** method **(Newhall, 1980).** The soil moisture budgets were determined **following** the approach of Thorthwaite **(1948)** as **modified** by Thorthwaite and **Mather** (1955).

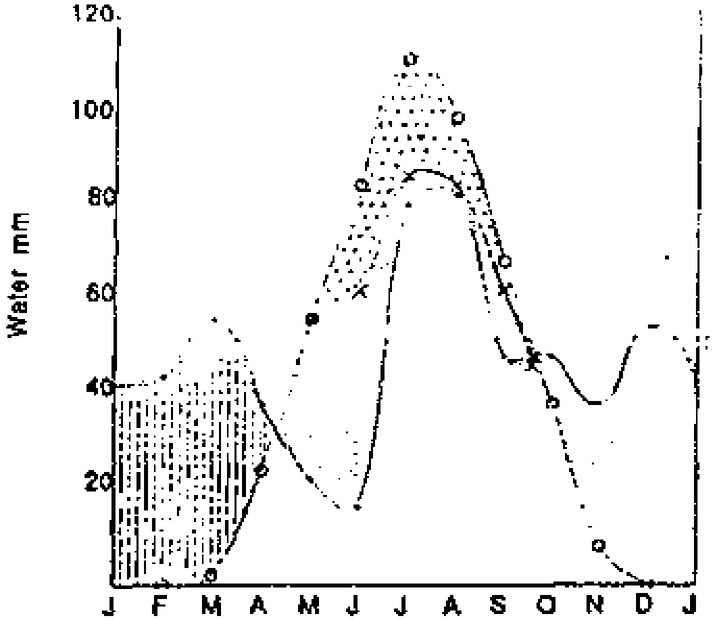
The **soil** climate **(Soil Survey Staff,** 1985) of the tour area ranges from **mesic-ustic** (bordering on **aridic)** to **udic-cryic at** the **higher elevations.**

Since many soils date back into the **Pleistocene** past **climatic conditions** may have had a strong influence on the properties of these **soils. A** wealth of **evidence** is **accumulating** from which generally consistent inferences about the climate of the southwestern United States during the past 50,000 years or so can be made. This **evidence** comes **chiefly from paleobotanical, palynological,** dendrochronological, **paleozoological,** glacial and **pluvial** studies.

Pleistocene alpine **glaciation** in Arizona occurred on San **Francisco Mountain providing evidence of colder climatic conditions** (Sharp, 1942; **Péwé** and **Updike, 1970; Updike** and **Péwé,** 1974; Duncklee, **1978). Periglacial** phenomena occurred in nonglaciated areas **during times** of **glaciation** on Kendrick Peak located northwest of San **Francisco Mountain.**

A number of pollen-stratigraphic **studies** made **in** the southwestern **United** States were **reviewed** by **Hevly** and Karlstrom **(1974).** The results of these studies **showed** that the Southwest **paleoclimate** was in phase **with** those of the **Pacific** Coast and **mid-continental** North **America**. When continental **glaciers** were **expanding,** Southwest **biotic communities** were **displaced to** lower elevations and more southerly **latitudes. Pluvial lakes expanded and** alluvial deposition was augmented by the actions of more moist and cooler climates. As continental glaciers waned, the reverse biotic, geological and climatic phenomena occurred.

Widespread occurrences and discoveries in the Southwest of extremely old packrat (genus *Neotonma*) mlddens containing abundant, well-pressured plant macrofossils recently have provided good information about the nature of paleoplant communities and inferred climatic conditions (Betancourt et al.. 1990). Results of analysis and dating of numerous packrat middens show vegetation changes indicative of cooler and more moist climates In the Southwest during the late Pleistocene. The results of studies of packrat mlddens in the Grand Canyon and on the remainder of the Colorado Plateau were reviewed and summarized by Cole (1990) and Betancourt (1990), respectively. *In* addition to a lowering of the vegetation zones Betancourt (1990) noted the absence of ponderosa pine on the Colorado Plateau during the late Wisconsin. He attrlbutes this absence to cooler and drier summers. Cole (1990) suggests that Wisconsin mean annual precipitation was about 8.7 cm greater and mean annual temperatures about $6.7^{\circ}C$ less than today. Early Holocene climates of the Grand Canyon had summer precipitation greater than today with temperatures similar to or as much as $1^{\circ}C$ greater than today (Cole. 1990). The middle Holocene climates of the Grand Canyon were probably about one degree warmer with slightly less mean annual precipitation than today.



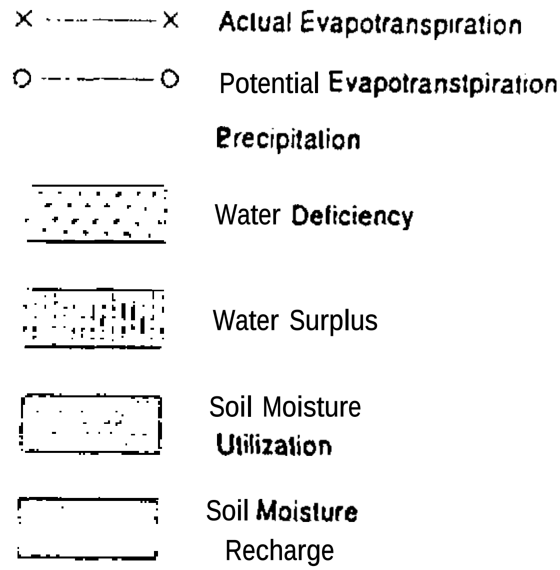


Figure 2. Waler balance for Fort Valley.

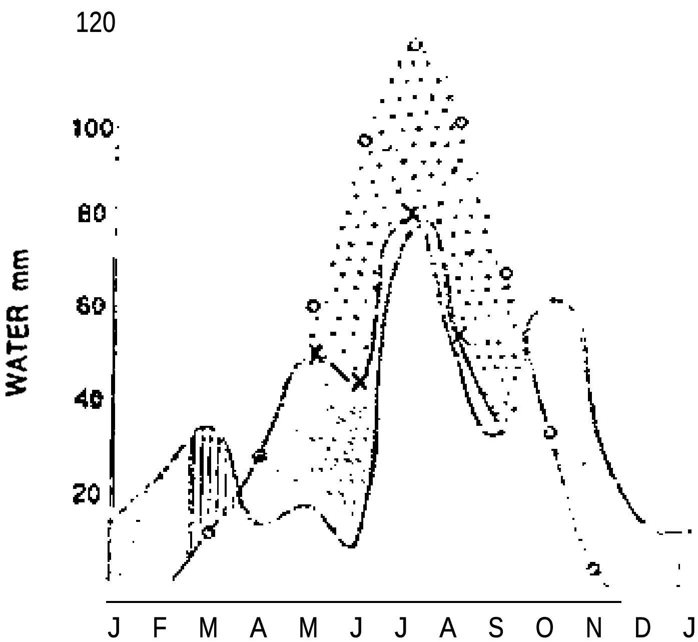


figure 3. Waler balance for Sunsel Crater area

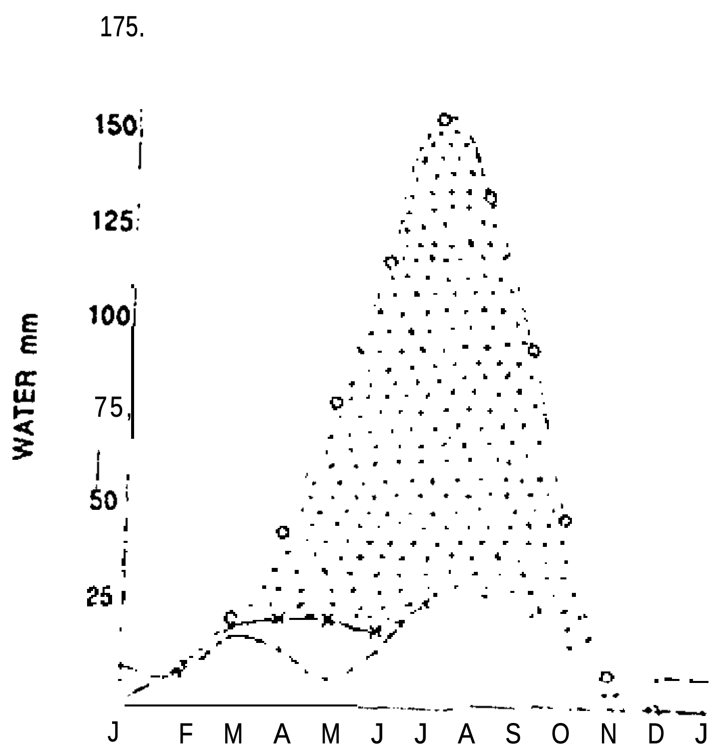
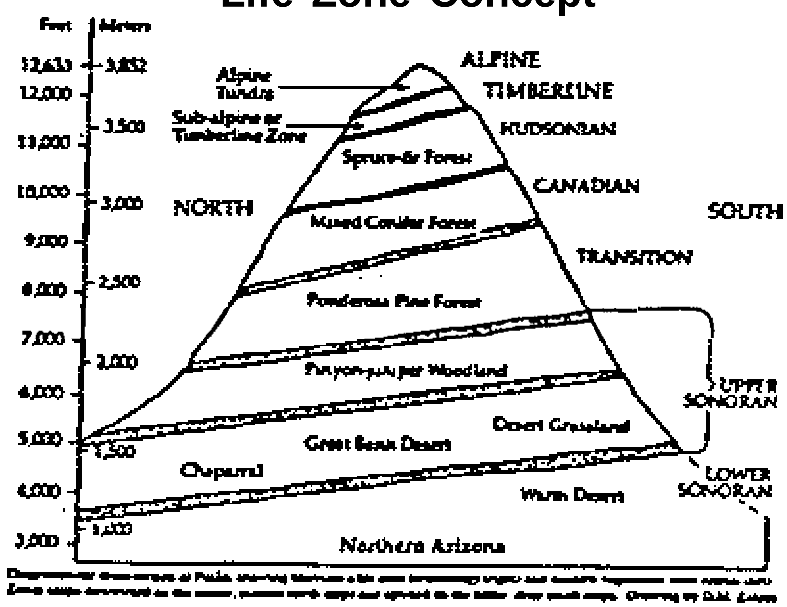


Figure 4. Waler balance for Leupp

Vegetation of the Coconino National Forest

The Coconino National Forest is located within the Grand Canyon Section of the Colorado Plateau physiogtaphic province. vegetation in the area of the Forest is diverse due to differences in elevation. temperature, precipitation (amount and seasonal distribution), topography and geology. The area of the San Francisco Peaks and surrounding north-central 'Arizona has been studied extensively. Merriam (1890) developed the concept of vertical life zones in this area. His two month field expedition into the San Francisco Peaks and surrounding areas provided the first comprehensive description of the plant end animal life. Merriam defined seven life zones on the San Francisco Peaks and provided a brief description of the habitat of each zone and a discussion of dominant plants. These seven life zones are depicted diagrammatically below.

The San Francisco Peaks and the Life Zone Concept



Taken from Plateau magazine of the Museum of Northern Arizona. Volume 60, Number 2.

Following is a brief description of the major vegetation zones occuring on or near the Coconino National Forest.

Alpine Tundra

The only true alpine tundra zone in Arizona is restricted to the San Francisco Peaks at elevations exceeding 3,500 meters (11,500 feet) upon Humphreys and Agassis peaks. It occupies an area approximately 1600 acres in size. Little (1941) described two plant associations, the alpine rock-field (rubbleland) and alpine meadow.

The alpine rock-field association occupies most of the area above timberline. It occurs on more unstable and less weathered substrate than the alpine meadow association. It is characterized by mosses and lichens on rock and by vascular plants scattered among boulders. This vegetative community represents a relict alpine tundra flora related to the tundra of the Rocky Mountains (Moore, 1965).

Representative plant species include *Geum rosii* var. *turbinatum* (mountain avens), *Carex bella* (beautiful sedge), *Polemonium viscosum* (sticky Jacob's ladder). *Silene acaulis* (moss campion), *Oxyria digyna* (mountain sorrel), *Heuchera versicolor* (painted alumroot), *Sedum rhodanthum* (Queen's crown), *Trisetum spicatum* (spike trisetum), *Agropyron scibneri* (spreading wheatgrass) and *Senecio franciscanus* (San Fransisco Peaks groundsel). *S. franciscanus*. a threatened species, is the only plant in the alpine tundra zone of the San Francisco Peaks found nowhere else in the world.

Sub-Alpine or Timberline Zone

Below the alpine tundra is a transition zone characterized by weather-beaten, dwarfed stands (krummholz) of Bristlecone pine and Englemann spruce. Exposure to strong and cold winter winds shape the stunted trees and shrubs. Rominger and Paulik (1983) described this zone as the Pinus aristata habitat type. This habitat type is commonly found on sooth aspects at elevations ranging from 3200 meters (10,500 feet) to 3500 meters (11,500 feet). It is characterized by widely spaced trees and a very sparse understory.

Representative plant species in this vegetation zone include Pinus aristata (bristlecone pine), Picea engelmannii (Englemann spruce), Juniperus communis (common juniper), Ribes montigenum (gooseberry currant), Thlaspi fendleri (wild candy tuft). Draba aurea (yellow draba), penstemon whippleanus (Whipple's penstemon) and Festuca ovina var. brachyphylla (alpine fescue).

Spruce-Fir Forest

The spruce-fir forest on the Coconino National Forest is dominated by Englemann spruce and Corkbark fir. This dense, moist forest type is characterized by a sparse understory. Moir and Ludwig (1979) have classified this community into 8 spruce-fir habitat types (plant associations) in the Southwestern Region. Rominger and Paulik (1983) recognized 4 of these habitat types in their investigations of the San Francisco Peaks Research Natural Area. Quaking aspen is recognized as a major seral species of this life zone.

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Representative plant species in this vegetation zone include Picea engelmannii (Engelmann spruce), Abies lasiocarpa var. arizonica (corkbark fir). Populus tremuloides (quaking aspen). Ribes montigenum (gooseberry currant), Lonicera involucrata (bearberry honeysuckle), Fragaria ovalis (wild strawberry), Epilobium angustifolium (fireweed), Helenium hoopesii (orange sneezeweed), Swertia radiata (elkweed), Lathyrus arizonicus (Arizona peavine), Erigeron superbus (showy fleabane) and Bromus ciliatus (fringed brome).

Mixed Conifer Forest

The mixed conifer forest is probably the most vegetatively diverse zone with respect to composition and *frequency of species.* It is characterized by four tree species -- Douglas Fir, White Fir, Limber Pine and Quaking Aspen. The forest floor is typically very lush in herbaceous and shrub species. Aspen is a major seral species in this zone and may occur intermixed with the coniferous species or in nearly pure stands. Moir and Ludwig (1979) have classified this community into 11 habitat types in the Southwestern Region. Three other habitat types were recognized as occuring in the San Francisco Peaks but were not included due to limited geographic range.

Representative plant species in this vegetation zone include Pseudotsuga menziesii var. glauca (Douglas fir), Abies concolor (white fir), Pinus flexulis (limber pine), Pinus ponderosa var. scopulorum (ponderosa pine), Populus tremuloides (quaking aspen), Quercus gambelii (Gambel oak), Acer grandidentatum (bigtooth maple), Berberis repens (Oregon grape). Robina neomexicana (New Mexican locust), Lathyrus arizonicus (Arizona peavine), Thalictrum fendleri (meadowrue), Achillea millifolium lanulosa (yarrow), Erigeron superbus (showy

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fleabane), Festuca arizonica (Arizona fescue), Muhlenbergia montana (mountain muhly), Koelaria pyramidata (junegrass), Carex foenea (sedge) and Sitanio" hystrix (bottlebrush squirreltail).

Ponderosa Pine Forest

This vegetation zone is the most prominent on the Coconino NF. The forest surrounding the Flagstaff area is part of the largest, contiguous stand of Pondsrosa pine in the world. This vegetative zone is characterized by a single species of tree, Ponderosa pine. It typically occurs as open stands with a" understory comprised of Arizona fescue and Mountain muhly. Gambel oak may occur as a shrub or understory tree and is recognized a.8 a long-lived seral species in this vegetative zone.

Hanks, Fitzhugh and Hanks (1983) recognized and described 4 habitat types, sub-divided into 12 phases, in the ponderosa pine forests of northern Arizona. Their separation of phases was based on the change in understory species as a response to increasing precipitation.

Representative plant species in this vegetation zone include Pinus ponderosa var. scopulorum (ponderosa pine), Juniperus scopulorum (Rocky Mountain juniper), Juniperus deppeanna (alligator bark juniper), Quercus gambelii (Gambel oak), Ceanothus fendleri (Fendler's ceanothus), Robina neomexicana (New Mexico locust), Antennaria parvifolia (Rocky Mountain pussytoes), Eriogonum racemosum (redroot buckwheat), Lathryus arizonicus (Arizona peavine), Senecio uootonii (groundsel), Festuca arizonica (Arizona fescue), Muhlenbergia montana (mountain muhly), Poa fendleriana (muttongrass) and Blepharoneuron tricholepis (pine dropseed).

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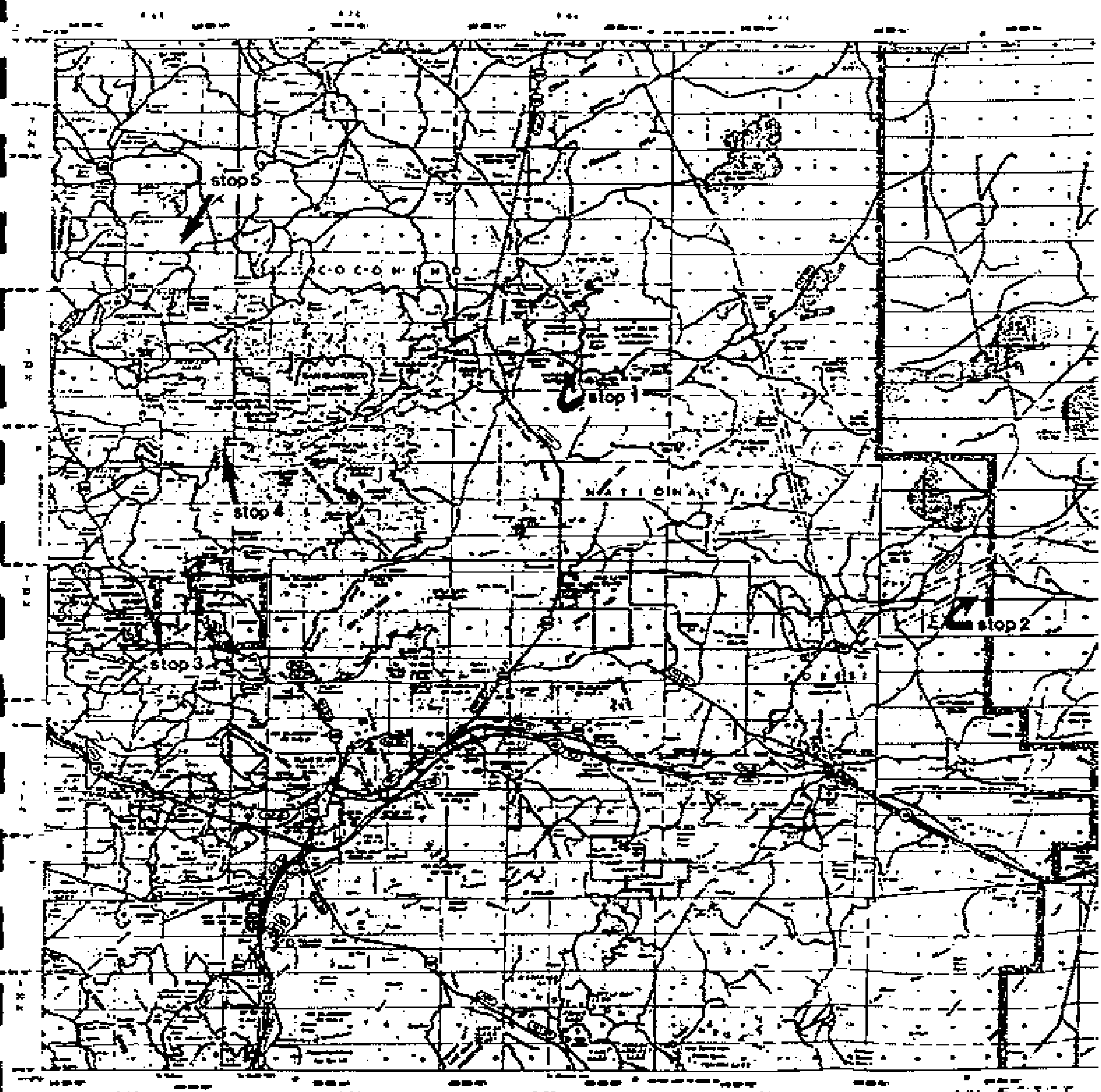
Pinyan-Juniper Woodland

This vegetative zone is second only to the ponderosa pine forest in area1 extent on the Coconino NF. It is characterized by Pinyon pine, Utah and One-seed juniper and may include Alligator bark juniper in some geographic areas. The Pinyon-Juniper woodland is typically open with various shrub and herbaceous species common in the interspace between the trees.

Larson and Moir (1986) recognized and described 11 habitat types in the northern and central parts of Arizona.

Representative plant species include Pinus edulis (pinyon pine), Juniperus osteosperma (Utah juniper), Juniperus monosperma (one-seed juniper), Cercocarpus montanus (mountain mahogany), Rhus trilobata (squawbush), Opuntia polycantha (plains pricklypear), Yucca elata (soaptree yucca), Berberis fremontii (Fremont barberry), Chrysothamnus nauseosus (rubber rabbitbrush), Penestemon linarioides (beardtongue), Eriogonum jamesii (antelope sage), Hymenoxys richardsonii (bitterweed), Bouteloua gracilis (blue grama), Bouteloua curtipendula (sideoats grama), Poa fendleriana (muttongrass), Koeleria pyramidata (junegrass), Hilaria jamesii (galleta) and Aristida spp. (three-awn).



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COCONINO COUNTY, ARIZONA

GENERAL ROAD LOG

Depart NAU Student Union parking lot at 7:00 am
(Travel time: 35 minutes)

As you travel east on I-40 you will have a view of the San Francisco Peaks and Elden Mountain in the foreground.

Elden Mountain is a dacite dome believed to be a laccolith which ruptured its sedimentary cover. It is one of several silicic volcanic centers that range in composition from &cite to rhyolite. Columnar jointed dacite lava flows are visible on the southern flanks of the mountain. As we travel further North along U.S. 89 you will notice the barren north slope. This is the result of the Radio Fire of 1977.

The San Francisco Peaks have formed within the last 1 million years. Humphrey's Peak, elevation 12,670 feet is the highest point in Arizona. It consists of 2,000 feet of andesites and dacites that erupted over a period of 470,000 years. The once steep-sided shape was modified at the summit and the northeast side by an explosive sidewards collapse into the caldera. This event happened approximately 300,000 years ago, forming an interior valley called the Inner Basin. The Inner Basin shows evidence of Pleistocene glaciation in the form of U-shaped valleys, glacial moraines and outwash deposits. The glacial sculpturing of the collapsed volcano left the peaks you see to&y - Doyle, Fremont, Agassiz and Humphreys.

Exit I-40 and turn north on U.S. Highway 89 towards Page. On the right hand side of the highway is a commercial cinder quarry. Material is used es a base material for construction of roads and buildings.

Approximately 2 miles to north is Doney Park, a large inter-cone basin. Soils in this area and further north in Black Bill Park are classified as fine-loamy, mixed. Typic Haploborolls.

To the north of Black Bill Park, on the east side of Highway 89. is an area of basalt flows and overlying cinder deposits. To the west is an outwash plain of mixed alluvium from the San Francisco Peaks. Soils occuring in this alluvial material have been classified as loamy-skeletal, mixed, Mollic Eutroboralfs.

Approximately 30 minutes after departure you reach Forest Road 545 which leads to Sunset Crater National Monument. AS you travel towards the entrance, Sunset Crater is visible to the east.

Stop #1 - Bonito Campground Amphitheater for a presentation by Sunset Crater personnel on the natural history, geology and cultural resources of the area.

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After lunch and the visit at Fort Valley, we will return east on U.S. Highway. 180 to Forest Road 516. We will then travel north on this road to the Fairfield Snowbowl Ski Area.

The dominant geology along the road includes dacite and andesite. As elevation increases along the route, the transition from Ponderosa pine to mixed conifer forest can be seen. This transition occurs at approximately 8000 to 8400 feet depending on aspect. The dominant soils occuring in the ponderosa pine are loamy-skeletal, mixed. Mollic Eutroboralfs. In the mixed conifer areas, the dominant soils are loamy-skeletal, mixed, Eutric Glossoboralfs.

Continuing along this highway, the transition from mixed conifer to spruce-fir forests becomes evident at approximately 9400 feet in elevation. Common soils occuring in the areas of spruce-fir forest are loamy-skeletal, mixed, Argic Cryoborolls.

Visible from Stop 4 is the only area of alpine tundra in the state of Arizona. This vegetation community occupies approximately 1600 acres at the summit of the San Francisco Peaks. Soils occuring in this area have been classified as sandy-skeletal, mixed, Pergelic Cryochrepts.

Stop #4 - loamy-skeletal, mixed, Pachic Cryoboroll
(Stop time: 60 minutes)

Depart Stop #4
(Travel time: 40 minutes)

After our stop near the Fairfield Snowbowl Ski Area, we will return via Forest Road 516 to U.S. Highway 180. We will then travel northwest approximately 14 miles to Kendrick Park.

The geology along this route is dominantly basaltic lava. The most common soils occuring in these areas are fine. montmorillonitic, Mollic Eutroboralfs and fine, moncmorillonitic, Typic Argiborolls.

To the east of the highway, the prominant landform is the San Francisco Peaks. As we near the intersection of U.S. Highway 180 and Forest Service Road 514, Kendrick Peak is visible to the west.

Proceed east on Forest Road 514 approximately 1.5 miles to Stcp 5.

Stop #5 - ashy-skeletal Over cindery, frigid Mollic Haplustands or
Vitric Haplustands
(Stop time 60 minutes)

Depart stop #5
(Travel time: 45 minutes)

This concludes the field tour. We will return to Flagstaff along U.S. Highway 1.90. Travel time back to the NAU campus is approximately 45 minutes.

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After lunch and the visit at Fort Valley, we Will return east on U.S. Highway 180 to Forest Road 516. We will then travel north on this road to the Fairfield Snowbowl Ski Area.

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Proceed east on Forest Road 514 approximately 1.5 miles to Stcp 5.

Stop #5 - ashy-skeletal over cindery, frigid Mollic Haplustands or Vitric Haplustands
(Stop time 60 minutes)

Depart stop X5
(Travel time: 45 minutes)

This concludes the field tour. We will return to Flagstaff along U.S. Highway 180. Travel time back to the NAU campus is approximately 45 minutes.

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Stop 1. Sunset Crater National Monument

sunset Crater and its associated lava flows. together with nearby scorla and agglutlnate cones, are the youngest volcanic features in the San Francisco volcanic field. The Sunset Crater volcanism is of interest not only from the view point of geology but from archeology as well because of its effects on the indigenous Indian population of northern Arizona (Pllles, 1979).

Geology: Volcanlc deposits formed during the Sunset Crater eruptlon include the scoria cone of Sunset Crater, two basalt lava flows that extruded from Its base, three rows of small scoria and agglutlnate cones east- southeast of Sunset Crater, a basaltlc lava flow from a vent (vent 512) about 10 km east- southeast of the crater, and a tephra blanket that originally covered over 2080 km^2 (Colton, 1932; Moore and wolfe, 1976).

The eruptlon history of sunset Crater has been reviewed and summarized by Holm and Moore (1987) as follows: The eruptlon began between the growing seasons of A.D. 1064 and 1065 and continued. probably intermittently, for about 150 years. During this tlme about 0.3 km’ of magma was erupted from the vent area at Sunset Crater. Approxlmately three-fourths of the magma erupted explosively as scorla and was deposited in nearly equal amounts In the scorla cone of Sunset Crater and the tephra blanket: about one-fourth of the magma was extruded as lava. with nearly three-fourths of the lava contrlbuted to the Bonita flow, a basalt flow along the western to northwestern base of Sunset Crater.

Elemental and mineralogical (model) analysis of a sample of basalt from Bonita lava flow are glven In Table 2.

Cllmate: The climatic conditions for the Sunset Crater area are presented In Flgure 3.

Vegetatlon: With the eruptions of Sunset Crater vegetatlon was completely destroyed for a dlstance of at least 3 km In all dlrections from the base of the cone (Eggler, 1965). Because soll formatlon on the Sunset Crater volcanic materlals hns not progressed very far the vegetatlon Is generally rather sparse. The best developed vegetation on Sunset Crater occurs on the lower half of the north slope consisting mostly of ponderosa pine with lesser amounts of limber and pinyon pine (Eggler, 1965). The other aspects of the cone have scattered trees where there are depressions which favor snow accumulation In winter and protect young plants against desiccating winds. Stands of ponderosa pine are common on the tephra in the level areas beyond the base of the cone. Lava flows have even more restricted plant growth than the cone with crustose lichens forming a thin cover over a part of the bare surface In some areas. Vascular plants are restricted to those parts of flows where there is an accumulation of eollan material.

Soil Formation: The coal and relatively dry climate has resulted only in incipient soil formation. Typic Ustorthents are the domlnant soils present in the Sunset Crater tephra. Soil formation has not progressed far enough for the soils to have developed andlc properties to the extent that they would be classified as Andisols. One exceptlon to thls Is the presence of a Vitrandic Haploboroll formed from tephra deposited on the north slope near the top of O'Leary Peak to the north of Sunset Crater. The thickness of the original tephra and the subsequent andic soil material was too thin to qualify as an Andisol. Thls higher elevation soil contains a mixed conifer vegetation. The basalt flows except where covered by tephra and/or other eollan material lack soils.

Table 2. Elemental and mineral (model) data for Bonlta lava flow from (Holm, 1986).

SiO_2	TiO_2	Al_2O	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
48.67	1.93	14.54	1.77	9.21	0.19	8.78	10.32	3.33	0.81	0.44

Plagioclase	Olivine	Climopyrxene	Magnetite	Groundmass
42.7	32.7	12.6	12.0	65.8

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STOP 2. FRANCIS CRATER

The soil at this stop, tentatively classified as a medial. mesic Mollic Durustand, has a duripan as its most characteristic feature.

This soil occurs on nearly level to gently sloping elevated plains. The Parent materials are derived from basalt pyroclastic sheet deposits of ash and cinders of Quaternary age and consist of tephra and non-volcanic eolian material (dust) deposited on a basalt flow. The Climatic data for Leupp (figure 4) although a little drier and warmer approximates the climate of the site. The laboratory characterization data are presented in Table 3. followed by the pedon and vegetation descriptions. This soil is in complex with medial. mesic Mollic Haplustands.

Bouteloua gracilis.

If this site were an edaphic climax it would be characterized by vegetation of the subseries Pinus edulis (pinyon pine), Juniperus monosoerma (one-seed juniper) and Bouteloua gracilis (blue grama). Currently, this subseries is an edaphic-rootic disclimax. Mean annual precipitation is 40 centimeters (16 inches), mean annual air temperature is 9 degrees Celsius (46 degrees Fahrenheit), mean elevation is 1900 meters (6200 feet). Approximately 40 percent of the annual precipitation occurs during the periods of 01 October to 31 March.

Ground cover consists mainly of graminoida with Bouteloua gracilis and Hilaria jamesii (galleta) being the most common. Other graminoids that may be present are Bouteloua curtiopendula (sideoats grama), Aristida spp. (three-awn) and Sitanium hystrix (bottlebrush squirreltail). Forbs that may be present are Sphaeralcea spp. (globemallow), Hvmenoxvs richardsonii (bitterweed), Mirabilis multiflora (four o'clock), Astragalus spp. (locoweed) and Lotus wrightii (Wright deervetchb Shrubs that may be present include Chrysothamnus nauseosus (rubber rabbitbrush), Chrysothamnus depressus (dwarf rabbitbrush), Opuntia whipplei (Whipple cholla) and Yucca elata (soaptree yucca).

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Table 3. Laboratory characterization of the Mollic Durustand.

Hor	Depth cm	>2mm %	Sand	Silt	Clay	Org C	N	C:N	pH H_2O	pH $CaCl_2$	Ca	Mg	Na	K	CEC	Base Sat %
			% of fine earth								cmol (+) per kg					
A	0- 5	15.8	61.7	29.2	9.1	0.94	0.072	13.1	7.48	6.35	5.7	1.9	Tr	1.4	7.3	100
BA	5- 20	8.5	41.3	39.2	19.5	0.86	0.078	11.0	8.17	7.26	9.9	4.6	0.10	1.5	16.2	99
Bw	20- 37	14.3	24.0	41.7	34.3	0.82	0.082	10.0	8.38	7.63	14.0	6.3	0.42	0.60	23.0	93
Bk1	37- 58	29.8	30.0	31.4	38.6	0.70	0.073	9.6	8.94	8.15	10.6	8.1	2.1	0.42	20.4	100
Bk2	58- 81	69.6	28.1	27.4	44.5	0.72	0.053	13.6	8.91	8.18	8.6	8.5	5.0	0.15	20.3	100
Bqkm	81-107	----	----	----	----	----	-----	----	----	----	----	---	---	----	----	---
C	107+	68.7	54.6	17.6	27.8	0.14	n.d.	----	9.23	8.31	9.0	8.5	4.0	0.082	20.5	100

Hor	Al_p[1]	Fe_p	Al_o	Fe_o	Si_o	Al_d	Fe_d	$Al_o + 0.5 Fe_o$	$(Al_o - Al_p)/Si_o$ atomic ratio	P-Retention %
	% of fine earth									
A	0.096	0.048	0.97	1.33	0.48	0.27	0.99	1.66	1.89	13.5
8.4	0.071	0.042	1.30	1.55	0.69	0.39	1.36	2.08	1.85	22.0
Bw	G.15	0.057	1.01	1.33	0.42	0.47	1.86	1.68	2.13	27.0
Bk1	0.050	0.017	1.16	1.19	0.47	0.57	1.30	1.76	2.46	71.7
Bk2	0.026	0.01'	0.35	0.16	0.16	0.25	0.72	0.43	2.11	80.9
Bqkm	....	....	...	----	----	----	....	..	----	----
C	0.010	0.017	0.64	0.32	0.19	0.37	1.20	0.80	3.45	30.6

Al_p and Fe_p = pyrophosphate extractable Al and Fe; Al_o, Fe_o, Si_o = oxalate extractable Al, Fe and Si; Al_d, Fe_d = dithionite - citrate extractable Fe and Al.

Hor	Sm[2]	V	C	M	K	Q	F
A	3[3]	1	0	2	2	1	1
BA	3+	1	0	2	2	2	1
Bw	3+	1	0	2	2	1	1
Bk1	3+	1	0	1	2	2	1
Bk2	3+	1	0	1	1	2	1
Bqkm	-	-	-	-	-	-	-
C	3	0	0	2	2	2	1

[2] Sm = smectite, V = vermiculite, C = chlorite, M = mica, K = kaolinite, Q = quartz and F = feldspar
[3] 0 = not detected, 1 = trace quantities, 2 = small quantities, 3 = medium quantities, 4 = large quantities

Unit Soil: 444 Xollic Durustand --- medial mesic	Phase : mod. deep, cl-sl Climax : Edaphic-zootic Surface rock : Class 1 Erosion : Class 1 Rock outcrop : Class 1 Drainage : Class 3 Surf. runoff : Medium O.M. : 3 % MAP : 35.	Slope gradient : 1% Slope complexity : Simple Shape contour : Linear Shape slope : Linear Slope length : 20 m Slope aspect : 70 ° Position/slope : BT Soil temp. @ --- cm ---°C
Veg : Bogr2 By : BB/TE Photo : 346-342 Date : 10/27/88 Stop : P1 T : 22N State : AZ R : 10E Cou. : Coconino Sec. : NE,SW 28 For. : Coconino Elev : 1830 m Dist. : Peaks	P.M.: Residuum from basaltic cinders & ash Gf. : Elevated plain Fm : Qbbp - Basalt pyroclastic sheet deposit	

Horizon/Layer Symb.	Depth Thick cm	Bound	Text. USDA Clay (%)	%Frag g. c. s. b. %/Vol.	Soil Color p/d c/d p/m r/m	Struct Gr. Si. Sh.	Surf Fe. Am. Dis. Ki. Loc.	Consis. St. d/m P. S.	Pores Si. Qu. Sh.	Roots Si. Qu. Lo.	Reac. pH CaCO3 Eff.	Accessory Property (ie. Conc., Pres.face)
A	0-5	as	cl sl 8	20 0 0 0	10YR3/3 10YR5/3 10YR3/3 10YR3/3	w f gr --- ---	--- --- ---	lo lo sp ss ---	vf m i ---	vf,f f --- ---	7.0 ne	---
B1	5-20	cs	--- sl 19	5 0 0 0	10YR4/3 10YR4/3 10YR3/2 10YR3/2	w f,m gr --- ---	--- --- ---	so vfr sp ss ---	vf,f c t ---	vf,f f --- ---	7.0 ne	---
Bw	20-37	gs	--- l 27	10 0 0 0	7.5YR4/4 7.5YR4/4 7.5YR3/2 7.5YR3/2	m m,c sbk --- ---	--- --- ---	sh fr sp ss ---	vf,f c t ---	vf,f f --- ---	7.4 ne	---
Bk1	37-58	as	--- scl 24	10 0 0 0	10YR6/3 10YR6/3 10YR4/4 10YR4/4	m m,c sbk --- ---	--- --- ---	h fr sp ss ---	vf,f c t ---	vf,f f --- ---	7.6 ve	---
Bk2	58-81	as	cl sl 10	40 20 5 0	10YR6/2 10YR6/2 10YR5/3 10YR5/3	--- --- mass --- ---	--- --- ---	lo lo sp ss ---	vf c i ---	vf,f c --- ---	8.0 ve	CaCO3 on top & SiO2 pend. under rfs.
Bkqm	81-87	---	--- --- ---	-- -- -- --	--- --- --- ---	--- --- mass --- ---	--- --- ---	--- ---	--- ---	--- ---	8.0 ve	Extremely hard [illegible]
C	87-149	---	cl sl [illegible]	50 -- -- --	[illegible] [illegible] 10YR5/4 10YR5/4	--- --- mass --- ---	--- --- ---	[illegible] [illegible] sp ss ---	[illegible] ---	[illegible] --- ---	[illegible]	---

Notes: Pedon sampled for analysis of [illegible] properties on 5/13/93 by [illegible] and [illegible]. [illegible] horizons. [illegible] were taken from A, B1, Bw, and Bkqm horizons. pH [illegible] 5.4 - 6.2[illegible]. [illegible] 10% [illegible].

R3-FS-2500-6 (10/91)

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Map Symb: 444

VEGETATION

Trees	%CC	Shrubs	%CC	Forbs	%CC	Graminoids	%CC
Juno	T	Yuel	T	Saka	1	Bogr2	3
—	---	Chna2	6	SPHAE	1.5	ARIST	1
---	—	Chde2	1	ERIGE	P	Rija	8
---	—	Opwh	P	ASTRA	0.5	—	—
—	—	Rhtr	P	—	—	—	---
---	---	—	—	---	—	—	—
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Notes

Ecosystem is a converted piayoo-juniper woodland and according to Forest Plan objectives will be maintained as a seral grassland. Site has a history of heavy grazing as indicated by low canopy cover oi graminoids and forbs.

Surface Component

category	%
Graminoid (BA)	4
Pcrb (BA)	T
Tree/Shrub (BA)	1
titter () 2.5 cm)	5
Gravel 1.2-2 cm	15
Gravel (2-7.5 cm)	10
Cobble (7.5-25 cm)	T
stone (25-60 cm)	?
Boulder (> 60 cm)	0
Rock outcrop	0
Bare roll	65
Cryptogams	0
% Overstory cover	5

Forest

Species:	---	---	---	---	---	---
Height :	---	---	---	---	---	---
Age :	---	---	---	---	---	---
SI :	---	——	——		. .	---
Avg. SI		---				

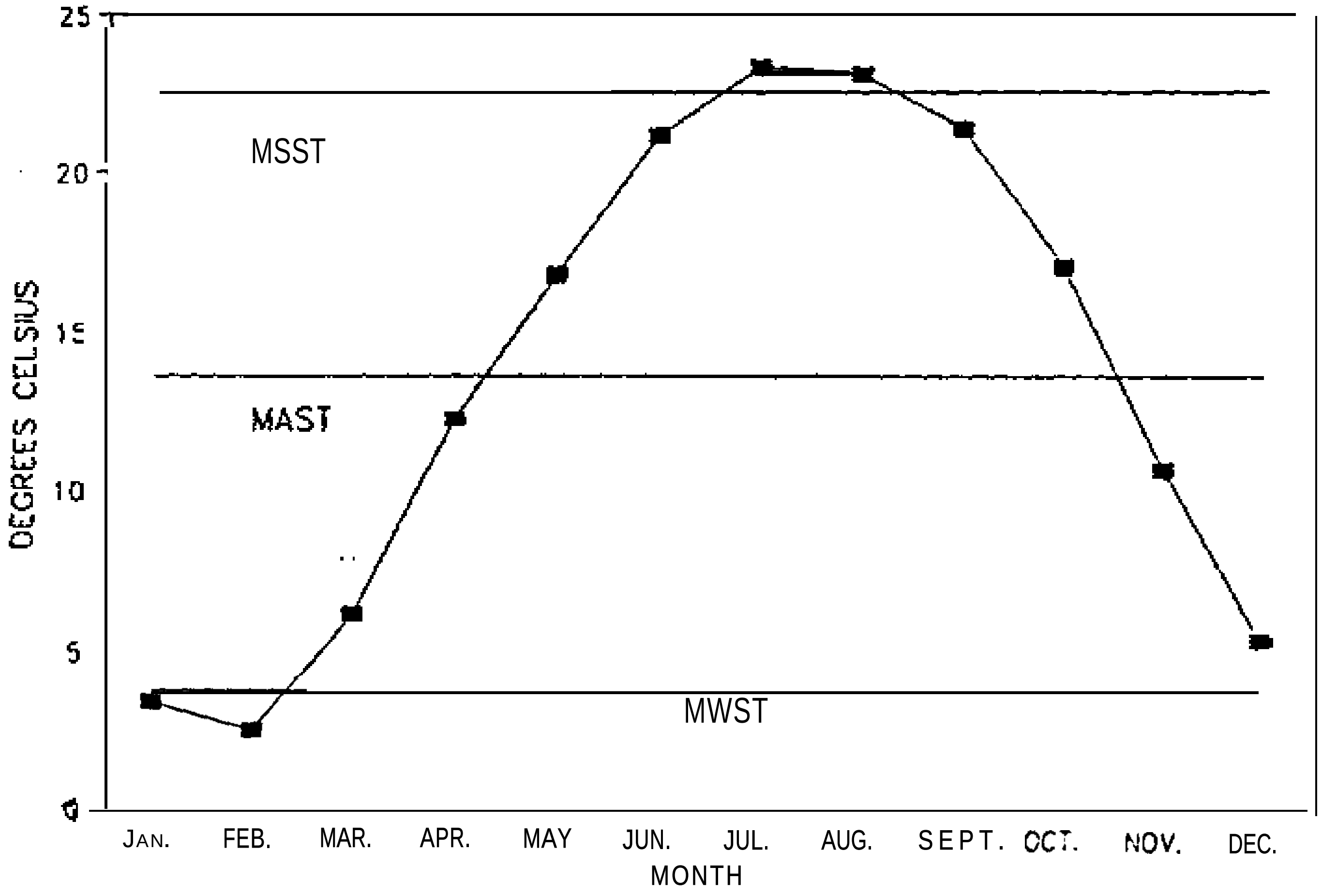
Species:	---	---	---	---	---
Height :	---	---	---	--	--
Age :	---	---	---	---	--
SI :	---	---	---	---	--
Avg. SI		---			---

Woodland

Less than 1 cord/acre.

Pinyon Pine/One Seed Juniper

MEAN MONTHLY SOIL TEMPERATURES 1990-91



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Pinyon pine - One-seed juniper
Soil Temperature Study

January 1.1990 to December 31, 1991

Elevation 1841 meters (6038 feet)
Precipitation 41 centimeters (16 inches)

	Mean Monthly Temp.	Standard Deviation
January	3.35	0.41
February	2.4')	0.38
March	6.14	1.91
April	12.21	1.89
May	16.73	1.68
June	21.13	1.64
July	23.32	0.82
August	23.08	0.59
September	21.36	1.19
October	17.01	1.58
November	10.61	1.68
December	5.40	0.93

MAST	Std. Dev.	MWST	Std. Dev.	MSST	Std. Dev.
13.57	7.56	3.77	1.34	22.51	1.24

MAST - Mean annual soil temperature
MWST . Mean winter soil temperature (December, January, February)
MSST - Mean summer soil temperature (June, July, August)

STOP 4. FAIRFIELD SNOWBOWL

The soil at this stop is classified as a loamy-skeletal. mixed, Pachic Cryoboroll.

This soil, located adjacent to the Fairfield Snow Bowl. occurs on strongly sloping summit plains and has formed in colluvium and alluvium from Agassiz Peak. The colluvial and alluvial Parent materials are derived from andesite of Quaternary age. No climatic data are available for this site. The laboratory data are presented in Table 4, followed by the pedon and vegetation descriptions. This soil is in complex with loamy-skeletal. mixed. Argic Cryoborolls.

Picea engelmannii/Abies lasiocarpa arizonica/Populus tremuloides.

This subseries is characterized by mixed stands of Picea engelmannii (Engelmann spruce), Abies lasiocarpa aritonica (corkbark fir) and Populus tremuloides (quaking aspen). The absence of Pseudotsuaa menziesii glauca (Douglas fir) and Abies concolor (white fir) helps distinguish this from similar subseries. Mean annual precipitation76 centimeters (30 inches), mean annual air temperature is 1 degree Celsius (34 degrees Fahrenheit), mean elevation is 3000 meters (9800 feet), mean annual snowfall is 160 centimeters (71 inches) and mean annual snow accumulation is 120 centimeters (47 inches). Approximately 50 percent of the annual precipitation occurs during the months of 01 October to 30 March.

Understory is mostly an herbaceous ground cover with a 5 to 15 centimeter thick layer of litter. The understory may contain Berberis repens (Oregon grape), Ribes montiqenum (gooseberry currant), Symphoricarpos oreophilus (mountain snowberry), Erigeron superbus (showy fleabane), Senecio spp. (groundsel), Smilacina stellata (starry Solomon's seal),, Swertia radiata (elkweed). Lathyrus arizonicus (Arizona peavine), Geranium richardsonii (Richardson geranium), Helenium hoopesii (orange sneezeweed), Viola canadensis (Canada violet) and Thalictrum fendleri (Fendler meadow rue). There is very sparse grass cover but it includes Carex spp. (sedge). and Bromus ciliatus (fringed brome). At lower elevations Pseudotsuqa menziesii glauca and Abies concolor may be present.

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Table 4. Laboratory characterization of the Pachic Cryobo: oll.

Hor	Depth cm	>2mm %	Sand	Silt	Clay	Org C	N	C:N	pH H_2O	pH $CaCl_2$	Ca	Mg	Na	K	CEC	Base Sat %
			% of fine earth								cmol (+) per kg					
A1 A2	12-0-3312	24.2 28.2	25.8 2t.2	49.1 50.3	25.1 25.5	3.70 2.84	0.27 0.22	13.7 12.9	5.36 5.50	4.86 4.66	8.6 6.9	2.6 2.4	0.27 0.27	1.3 1.4	20.0 18.1	64 61
A3	33- 59	28.1	2t.a	56.0	19.2	2.46	0.20	12.3	5.62	5.02	8.0	2.0	0.32	0.86	17.3	65
AB	59- 83	31.0	2P.B	51.4	18.2	1.70	0.12	14.2	5.71	5.13	6.1	1.7	0.32	1.2	14.4	65
Bt1	83- 96	26.4	31.P	48.7	19.4	0.76	0.055	13.8	5.83	5.30	5.2	1.8	0.35	1.1	11.5	73
Bt2	96-102	40.4	33.1	45.2	21.7	0.68	0.043	15.8	6.19	5.45	5.4	2.1	0.33	0.88	11.3	77

Hor	Al_p [1]	Fe_p	Al_o	Fe_o	Si_o	Al_d	Fe_d	$Al_o + 0.5\ Fe_o$	$(Al_o - Al_p)/Si_o$ atomic ratio	P-Retention %
	% of fine earth									
A1	0.88	0.29	0.93	1.78	0.28	1.23	4.38	1.82	0.19	62.9
A2	0.78	0.25	0.90	1.69	0.28	1.10	4.34	1.75	0.45	66.6
A3	0.84	0.25	1.00	1.85	0.34	1.12	4.48	1.93	0.49	69.0
AB	0.48	0.16	0.89	2.23	0.43	0.86	4.24	2.01	0.99	62.9
Bt1	0.15	0.058	0.45	2.20	0.41	0.35	4.17	1.55	0.76	44.2
Bt2	0.13	0.040	0.36	1.52	0.30	0.45	3.70	1.12	0.80	40.5

[1] Al_p and Fe_p = pyrophosphate extractable Al and Fe; Al_o and Fe_o, Si_o = oxalate extractable Al, Fe and Si; Al_d and Fe_d = dithionite - citrate extractable Fe and Al.

Hor	Sm [2]	V	C	M	K + H	Q	F
A1	2 [3]	1	0	1	2	1	1
A2	2	1	0	1	2	1	1
A3	1	2	0	1	2	1	1
BA	2	1	0	1	2+	1	1
Bt1	1	1	0	1	3	1	2
Bt2	1	1	0	1	3	1	2

[2] Sm = smectite, V = vermiculite, C = chlorite, M = mica, K + H = kaolinite + halloysite, Q = quartz and Fe = feldspar
[3] 0 = not detected, 1 = trace quantities, 2 = small quantities, 3 = medium quantities, 4 = large quantities

mCat Soil: Pachic Cryoboroll --- --- 740 loamy-skeletal mixed ---	Phase : deep, loam Climax : Edaphic Surface rock : Class 2 Erosion : Class 1 Rock outcrop : Class 1 Drainage : Class 3 Surf. runoff : Medium O.M. : 1.5 %	Slope gradient : 10% Slope complexity : Simple Shape contour : Convex Shape slope : Linear Slope length : 10 m Slope aspect : 260° Position/slope : Lower1/3 Soil temp. @ 50. cm 1.°C
Veg : Ablaa/Pien/Potr5 By : GK/KS Photo : 586-112 Date : 05/08/91 Stop : 71 T : 23N State : AZ R : 66 Cou. : Coconino Sec. : NW,SE 36 For. : Coconino Elev : 2877 m Dirt. : Peaks	P.M.: Colluvium and alluvium from andesite Lt. : Summit plain Fm : Quaternary gravels	

Horizon/Layer Symb.	Depth Thick cm	Boun	Text. USDA Clay (%)	RkFrg g. c. s. b. %/Vol.	Soil Color d/d c/d m/m r/m	Struct Gr. Si. Sh.	Surf Fe. Am. Dis. Ki. Loc.	Consis. St. d/m P. S.	Pores Si. Qu. Sh.	Roots Si. Qu. Lo.	Reac. pH CaCO3 Eff.	Accessory Property (ie. Conc., Pres.face)
Oi	8-5	---	--- ---	-- -- -- --	--- --- --- ---	--- --- --- --- ---	--- --- ---	--- --- ---	--- --- ---	--- --- ---	--- ---	Potr5 leaves & Ablaa & Pien needles
Oe	5-0	---	--- --- ---	-- -- -- --	--- --- --- ---	--- --- --- --- ---	--- --- ---	--- --- ---	--- --- ---	--- --- ---	--- ---	Highly decomp. leaves & needles
A1	0-12	cw	--- l 18	10 0 0 0	10YR4/3 10YR4/3 7.5YR3/3 7.5YR3/2	m f,m gr --- ---	--- --- ---	so vfr np ns ---	it c irr ---	vf,f m m m c c	6.0 ne	Krotovinas present
A2	12-33	cs	gr l 14	50 5 0 0	7.5YR3/3 7.5YR3/2 7.5YR3/2 7.5YR3/2	m m gr --- ---	--- --- ---	so vfr np ns ---	vf,f c irr ---	vf,f m m m c f	6.0 ne	Krotovinas and worm casts present
A3	33-59	cs	cbr l 16	10 20 5 0	7.5YR4/2 7.5YR4/2 7.5YR3/2 7.5YR3/2	m m gr --- ---	--- --- ---	so vfr np ss ---	f c t ---	vf,f m m,c c ---	6.2 ne	Krotovinas and worm casts present
AB	59-83	cw	cb l 16	15 35 0 0	7.5YR4/2 7.5YR4/2 7.5YR3/2 7.5YR3/2	m m sbk --- ---	--- --- ---	so vfr ss ss ---	f c t ---	vf,f m m m c c	6.4 ne	---
Bw1	83-96	cs	cbs scl 25	20 35 5 0	7.5YR5/2 7.5YR5/2 7.5YR4/2 7.5YR4/2	m f,m sbk --- ---	c f cs pf ---	sh fr ss ss ---	f,m c t ---	f,m c --- ---	6.4 ne	
Bw2	96-112	cw	cbr scl 21	30 25 15 0	7.5YR5/2 7.5YR5/2 7.5YR3/2 7.5YR3/2	m m sbk --- ---	c f cs pf ---	sh fr ss ss ---	vf,f c t ---	f f --- ---	6.2 ne	---
C	112-125	---	cbs sl 18	35 35 15 0	7.5YR5/2 7.5YR5/2 7.5YR3/2 7.5YR3/2	--- --- Massive --- ---	--- --- ---	sh fr ss ss ---	f c irr ---	f f --- ---	6.5 ne	---

Notes: Colors of A1 and A2 are mottled, 7.5YR3/2 and 7.5YR3/4, mostly due to burrowing animals., pH indicates noncalcareous ...

Map Symb: 740

VEGETATION

Trees	%CC	Shrubs	%CC	Forbs	%CC	Graminoids	%CC
Pien	3	Rimo2	P	Agch	T	CAREX	0.5
Ablaa	65	---	---	Geri	1	Brci	T
Potr5	20	---	---	Heho5	0.1	---	---
Pifl	P	---	---	Irmi	P	---	---
---	---	---	---	Laar6	2	---	---
---	---	---	---	LUPIN	P	---	---
---	---	---	---	Mefr	0.1	---	---
---	---	---	---	Psmo	0.2	---	---
---	---	---	---	SENEC	T	---	---
---	---	---	---	Smst	P	---	---
---	---	---	---	Swra	0.2	---	---
---	---	---	---	Thfc	P	---	---
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Notes

When this site was described, rost of the area was snow covered. Only a small amount of ground vegetation and surface rock was visible, and estimates were made from these observations. Layering of trees account for the higher total canopy cover. Site was re-visited on 6/11/91. Several forbr were identified tbat were not included on original list.

Surface Component

category	%
Graminoid (BA)	T
Forb (BA)	T
Tree/Shrub (BA)	10
Litter (> 2.5 cm)	95
Gravel (.2-2 cm)	0
Gravel (2-7.5 cm)	2
Cobble (7.5-25 cm)	0
Stone (25-60 cm)	0
Boulder (> 60 cm)	5
Rock outcrop	0
Bare soil	0
Cryptogams	T

% Overstory cover: 90.

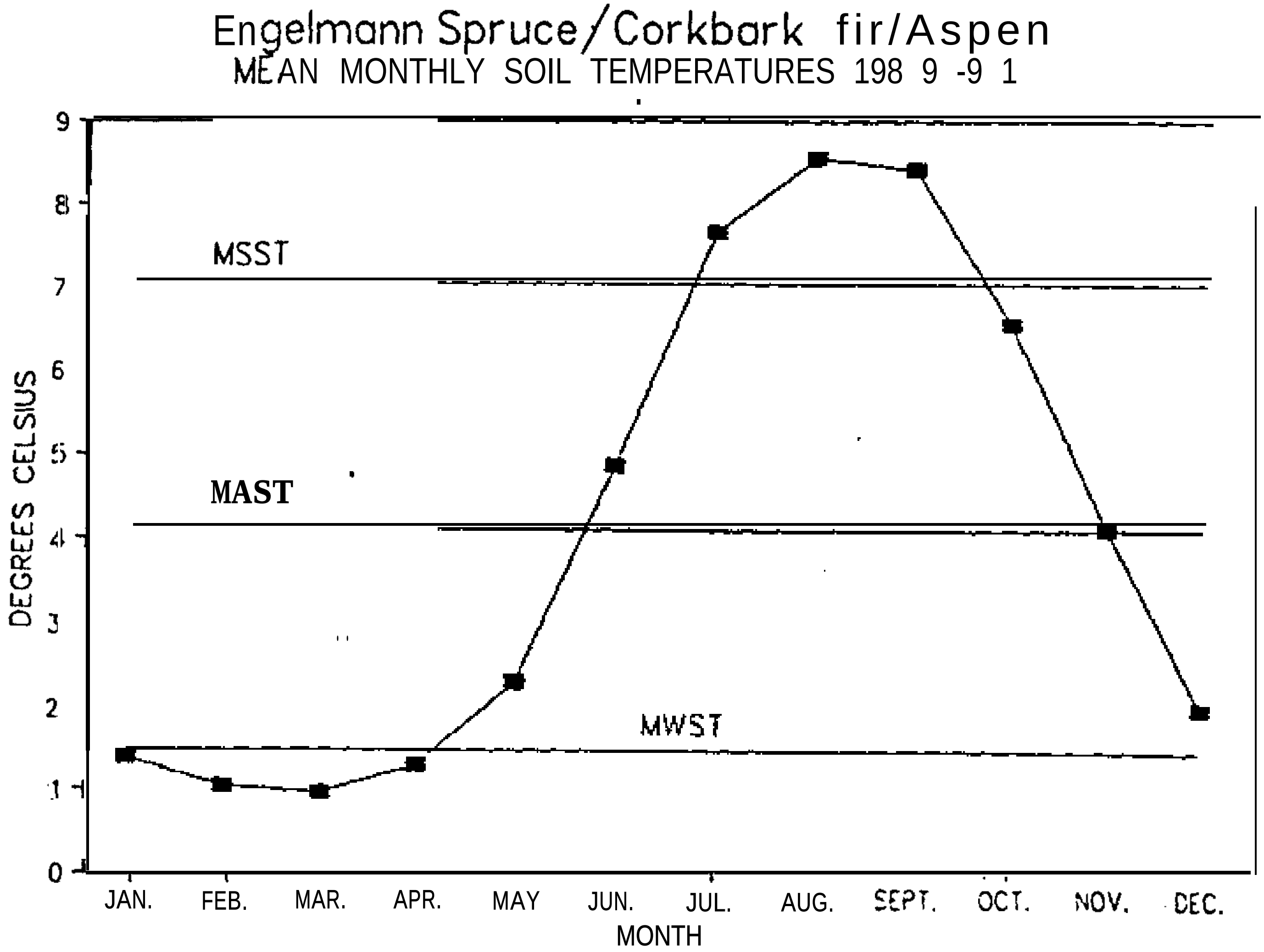
Forest

Species:	Potr5	---	---	---	---	---
Height :	70.	---	---	---	---	---
Age :	115.	---	---	---	---	---
SI :	60.	---	---	---	---	---
Avg. SI	---				---	

Species:	---	---	---	---		
Height :	---	---	---	---	---	---
Age :	---	---	---	---		
SI :	---	---	---	---	---	---
Avg. SI	---					

Woodland

Not applicable on this site.


Engelmann Spruce/Corkbark fir/Aspen
MEAN MONTHLY SOIL TEMPERATURES 198 9 -9 1
MSST
MAST
MWST
DEGREES CELSIUS
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8
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JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEPT.
OCT.
NOV.
DEC.
MONTH

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Engelmann Spruce - **Corkbark** Fir - Quaking Aspen
Soil Temperature Study

January 1, 1989 to December 31, 1991

Elevation 2877 meters (9440 feet)
Precipitation 76 centimeters (30 inches)

	Mean Monthly Temp.	Standard Deviation
January	1.40	0.31
February	1.07	0.20
March	0.99	0.08
April	1.33	0.31
May	2.34	0.59
June	**4.89**	1.03
July	7.69	0.61
August	8.56	0.27
September	0.42	0.44
October	6.57	0.70
November	4.15	0.48
December	2.04	0.49

MAST	**Std. Dev.**	**MWST**	Std. Dev.	**MSST**	**Std. Dev.**
4.12	2.88	1.55	**0.53**	[illegible]5	1.71

MAST - **Mean annual soil** temperature
MWST - Mean winter **soil temperature (December,** January, February)
MSST - Mean summer soil temperature (June, **July**. August)

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STOP 5. KENDRICK PARK

The soil at this stop is tentatively classified as ashy-skeletal over cindery, frigid Mollic Haplustand or Vitric Haplustand (subgroup placement pending determination of 1500 kPa water retention).

This soil occurs on nearly level to gently sloping elevated plains and is formed in a pyroclastic sheet deposit of cinders and volcanic ash younger than 17,000 years (Wolfe et at.. 1987) in Kendrick Park. The cinders af this sheet deposit contain abundant microlites and microphenocrysts of plagioclase and scattered phenocrysts of clinopyroxene and olivine set in a glassy, vesicular groundmass. The climatic data for Fort Valley (Figure 2) approximate the climate of this site. Laboratory data, are given in Table 5. followed by the pedon and vegetation descriptions.

Festuca arizonica/Muhlenbergia montana.

If this site were an edaphic climax it would be characterized by the Pinus ponderosa (Ponderosa pine) and Festuca arizonica (Arizona fescue) habitat type. Currently, this subseries is an edaphic-fire disclimax. It occurs in areas with a history of intensive grazing. Graminoids are abundant and diverse. Mean annual precipitation is 55 centimeters (22 inches). mean annual air temperature is 6 degrees Celsius (43 degrees Fahrenheit). mean elevation is 2200 meters (7200 feet), mean annual snowfall is 120 centimeters (47 inches) and mean annual snow accumulation is 35 centimeters (14 inches). Approximately 55 percent of the annual precipitation occurs during the periods of 01 October lo 31 March.

Graminoids consist mainly of Festuca arizonica, Muhlenberaia montana (mountain muhly), Poa pratensis (Kentucky bluegrass), Blepharoneuron tricholepis (pine dropseed), Carex spp. (sedge), Koeleria pyramidata (Junegrass), Muhlenbergia wrightii (spike muhly), Sitanion hystrix (bottlebrush squirreltail), Agropyron smithii (western wheatgrass) and Bromus anomalus (nodding brome). Forbs that may be present are Achillea millefolium lanulosa (western yarrow), Artemisia frigida (fringed sagebrush), Lupinus argenteus (silvery lupine). Antennaria rosea (pussytoes). Lathyrus arizonica (Arizona peavine). Oxytropis lambertii (Lambert locoweed), Geranium caespitosum (purple geranium). Eriogonum racemosum (redroot wild buckwheat). Erigeron speciosus (Oregon fleabane), Hymenoxvs richardsonii (bitterweed), Verbascum thapsus (mullein), Senecio spp. (groundsel), Penstemon spp. (beardtongue), Tragopogon dubius (salsify) and Gutierrezia sarothrae (broom snakeweed). Shrubs are generally absent.

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Table 5. Laboratory Characterization of the Mollic Haplustand (or Vitric Haplustand)

Hor	Depth cm	>2mm %	Sand	Silt	Clay	Org C	N	C:N	pH H_2O	pH $CaCl_2$	Ca	Mg	Na	K	CEC	Base Sat %
			% of fine earth								cmol (+) per kg					
A1	0- 10	29.5	29.0	46.7	24.3	3.02	0.23	13.1	6.66	6.09	15.0	4.1	0.28	1.2	22.0	9.35
A2	10- 32	33.8	30.4	46.3	23.3	2.68	0.22	12.2	7.31	6.71	20.0	5.4	0.42	0.20	28.2	92.3
A3	32- 46	43.1	44.2	42.9	12.9	2.10	0.16	13.1	7.86	7.38	19.3	5.0	0.42	0.12	23.4	100
Bk	46- 55	50.5	47.7	41.7	10.6	1.51	0.11	13.7	7.98	7.54	16.0	4.9	0.39	0.15	21.5	100
2C1	55- 84	91.4	97.6	2.1	0.3	0.28	0.015	18.7	8.29	7.59	3.5	0.9	0.23	0.13	4.67	100
2C2	84-115	77.7	98.2	1.6	0.2	0.19	0.0083	22.9	8.12	7.21	1.8	0.6	0.17	0.083	2.92	91

Hor	Al_p[1]	Fe_p	Al_o	Fe_o	Si_o	Al_d	Fe_d	$Al_o + 0.5\ Fe_o$	$(Al_o + Al_p)/Si_o$ atomic ratio	P-Retention %
	% of fine earth									
A1	0.20	0.077	0.66	2.65	0.50	0.62	3.87	1.99	0.96	40.1
A2	0.26	0.067	1.13	2.85	0.80	0.92	4.48	2.56	1.13	57.1
A3	0.35	0.063	2.15	4.22	1.64	1.49	4.59	4.26	1.14	79.0
Bk	0.26	0.048	2.04	4.24	1.55	1.33	4.24	4.16	1.20	72.7
2C1	0.10	0.033	1.10	2.60	1.53	0.36	0.47	2.40	0.97	16.5
2C2	0.052	0.025	0.97	2.78	1.68	0.20	0.34	2.36	0.59	10.9

[1] Al_p and Fe_p = pyrophosphate extractable Al and Fe; Al_o, Fe_o, Si_o = oxalate extractable Al, Fe and Si; Al_d, Fe_d = dithionite - citrate extractable Fe and Al.

Hor	Sm[2]	V	C	M	K	Q	F
A1	2	0	0	2	2	1	1
A2	2	0	0	1	2	1	1
A3	1	0	0	1	2	1	1
Bk	1	0	0	0	1	1	1
2C1	1	0	0	0	1	1	1
2C2	0	0	0	0	1	0	1

[2] Sm = smectite, V = vermiculite, C = chlorite, M = mica, K = kaolinite, Q = quartz and F = feldspar
[3] 0 = not detected, 1 = trace quantities, 2 = small quantities, 3 = medium quantities, 4 = large quantities

MUat Soil: Mollic Haplustands --- --- 594 ashy-sk./cindery frigid	Phase : deep, cis-sandy loam Climax : Edaphic-fire Surface rock : Class 1 Erosion : Class 1 Rock outcrop : Class 1 Drainage : Class 2 Surf. runoff : V.Slow O.M. : 3 %	Slope gradient : 1% Slope complexity : Simple Shape contour : Linear Shape slope : Linear Slope length : 25 m Slope aspect : Nl ° Position/slope : Nl Soil temp. @ --- cm ---°C
Veg : Fear2/Muno By : 45/59 Date : 08/01/91 T : 24N R : 6E Sec. : SE,SE 35 Elev : 2401 m Photo : 584-84 Stop : Pt State : AZ Co. : Coconino For. : Coconino Dist. : Peaks	P.M.: Pyroclastic cinders and ash Lf. : Elevated plain Fm : Qbpb - pyroclastic sheet deposit	

Horizon/Layer Symb.	Depth Thick cm	Bound	Text. USDA Clay (%)	CfFrg g. c. s. b. %/Vol.	Soil Color p/d c/d p/m r/m	Struct Gr. Si. Sh.	Surf Fe. Am. Dis. Ii. Loc. P. S.	Consis. St. d/m	Pores Si. Sk.	Roots Qu. Si. Qu. to.	Reac. pH CaCO3 Eff.	Accessory Property (lit. Conc., Pres.face)
A1	0-10	as	ci sl 9	30 0 / 0 0	10YR5/3 10YR5/3 10YR3/1 10YR3/2	w f,c gr --- ---	--- --- ---	so wfr sp ns ---	vf,1 c t ---	vf,f c --- ---	7.4 ne	---
A2	10-32	cw	civ sl 11	45 0 / 0 0	10YR4/2 10YR4/2 10YR3/2 10YR3/2	w m sbkw f gr ---	--- --- ---	vso vfr sp ss ---	vf,f c t ---	vf,f c --- ---	7.6 ne	---
A3	32-46	cw	civ cosl 10	50 0 / 0 0	10YR4/3 10YR4/3 10YR3/2 10YR3/2	w m,f sbk --- ---	--- --- ---	vso vfr sp ns ---	vf,f f irr ---	vf c f f ---	8.0 ne	---
Bk	46-55	cw	cix lcos 4	60 0 / 0 0	10YR5/3 10YR5/3 10YR3/3 10YR3/3	w f sbkw f gr ---	--- --- ---	lo lo sp ns ---	--- --- ---	vf c f f ---	8.0 e	SiO2 & CaCO3 pend. on co. fragments
2C1	55-84	dw	cix vcos 0	90 0 / 0 0	10YR3/1 10YR3/1 10YR2/1 10YR2/1	--- --- SG --- ---	--- --- ---	lo lo po ps ---	--- --- ---	--- --- ---	8.2 ne	SiO2 & CaCO3 pend. on co. fragments
2C2	84-115+	---	cix vcos 0	90 0 / 0 0	10YR3/1 10YR3/1 10YR2/1 10YR2/1	--- --- SG --- ---	--- --- ---	lo lo po ps ---	--- --- ---	--- --- ---	7.8 ne	Pyrocl. cinder deposit finer than 2C1

Notes: The upper 55cm has ash influence and is contrasting to 2C horizons. This profile was used for a [illegible] of 1.

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Map Symb: 594

VEGETATION

Trees	%CC	Shrubs	%CC	Forbs	%CC	Graminoids	%CC
---	---	---	---	Acmil	0.5	Bltr	5
---	---	---	---	Anro3	T	Bogr2	P
---	---	---	---	Arfr4	0.2	BROMU	T
---	---	---	---	ASTRA	0.1	Fear2	5
---	---	---	---	ERIGE	T	Kopy	a
---	---	---	---	Gusa2	T	Muмo	30
---	---	---	---	Hyri	2	Siby	5
---	---	---	---	OXYTR	0.6	---	---
---	---	---	---	PENST	T	---	---
---	---	---	---	SENEC	0.2	---	---
---	---	---	---	TRAGO	T	---	---
---	---	---	---	Vetb	0.5	---	---
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Notes

Pear2 is much more abundant on S and SW side of plot and along lower lying area to N. Ecosystem is in a disclimax due to past wildfires and will be maintained in this seral stage for cattle grazing, according to Forest Plan. Habitat type for the edaphic situation is Pipos/Fear2.

Surface Component

Category	%
Graminoid (BA):	13
Forb (BA):	2
Tree/Shrub (BA):	0
Litter (> 2.5 cm):	10
Gravel (.2-2 cm):	30
Crawl (2-7.5 cm):	10
Cobble (7.5-25 cm):	0
Stone (25-60 cm):	0
Boulder (> 60 cm):	0
Rock outcrop :	0
Bare soil :	25
Cryptogams :	0
% Overstory cover :	0.

Forest

Species:	---	---	---	---	---	---
Height :	---	---	---	---	---	---
Age :	---	---	---	---	---	---
SI :	---	---	---	---	---	---
Avg. SI	---				---	
Species:	---	---	---	---	---	
Height :	---	---	---	---	---	---
Age :	---	---	---	---	---	---
SI :	---	---	---	---	---	---
Avg. SI					---	

Woodland

Not applicable.

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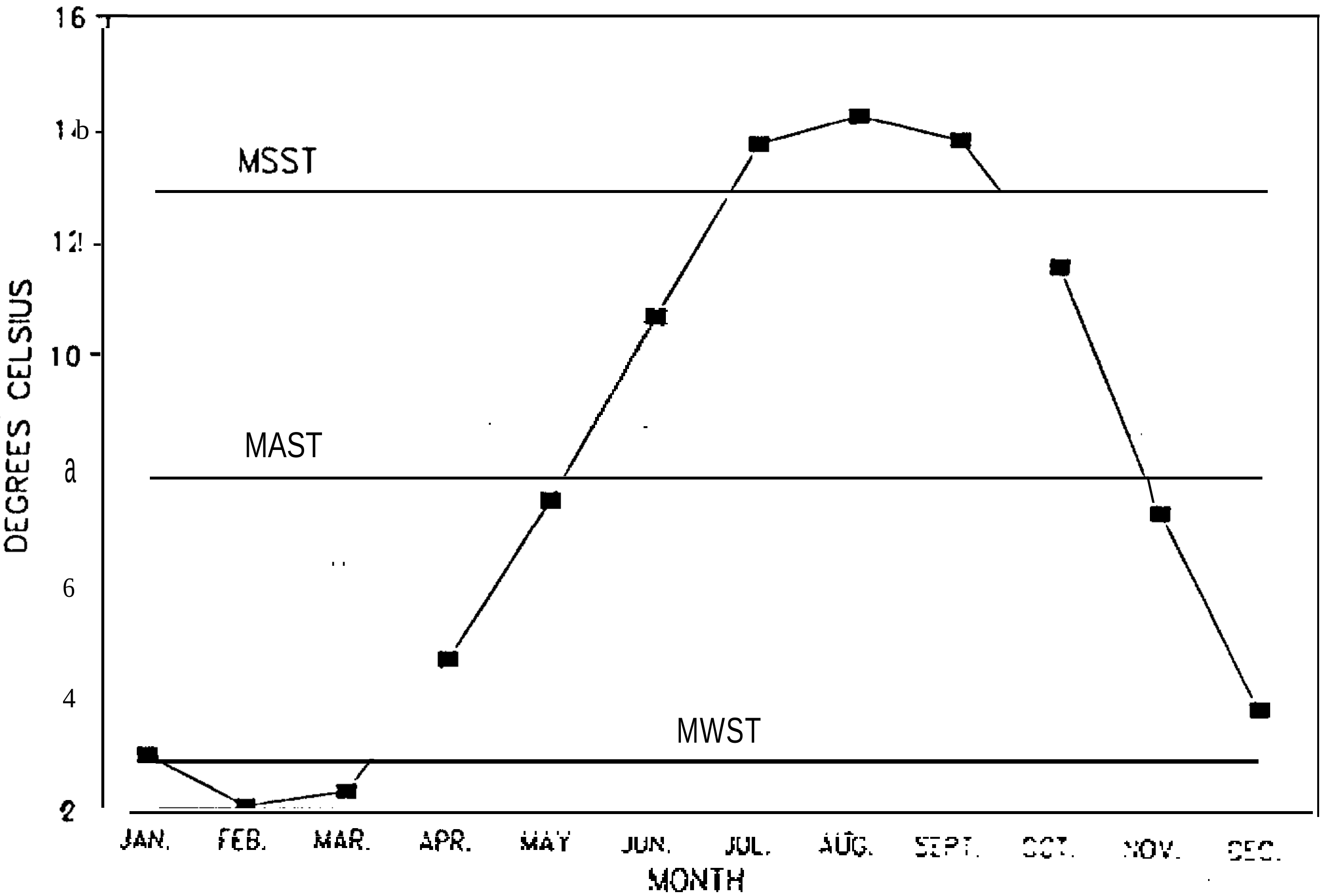
Ponderosa Pine/Gambel Oak
MEAN MONTHLY SOIL TEMPERATURES 1990-91



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Ponderosa Pine - Gambel Oak
Soil Temperature Study

January 1, 1990 to December 31, 1991

Elevation 2235 meters (6930 feet)
Precipitation 51 centimeters (20 inches)

	Mean Monthly Temp.	Standard Deviation
January	2.94	0.53
February	2.03	0.31
March	2.31	0.63
April	4.72	1.06
May	7.49	1.00
June	10.67	1.16
July	13.71	0.43
August	14.21	0.23
September	13.00	0.42
October	11.55	1.12
November	7.28	1.13
December	3.85	0.57

MAST	Std. Dev.	MWST	Std. Dev.	MSST	Std. Dev.
7.88	4.53	2.99	0.83	12.86	1.58

MAST - Mean annual soil temperature
MWST - Mean Winter soil temperature (December, January, February)
MSST - Mean summer soil temperature (June, July, August)

Appendix A - Andic Soil Properties

To have andic soil properties, the soil material must have less than 25 percent organic carbon and meet one or both of the following two requirements:

1. Either

   a. Acid-oxalata-extractable aluminum plus 1/2 acid-oxalate extractable iron is 2.0 percent or more in the less than 2.0 mm fraction, and

   b. Bulk density of the less than 2.0 mm fraction measured at 33 kPa water retention, is 0.90 g cm^{-3} or less, and

   c. Phosphate retention' of the less than 2.0 mm fraction is 85 percent or more; or

2. The less than 2.0 mm fraction has phosphate retention of more than 25 percent and the 0.02 - 2.0 mm fraction is at least 30 percent of the less than 2.0 mm fraction; and meets one of the following three requirements:

   a. The less than 2.0 mm fraction hae acid-oxalate-extractable aluminum plus 1.2 acid-oxelate-extractable iron of 0.40 percent or more, end there is et least 30 percent volcanic glass in the 0.02 - 2.0 mm *fraction, or*

   b. The less then 2.0 mm fraction has acid-oxalate-extractable aluminum plus 1/2 acid-oxalate-extractable iron of 2.0 *percent* or more, and there is at least 5 percent volcanic glass in the 0.02 - 2.0 mm fraction, or

   c. The less than 2.0 mm fraction has acid-oxalate-extractable aluminum plus 1/2 acid-oxalata-extractable iron of between 0.40 percent and 2.0 percent, and there is enough volcanic glass in the 0.02 - 2.0 mm fraction that the percentage of glass, when plotted against the percentage of glass, when plotted against the percentage of acid-oxalate-extractable aluminum plus 1/2 acid oxalate-extractable iron, gives a point within the shaded area of Figure 1.

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In this key and the other keys that follow, the diagnostic horizons and the properties mentioned do not include the properties of buried soils except their organic carbon if of Holocene age, andic soil properties, and base saturation. Properties of buried soils are considered in the categories of subgroups, families, and series but not in those of order, suborder, and great group. The meaning of the term "buried soil" is given in chapter 1.

A. Soils that either

1. Have organic soil materials that extend from the surface to one the following:

a. A depth within 10 cm or less of a lithic or paralithic contact, provided the thickness of the orgbinic soil materials is more than twice that of the mineral soil above the contact; or

b. Any depth if the organic soil material rests on fragmental material (gravel, stones, cobbles) and the interstices are filled with organic materials, or rests on a lithic or paralithic contact; or

2. Have organic materials that have an upper boundary within 40 cm of the *surface*, and

a. Have one of the following thicknesses:

(1) 60 cm or more if three-fourths or more of the volume is moss fibers or the moist bulk density is less than 0.1 per cubic centimeter (6.25 lbs per cubic); or

(2) 40 cm or more if

(a) The organic soil material is saturated with water for long periods (more than 6 months) or is artificially drained; and

(b) The organic material consists of sapric or hemic materials or consists of fibric materials that are less than three-fourths moss fibers by volume and have a moist bulk density of 0.1 or more; and

b. Have organic soil materials that

(1) Do not have a mineral layer as much as 40 cm thick either at the surface or whose upper boundary is within a depth of 40 an within the upper 80 cm from the surface; and

(2) Do not have mineral layers, taken cumulatively, as thick as 40 cm within the upper 80 cm; and

c. Do not have andic soil properties in layers 35 cm or more thick within a depth of 60 cm from the surface.

Histosols, p.225

B. Other soils that have andic soil properties throughout subhorizons whether buried or not, which have a cumulative thickness of 35 cm or more within 60 cm of the mineral soil surface or upper boundary of an organic layer that meets andic soil properties, whichever is shallower.

Andisols, p.129

Appendix B – Laboratory Methods

The following laboratory methods were used for the characterization of the three soils:

1. Particle size analysis. The fine earth was separated from the coarse fragments by sieving through a 2 mm sieve with the two separates being determined gravimetric. The coarse fragments of the soils of the two Andisols were further subdivided at 0.5 θ ($\theta = -\log_2 d$) intervals by sieving. The organic matter was removed from the fine earth with H_2O_2 and NaOAc buffer at pH 5. Dispersion was accomplished by a combination of ultrasonics and chemical treatment (either HCl or Na pyrophosphate) (Kanno and Arimura, 1967). Sand was separated from silt + clay by wet sieving. Clay was separated from silt by repeated centrifugation and decantation (Jackson. 1956) and determined gravimetrically. The sand separate was further fractionated at 0.6 θ intervals by sieving. The silt was also further fractionated at 0.5θ intervals by repeated gravity sedimentation and decantation using the appropriate settling time for each particle size separate based on Stokes' Law (Jackson, 1956). The separated fractions were measured gravimetrically.
2. Organic Carbon. The organic carbon was measured using a modified Mebius method (Yeomans and Bremner, 1966).
3. Nitrogen. The nitrogen content was determined using the conventional semi-micro Kjeldahl method (Bremner. 1965).
4. pH. The pH values were obtained in 1:2 soil:water and 1:2 soil:0.01 M $CaCl_2$ using a glass electrode pH meter.
6. Cation Exchange Capacity and Exchangeable Cations. The conventional ammonium acetate (pH 7.0) method was used to extract the exchangeable bases and determine the cation exchange capacity of the soils (Chapman, 1965). The extracted Ca^{2+} and Mg^{2+} were determined by atomic absorption and the Na^+ and K^+ by flame emission analysis. The NH_4 was determined following a semi-micro Kjeldahl distillation.
6. Pyrophosphate extractable Fe and Al. The extraction and determination of pyrophosphate Fe and Al followed that of McKeague (1967).
7. Ammonium Oxalate Extractable Fe, Al and Si. The ammonium oxalate extractions in the dark and the determinations of Fe and Al were carried out using the Procedure of

Schwertmann (1973). The extractable Si was determined specrrophotometrically (Weaver et al.. 1966).

8. Sodium Dithionite-Citrate Extraction. This extraction used the method of Holmgren (1967) as modified by Blakemore et al (1987).

9. Phosphorus Retention. The phosphorus retention was measured using the technique described by Blakemore et al (1987).

10. Clay Mineral Analysis. The clay mineral analysis was carried on the clay (<2 µm) by x-ray diffraction. Subsamples were saturated wlth Mg and with K and oriented mounts were prepared on glass slides (Theissen and Harward. 1962). X-ray scans were made of the Mg saturated samples following air drying and solvating wlth ethylene glycol and of the K-saturated samples following air drying and heating at 300^0 and 500^0C.

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Appendix C - Integration of Terrestrial Ecosystem Components

The complex interaction of climate, soil and vegetation gives rise to several different terrestrial ecosystems. The interrelationship between soil, climate and vegetation is depicted in the following diagram:

```
          CLIMATE
            /\
           /  \
          /    \
    SOIL <------> VEGETATION
```

The diagram indicates that soil and vegetation are influenced by climate and by each ocher. The product of these interactions is a terrestrial ecosystem (Jenny, 1958)

The three components of a terrestrial ecosystem can be arranged into a infinite number of combinations. Direct gradient analysis (Kessell, 1979) is used to integrate these components to a realistic number. The basis for the initial segmentation of the gradient into uniform segments is by soil moisture and temperature regimes. This results in the preliminary continuum. The correlation of indicator plants with the soil moisture-temperature regimes results in a further refinement of the segments. The final phase consists of integrating soil categories (<u>Soil Taxonomy</u>) to form individual terrestrial ecosystems. The resultant ordered alignment of terrestrial ecosystems is a continuum of climax categories of vegetation and their associated soils. These ecosystems are arranged sequentially in climatic columns numbered 1-8 along a gradient from hot-dry to cold-wet extremes. Within each climatic column ecosystems can be related to climax and disclimax classes. It is possible to move from climax to disclimax or vice-versa within limits indicated in the columns, but not between columns.

1	2	3	4	S	6	7	8	Descriptor		
								"SC		
								Climate		
		Vaughn	Mtn.	Air Flagstaff	Cloudcrof			NOAA Wx. Sta:		
		12	9	S	4	1	-3	MAAT	deg. C	0
		---	10	6	S	2	-2			-1
		11	8	5	3	0	---			+1
		---	---	3/16/21/7	3/15/20/6	0/10/17/3		AT 4 Se.	deg. C	0
		---	---							-1
		---	---							+1
		---	---	18/5	17/4	14/1		AT 2 Se.	deg.C	0
		---	---							-1
		---	---							+1
		---	---	2212	21/1	17/-1		AT S Se.	deg. C	0
		---	---							-1
		---	---							+1
		13	10(10)	6(6)	5(5)	2(2)	-2	MAST	deg. C	0
		---	11	7	6	3131	-1(-1)			-1
		12	9	6	4	1(2)	---			+1
		---		12	9	6	4	MSST	deg. C	0
		---		13	10	7	4			-1
				11	8	5	---			+1
		---	S	2	1	-1	-6	MWST	deg. C	0
		---	6	3	0	0	-5			-1
		7	4	2	0	-2				+1
		---	---	7	6	3	-2	MAST	deg. C 5 Disc.	0
		...	...							-1
		...	---							+1
		---	---	12	10	7	4	MSST	deg. C @ Disc.	0
		...	...							-1
		---	---							+1
		165	150(153)	120	90	60	30	FFP	no. days	0
		...	160	130	100	70	40			-1
		165	140	110	80	so	...			+1
		30	40	56	68	76	38	MAP	cm	3
		...	36	so	64	74	84			-1
		31	46	60	72	80	...			+1
		...	---	11/26/50/1515/14/53/1928/13/32/27				P 4 Se.	% of annual	
			.							-1
		..	...							+1
		..		75/25	67/33	45/55		P 2 Se.	% of annual	3
		.								-1
		.	---							+1
				57/15	62/19	40/35		P S.Se.	% of annual	0

1	2	3	4	5	6	7	8	Descriptor HSC		
		...	..							-1
		...	...							+1
		32	46	60	72	80				+1
		---	80	110	140	170	210	MAS	cm	0
		---	70	100	130	160	200			-1
		60	90	120	150	180				+1
		10P	10P	20P	50C	120C	15P	MASA	cm	0
		...	---	15P	35P	W C	15P			-1
			...	25P	70c	150C				+1
		1211	12/1	11/1	1111	10115	10115	SP	no.(s)	0
		4/1	4/1	3/1	4/1	5/15	6/1			
		...	...	12/1	1111	10/15	10115			-1
		---	...	3/1	3/1	5/1	6/1			
		...	...	11/1	10/15	10/15	...			+1
		---	...	(69)	(65)	(51)	(44)	aPET	cm	0
		...	--							-1
		...	...							+1
		...	(-32)	(-3)	(22)			H20 B	cm	0
		...	--							-1
		(-38)	...							+1
		40	40	45	50	50	50	MLSP	% of ann.	
		3.0	3.6	4.0	4.6	5.0	5.0	2yr 6hr	cm	
		1820	2100	2400	2700	3200	3800	ME	m	0
		1700	2000	2300	2600	3000	3600			-1
		1900	2200	2500	2800	3400				+1
		Ustic Mesic	Ustic Mesic	Ustic Frigid	Udic Frigid	Udic Cryic	Udic Perg.	SMR STR		
		Aridic Haplust.	Typic Haplust.	Typic Eutrobo.	Eutric Glossob.	Typic Cryobor.		Edaphic climax Soils		
		...	Pied (Jude2) (Juos) (Jumo)	Pipo Quga	Abco Psmeg Pipo Quga	Pien Ablaa PotrS		Vegetation		0
		...	(Juos) (Jumo)	Pipo Pied (Jude2) (Juos) (Jumo) (Quga) (Quun)	Psmeg Pipo Quga	Pien Ablaa Abco Psmeg				-1
		Hija BogrZ	Pied (Jude2) (Juos) (Jumo) (Quga) (Quun)	Pipo Quga	Abco Psmeg	Pien Ablaa				+1

List of Abbreviations for Direct Gradient Analysis Matrix

NOAA { }	National Oceanic and Atmospheric Adminstration-climatological data
Soil temp./moist. study [1	Long term soil temperature/moisture study (Forest I D number and location)
Data for modal site	Data not enclosed in { } or [ ] is predicted from from graphs etc. for modal site.
Climatic Type(Trewartha)	Classification according to Trewartha
MAAT deg. C	Mean annual air temperature
AT deg. C by 4 seasons	Air temp. by (Jan. Feb. Mar.)-(Apr. May June)-(July Aug. Sept.)-(Oct. Nov. Dec.)
AT deg. C by 2 seasons	Air temp. by (April-Sept.)-(Oct-Mar.)
AT deg. C by soil seasons	Air temp. by soil seasons (June-Aug.)-(Dec.-Feb.)
MAST deg. C @ 50 cm	Mean annual soil temperature
MSST deg. C @ 50 cm	Mean summer soil temperature (June-August)
MWST deg. C @ 50 cm	Mean winter soil temperature (Dec.-Feb.)
MAST deg. C @ 50 cm Disc	Mean annual soil temperature @ disclimax (Removal of overstory)
MSST deg. C @ 50 cm Disc	Mean summer soil temperature @ disclimax (Removal of overstory)
MWST deg. C @ 50 cm Disc	Mean winter soil temperature @ disclimax (Removal of overstory)
FFP no. days	Freeze free period
MAP cm	Mean annual precipitation
AP % of ann. by 4 seasons	Annual ppt. by (Jan. Feb. Mar.)-(Apr. May June)-(July Aug. Sept.)-(Oct. Nov. Dec.)
AP % of ann. by 2 seasons	Annual ppt. by (April-Sept.)-(Ott-Mar.)
AP % of ann. by soil seasons	Annual ppt. by soil seasons (June-Aug)-(Dec.-Feb.)
MAS cm	Mean annual snow
MASA cm	Mean annual snow accumulation
SP mo.(s)	Snow period
aPET cm	Adjusted potential evapo-transpiration
Water balance cm	Water balance
MLSP % Of Ann. (10/01-03-31)	Mean low sun precipitation as percent of annual
2 yr 6hr storm cm	Storm probability for USLE
ME m	Mean elevation
STR	Soil temperature regime
SMR	Soil moisture regime

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Business Meeting

- A short business meeting was held to discuss the location of the next Regional Cooperative Soil Survey Conference.

  Jim Culver reported the Midwest Region went on record at thier Regional Conference to hold a joint meeting with the West in 1994 - if the West was agreeable. Illinois is the host state for the Midwest in 1994 with the University of Illinois representative serving as Chair.

  Coeur D'Alene, Idaho was proposed with Bureau of Land Management (BLM) as Chair.

  Mark Jensen, US 3 and Gordon Decker, SCS proposed Bozeman, Montana.

  Carol Wettstein, SCS, proposed Colorado.

  A final decision on location was not made at this time.

- A recommendation was made that all committees should continue,

- Some discussion on the role of each cooperator in the NCSS program with respect to "Future Role of the Extension Service" took place. It was felt that this should be a topic at the 1994 conference.

  Mario Valverde, WNTC, made a motion, seconded by Tommie Parham, SSS, NM, to set up a committee with representatives from each cooperating agency. The steering committee will select the committee or panel.

NATIONAL COOPERATIVE SOIL SURVEY

Western Regional Conference Proceedings

Fairbanks, Alaska
June 17-22, 1990

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE
511 N. W. BROADWAY, RM. 248 PORTLAND, OREGON

PROCEEDINGS

FAIRBANKS, ALASKA

JUNE 1990

WESTERN REGIONAL SOIL SURVEY WORK PLANNING CONFERENCE
Fairbanks, Alaska
June 17 - 22, 1990
Theme -- "Influence of Climate on Soil Resource Inventorv and Management"

SUNDAY, June 17, 1990		M-B-S Complex Lobby, University of Alaska Fairbanks
	2:00 - 4:00 p.m.	Registration
MONDAY, June 18, 1990		Elvey Building Auditorium
	7:30 a.m.	Registration
	8:00 a.m.	Introduction and announcements Presiding: Chien-Lu Ping
	8:15 a.m.	Welcome and Opening Comments --James V. Drew, Dean, School of Agriculture and Land Resources Management, UAF, Fairbanks
	8:45 a.m.	Welcome and Opening Comments --Burton Clifford, State Conservationist, SCS, Anchorage
	9:00 a.m.	National Coooerative Soil Survev and its new Challenges' --Thomas Calhoun, Assistant Director, Soil Survey, SCS, Washington, D.C.
	9:30 a.m.	Low Input Sustained Agriculture (LISA) --Charles Smith, USDA-CSRS
	10:15 a.m.	(Break)
	10:45 a.m.	Concerns and Directions of Soil Interpretation --Gary Muckel. Head. Soils Staff., WNTC. SCS. Portland, OR.
	11:15 a.m.	Concerns in Soil Correlation --Jim Culver, Head, NSSQAS-NSSC, SCS, Lincoln, NE
	11.40 a.m.	Alternative Formats for Publishing Soil Survey Reports --Jim Culver, Head, NSSQAS-NSSC, SCS, Lincoln, NE
	12:00 noon	(Lunch) Presiding: Colin Voight
	1:30 p.m.	Methods and Procedures of Exploratory Soil Survey of Alaska --Sam Rieger, Retired Alaska State Soil Scientist, Seattle
	2:00 p.m.	Land Evaluation in Canada --Scott Smith, Agriculture Canada, Whitehorse, Yukon Territory, Canada

2:30 p.m.	Soil Inventory and Management in the Alaska Region --Earl Alexander, Regional Soil Scientist, Forest Service, Juneau, AK
3:00 p.m.	(Break)
3:30 p.m.	Climate and Terrain Challenges to Soil Survey in Alaska --Hayes Dye, State Soil Scientist, SCS, Anchorage, AK
4:00 p.m.	Soil Survey Through the Muskegs --Mark Clark, Party Leader, SCS, Palmer, AK

TUESDAY, June 19, 1990	Elvey Building Auditorium Presiding: Hayes C. Dye
8:00 a.m.	Global Climate Change and Forest Productivity --Keith Van Cleve, Professor, School of Agriculture and Land Resources Management, UAF, Fairbanks
8:30 a.m.	Alaska's Agriculture - Past and Future --Carol Lewis, Associate Professor, School of Agriculture and Land Resources Management, UAF, Fairbanks
9:00 a.m.	National Soil Survey Center Report --Steve Holzhey, Assistant Director, Soil Survey, NSSC, SCS, Lincoln, NE
10:00 a.m.	(Break)
10:30 a.m.	Committee Presentations and Discussions Committee 1 & 2
ALL DAY	Poster: SOTER Projects in Montana and Canada --Dave Yost, Soil Scientist, USDA-SMSS, Washington, DC
12:00 noon	Lunch Presiding: Bruce Buchanan
1:30 p.m.	Fire Ecology in Interior Alaska --Joan Foote, Institute of Northern Forestry, Forest Service, Fairbanks
2:00 p.m.	Soil Surveys and Permafrost --Joe Moore, Assistant State Soil Scientist SCS, Anchorage, AK
2:30 p.m.	Western Soil Climate Initiatives --Ron Paetzold and Phil Camp, Soil Scientists, NSSC, SCS, Lincoln, NE
3:00 p.m.	(Break)
3:20 p.m.	Permafrost Frontier (movie) --Nils Johansen, Department of Mining and Geological Engineering, UAF, Fairbanks, AK
3:50 p.m.	Field Trip Information --Joe Moore
4:00 p.m.	Agency Meetings

WEDNESDAY, June 20, 1990	FIELD TRIP Tour Leaders: Joe Moore, Robert Speck, and C.L. Ping
8:00 a.m.	Bus leaves M-B-S Complex 1) Effectsoflandclearingonpermafrostsoils; the T-Field and UAF Farm --Joe Moore and C.L. Ping, USDA-SCS and SALRM-UAF, respectively 2) Tour of permafrost tunnel and permafrost features --Robert Speck, Head, Department of Mining and Geological Engineering, UAF 3) Tour of Eielson Field Agriculture Project --Ann Rippy and Steve Hemshrot, USDA-SCS and CES-UAF, respectively
5:30 p.m.	Bus returns to M-B-S Complex
THURSDAY, June 21, 1990	Elvey Building Auditorium Presiding: Earl Alexander
8:00 a.m.	Revisions in Soil Taxonomy --John E. Witty, National Leader for Soil Taxonomy, SCS, Washington, D.C.
8:30 a.m.	Soil Use Dependent Properties --Robert Grossman, Research Soil Scientist, NSSL, SCS, Lincoln, NE
9:00 a.m.	Landscape Descriptors --Fred Peterson, Professor, University of Nevada, Reno, NV
9:40 a.m.	Soil Microvariability for Vertisols --Terry Cook, Soil Scientist, USDA-SMSS, Washington, DC
10:00 a.m.	(Break)
10:30 a.m.	Committee Presentations and Discussion Committee 3 & 4
12:00 noon	(Lunch) Presiding: Robert Meurisse
1:30 p.m.	Engineering Problems Associated with Permafrost --Nils Johansen, Department of Mining and Geological Engineering, UAF, Fairbanks, AK
2:00 p.m.	Agency Reports
3:00 p.m.	(Break)
3:30 p.m.	National Soil Data Base --Dave Anderson, National Leader, NSS Database Staff, NSSC/MWTC, SCS, Lincoln, NE
4:00 p.m.	Soil Taxonomy Insensitive to Native Vegetation in the Western U.S. --Larry Munn, Associate Professor, College of Agriculture, University of Wyoming, Laramie, WY
6:30 - 10:00 p.m.	Banquet and Alaska Show, Alaskaland and Cripple Creek, Fairbanks and Ester, respectively.

FRIDAY, June 22, 1990	Elvey Building Auditorium, UAF Presiding: Barbara Pierson
8:00 a.m.	GIS in SCS - Database, Imagery Analysis and Cartography --Richard Folsche, Head, National Cartographic Center. SCS. Fort Worth., TX
8:30 - 10:00 a.m.	GIS and Remote Sensing (3 groups) 1) GIS Demonstration -- Richard Folsche, Head, National Cartographic Center, SCS, Fort Worth, TX 2) Tour of the Satellite Aperture Radar (SAR) System -- Larry Sweet, Geophysical Institute, UAF, AK 3) Image Analysis Demonstration and Application in Mapping -- Rick Guritz and Tom George, Geophysical Institute, UAF, AK
10:00 a.m.	(Break)
10:30 a.m.	GIS: Status and Application of STATSGO Database --Mon Yee, Soil Scientist, WNTC,USDA-SCS, Portland OR
11:00 a.m.	Committee Reports Committee 1 - 4
12:00 noon	Lunch
1:30 p.m.	Business Meeting
3:00 p.m.	Conclusion and Wrap-ups --Gary Muckel, Head, Soils Staff, WNTC, SCS, Portland, OR

Welcome and Opening Comments from
Dr. James V. Drew

It's a pleasure to welcome the group from the Western Regional Soil Survey Work Planning Conference to Fairbanks, Alaska. You have lots of technical things on the agenda to talk about during your meetings and the field trip, so in filling in for Chancellor O'Rourke, who unfortunately could not be here today, I'm going to tell you a little bit about Fairbanks and about the University of Alaska, and try not to dwell very much on the technical subjects that you'll be hearing about in much more detail later on.

You hear a lot of discussion about wetlands these days, and I'm sure you're familiar with national issues on the reclamation of wetlands and what they mean in terms of people using the land. Most of Alaska is a wetland. As you come into Fairbanks and look around, everything's green, yet we have only about 18 inches of precipitation a year. Now if you were in eastern Colorado with that much precipitation, everything would be brown, but here it's green. Why is that? Well, across much of the area there is some permafrost, which tends to block the downward movement of moisture, so moisture stays in the upper layer. Even more importantly, the evapotranspiration stress is much less here because of our low sun angle. Even though the sun shines almost 24 hours a day at this time of year, it doesn't present the same kind of evapotranspiration stress that we find in, for example, eastern Colorado, where there might also be 11 inches of precipitation. So the combination of the permafrost and the low potential evapotranspiration leaves us with lands which frequently are perceived as being wet. But you will see on Wednesday's field trip that when the land is cleared and the moss layer is removed, and the permafrost table drops, it suddenly becomes a dryland. Yet you would classify it as a wetland when the original vegetation is there. So where else in the world can you clear land and markedly change the physical characteristics of the soil? I don't know of any other place where we really change the physical characteristics of the soil remarkably simply by clearing it and preparing it for crop production, urban development, airport development, or roads.

Why is Fairbanks here in the middle of Alaska? Well, if you've looked at a map, you may have noticed that there are some major rivers that drain Alaska; the Yukon, of course, is a massive river, larger than the Mississippi, and extends for a considerable distance on into Canada, out to the west coast of Alaska. The Tanana River is a tributary on the south side of the Yukon, but flows in a generally western direction to get to the Yukon; and there's a smaller stream called the Chena River, which is where we are here at Fairbanks, and the Chena River flows into the Tanana. In fact, Fairbanks is about five miles from the point where the Chena River enters into the Tanana River. They are interesting rivers because the Tanana water drains from glaciers in the Alaska Range to the south. As a result it's loaded with silt, and is very, very gray; it would not meet EPA standards for clean water for fish or for swimming. The Chena River is a very clear, spring-fed river, and there's a striking contrast in the sediment load and color of the two waters as they flow together at the mouth of the Chena.

In any event, how did Fairbanks happen to be here? It's an interesting and colorful history. Back in the late 1800's and early 1900's, there was substantial interest in gold discoveries in the Klondike area of Canada.

Riverboat travel started in the late 1800's by taking paddlewheel, steam-powered, wood-fuel-burning steamboats up the Yukon River to Dawson and other areas in the Klondike where gold was being mined. We all know about those areas because of Jack London and Robert Service and the legacy of literature that they left to us. But that provided experience in bringing supplies into northern Canada and into interior Alaska by riverboat. One of the people who was a successful merchant in those enterprises was a fellow named E.T. Barnette. In the late 1800's he had taken one or two successful supply missions by riverboat from the west coast of Alaska up almost the total length of the Yukon to the Dawson area, and had disposed of his goods to the miners, and had made a lot of money. So consequently he figured that would be a good thing to do again. In 1901 he loaded a boatload of supplies down in Seattle and brought them up through the inland waterway to the mouth of the Yukon River, intending to go into interior Alaska, or perhaps even farther on east into Canada, where he would surely find miners who were discovering gold and he could sell the supplies to them. Now what happened was that his boat got wrecked, at a place called St. Michael's, which is right near the mouth of the Yukon River. He was able to save the supplies that were in the boat, although the ship was a loss. But it so happened that there was another boat captain there, named C.W. Adams, who was able to come to the rescue of Mr. Barnette. They loaded all of the supplies that were in Barnette's original boat into Captain Adams' boat, and started up the Yukon with the idea of coming up to the Tanana and then up the Tanana as far as they could go to where there would be mining activity and they might be able to sell some of their supplies to the miners.

Well, they got up to the mouth of the Tanana River, and turned up the Tanana. The Tanana is very much like the Platte River in Nebraska; it's a very meandering stream with lots of river bars and very difficult to navigate. The paddlewheel boats burned about a cord of wood per day. They used to have caches, or supply points, of wood along the river where they could stop and load up and continue on. Well, the captain got his boat and Mr. Barnette and their supplies up to the mouth of the Tanana, turned up the Tanana and headed toward interior Alaska. When they got to where the mouth of the Chena River comes into the Tanana, the river was getting very very narrow--the channel is very shallow. Captain Adams was afraid that he was going to get the boat hung up on one of the river bars. But here was the Chena River, and it seemed to be a fairly open channel. They thought "Well, maybe we can continue on there." And somehow or other Barnette had the idea that he had talked to an Indian somewhere who said if they went up the Chena, then that would eventually come back into the Tanana and they could continue on west to Canada. So Captain Adams proceeded up the Chena River, and got as far as where Fairbanks is. He was afraid that if he went any farther, they'd be in trouble and get the boat stuck. So consequently he told Mr. Barnette he was going to have to unload right there. And Mr. Barnette was very upset because he wanted to get closer to the Klondike. So they had a big fight, and it ended up that Captain Adams--the captain of the ship--won the fight. So before they knew it, Mr. Barnette, his family, and all the supplies were sitting on the bank of the Chena River right where Fairbanks is right now. And that's how Fairbanks happened to start here.

Now it probably would not have been a success as a city except that sitting on top of Pedro Dome, a large dome-like mountain north of Fairbanks, were a couple people. The two people were a fellow named Felix Pedro, and another man named

Gilmore. Pedro was an Italian mining in the area. There are a number of domes here in the Fairbanks area and some of you may wonder why we end up with gold here; these are true geologic domes in which they represent an upwelling of molten magma which came up into the surface layers, and mineralized material at the adjacent content. As a result gold is frequently in these high domes that were pushed up by that upwelling of magma. So there's hard rock mining in that rock itself, but then we end up with placer mining because through erosion, the gold is washed down in the streams, and included in gravels, so most of the early mining here in Fairbanks was of the placer variety. Currently there's some hard rock mining going on, but in those days it was almost entirely placer mining.

Anyway, Gilmore and Pedro were sitting up there on what is now called Pedro Dome, and they saw this smoke from the steamboat out there at the river. So they knew that somebody was there, and they started down from the dome to the river. Pedro met Barnette and said that they were prospecting in the area for gold. Barnette said he'd set up his store there where they unloaded the supplies, and they were free to come and buy things from him. It turned out that two years later, in 1903, Felix Pedro made a major gold discovery here. So that set the stage for a permanent Fairbanks. By 1906 there were 6,000 people here just because of the gold.

Why is it called Fairbanks? Well, it's another interesting part of the history of how Barnette got here in the first place. There was a very famous territorial judge in the area named Wickersham, who served as a territorial delegate in the U.S. Senate from Alaska for many years. He was also a Federal judge in Alaska. His headquarters were in Eagle; if any of you ever read Coming into the Country by John McPhee, you know about Eagle, an area between here and the Canadian border. In any event, Wickersham happened to be down at St. Michael's at the same time that Barnette's boat was wrecked, and when he had to put his supplies over into Captain Adams' boat. And so Wickersham and Barnette had lots of opportunities to visit as they waited for all this unloading and loading. It turned out they were easily able to talk to each other because they were both Republicans. Wickersham asked Barnette what he was going to do. He said, "Well, I'm traveling up the Yukon and the Tanana where I intend to set up a trading post." And Wickersham said "Well, you might end up with a town there where that trading post is eventually." And he said "I'd suggest that you name that town Fairbanks, because I personally know a U.S. Senator from Indiana whose name is Charles W. Fairbanks, and if we ever get a town going there in the interior of Alaska, it would be pretty nice to have a friend in the U.S. Senate." So Barnette remembered that, and after he got his-store set up and after Pedro discovered gold, they named the town Fairbanks. Barnette was the first mayor of Fairbanks and seemed to be a very reputable businessman.

Why is the University of Alaska here? Well, by 1906 there were 6,000 people here in Fairbanks, and there was no railroad to bring in supplies and food. The only way to get supplies here was either by riverboat up the total length of the Yukon, or across an overland trail from Valdez, a trail that essentially followed the route of the Alaska Pipeline today. So consequently there wasn't very much to eat. So in 1906, the people of Alaska petitioned the U.S. Department of Agriculture to start an Agricultural Experiment Station here. In 1907 the U.S. Department of Agriculture responded and an Agricultural Experiment Station was established here at Fairbanks. It was pretty successful right from the outset.

In fact, it was so successful that about two years after it started, a few of the local townspeople who were also raising potatoes for sale in the community were very upset because the Experiment Station was producing potatoes which were cutting into their market. In this day and age we know how important it is to privatize research; you can see that there were some difficulties with it even back then at the start of the research program in Alaska.

Why would the University have been located here? If we think about it, if we go back to the early 1900's, by 1915 Anchorage was simply a tent city that was there primarily to establish a supply point for building the Alaska Railroad. Juneau was the capital of the state; it was the headquarters for government, it was the center of population at that point, but there was no agricultural potential in the Juneau area, or at least very little. So consequently the area of most agricultural potential at that time was here in interior Alaska, and of course that's where mining was going on also. So the people of the area began to work on the possibility of getting a college established here, and in 1917 the United States Congress and the territorial legislature of Alaska approved the establishment of an agricultural college and school of mines at Fairbanks. It didn't open until 1922; it took a few years to build some buildings and a road out here from downtown Fairbanks. It opened in 1922 with six professors and six students; that was a pretty good student/teacher ratio, and we've never had one that good since. By 1935, there were 18 professors and 150 students. It remained a fairly small university and almost got wiped out during World War II, when many of the buildings were taken over for military purposes, and of course the students were all off in the Armed Forces. But nevertheless, it did continue. So the reason the University campus is where it is is because the Agricultural Experiment Station was established here in 1906.

Currently we have a statewide University system. We are trying to model, I guess, Missouri, Nebraska, California, and other states that have statewide systems. We have a president and a whole array of vice presidents, and they preside over the entire educational enterprise within the state. We have three major senior campuses: one at Fairbanks, one at Anchorage, and one at Juneau. Our enrollment here in Fairbanks is probably about 5,000 students, including 500 graduate students. Here on our campus we have a 2250-acre campus site. We have eight different colleges: a College of Liberal Arts, a College of Natural Sciences, a Rural College, a Career and Continuing Education school, our own School of Agriculture and Land Resources Management, a School of Engineering, a College of Fisheries and Ocean Sciences, and a School of Mineral Engineering.

Our programs in comparison with other universities are all very small. We have a total of 22 faculty members in our school here at Fairbanks. We have 8 additional faculty members at our research center in Palmer. We actually have two research centers for agriculture; one is at our experiment farm here on the Fairbanks campus, and the other is at Palmer, which is about 50 miles northeast of Anchorage. The Palmer facility also represents a former Federal Agricultural Experiment Station that was started in 1915; and of course it got most of its prominence from the Matanuska Valley Colony which started in the 1930's as a result of a resettlement program initiated by the Roosevelt administration to take care of people who were destitute in some of the lake states during that particular time period.

Our School of Agriculture and Land Resources Management includes the Agricultural and Forestry Experiment Station. The faculty of the School and the Experiment Station are intertwined so that each faculty person has responsibilities in both the School and the Experiment Station. We have a Division of Plant and Animal Sciences, a Division of Forest Sciences, and a Division of Resources Management. We have a variety of research programs, all of which focus on problems specifically identified by people who are concerned about producing agricultural or forest products within Alaska, or who are concerned with the broader areas of resource management. In the area of soil science, we have research going on with respect to soil nitrogen regimes, soil genesis, and classification of cold soils. In the area of agronomy, we have the usual activities with variety trials, and soil and water conservation. In horticulture, we deal with native plants and trying to adapt them for horticultural purposes, greenhouse problems and vegetable production practices. In range science, much of our work has been directed toward revegetation problems on the North Slope of Alaska in connection with oil field development. In our animal science program we do some work with pigs, some with beef, much of it involves looking at the nutritional characteristics of feedstuffs that can be produced locally. And we do also have a dairy research program at our Palmer Research Center. But in addition to these animals, you'll also find reindeer within our research arena. One of our major research projects here in forestry is part of the long-term ecological research program which the National Science Foundation funds. We are also working with forest growth and yield, tree improvement, and natural areas. In the resources management area, we have programs such as agricultural economics, outdoor recreation, farming systems, and land use planning. Dog mushing is a big issue here in Alaska, and we have programs dealing with the economic implications of dog mushing. One of our animal scientists has developed dog food specifically for racing dogs and a local producer is exporting it to other northern areas such as Norway and Sweden.

Perhaps the most interesting thing that's happened to our school was a recent cooperative agreement for research that we have developed with the Siberian branch of the Soviet Academy of Agricultural Sciences. As you know, the concept of regional projects is designed to provide some synergy in a particular research problem, where people from a number of different experiment stations in areas of similar environment can worktogetherto solve the problem more expeditiously than they could if they worked on it individually. Well, now, Alaska has always had a problem in cooperating with experiment stations in other states because of the long hours of sunshine, permafrost, and the low evapotranspiration conditions that we have here. In the past,-we've had contacts with the Scandinavian countries such as Denmark, Sweden, Finland and Norway, which have marine climates rather than continental climates as we have in interior Alaska. The vast area of Siberia, where the Russians have done a considerable amount of agricultural development, is particularly appealing to us mainly because we've had virtually no contact with those folks over the last fifty years or so. We started the exchange last summer, and right now have three specific cooperative research projects: agricultural economics (marketing), land clearing, and plant breeding.

The last thing that might be of interest to you is that there is a substantial interest in this area of global change here in Alaska. The University administration has established a Center for Global Change Studies here, and a number of research projects in the Agricultural and Forestry Experiment Station, the Institute of Marine Science, the Geophysical Institute, and the Institute of Arctic Biology are looking at some of the phenomena associated or potentially associated with global change. In northern latitudes, indications of change because of permafrost or permafrost temperatures can be examined here at this edge of the environment that's conducive to agriculture, for example, and that might not be readily observable elsewhere. So there is substantial interest, just as this conference's theme "The Influence of Climate on Soil Resource Inventory and Management" indicates.

Have a successful conference and enjoy Fairbanks.

SOIL SURVEY CONFERENCE
JUNE 17-22, 1990

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WELCOME TO THE WESTERN REGIONAL SOIL SURVEY CONFERENCE

Burt Clifford
State Conservationist

Hayes Dye will have to be my stand in this morning in my effort to welcome you to our great state and to this conference. We have been looking forward to this meeting for the past two years since we learned about it following the Hawaii session. I personally was looking forward to spending some time with you this week as Fairbanks is my old field office; I worked here for nine years starting in 1966. I had come to be known as the local soils expert being involved in land development, land sales, federal homestead prove up's, urban building problems, septic systems, etc.

Those were good time, it was an opportunity to be a part of another phase of Alaska's awakening. This is not to say that all was good, but it was a process that some of us went through that is now hard to explain. I was involved with the bankers, realtors, developers, the state, but especially with the private land owner's which is where we get the most accomplished. It's also here that we, as professional technical people, can still do the most good.

The basis of these long ago activities was the Fairbanks and, finally, the Salcha-Big Delta soil surveys. The information in those old surveys, coupled with some good, practical, local experience and observations, always stood me in good stead as far as the practical application of the data. One of the unique aspects of that experience is what you will be looking at this week - permafrost soils.

Their characteristics to support development demand attention, but many of the problems inherent to some of these soils is offset by their potential. Other such soils, however, are best left along when it comes to development. One of the most interesting aspects of that work was the information program and resulting inquiries by potential homeowners looking to buy or build. There are a host of stones concerning this activity.

We had a very strong soils program in those days under the direction of Dr. Sam Rieger. Sam is not the most talkative person in the world, but he certainly was the technical expert in those days. I know Sam is with you this morning, and I want to acknowledge him to you and express my appreciation to him personally for the work he did. I gained a lot of background from Sam, far more than he may realize. Under his tutorage, I continued to gain a stronger respect for soil science.

I was also very appreciative of some special work Sam did for me. He was my writing critic. Most of you may have already figured out that writing is not one of my strengths just from listening to this presentation. When something of mine cam back from Sam, it was predominately red, red from the corrections. It was even accompanied one time with a note wondering where I went to school, or if I went to school? But you know the product Sam assisted with then always stood the test of the effort.

But enough of razzing Sam. I would hope you realize from these remarks the real respect I have for Dr. Rieger and what he stands for relative to the work with arctic and subarctic soils. Sam, thank you again for your many years of good service.

You're are in good hands this week in your association with Hayes Dye, our State Soil Scientist/State Resource Conservationist, and Joe Moore, our Assistant State Soil Scientist. They have helped put together an excellent program that I know you will find very interesting. They are providing a strong team effort in Alaska soil surveys, and I know they will serve as a good resource this week, as will our party leaders, for any information you might need now or any time in the future.

However, the real champion of this conference is Dr. Chien-Lu Ping. His excitement was almost beyond description when he called almost two years ago and let me know of the 1990 meeting site. He has worked diligently to make this week the success I know it will be. His enthusiasm has only grown to higher levels. Chien-Lu certainly stands as a prime example of interagency cooperation at it's very best as well as a true professional in the work he is carrying on through the University of Alaska Fairbanks. Chien-Lu, please except my personal gratitude for your work, both in our joint efforts in soil surveys and for the leadership of preparing for this meeting.

Others need to be recognized. However, let me close by simply welcoming you one more time to Alaska, to the great City of Fairbanks, and wishing you a successful week.

NATIONAL COOPERATIVE SOIL SURVEY AND ITS NEW CHALLENGES

The theme of the National Cooperative Soil Survey Conference held in Lincoln, Nebraska last July was The Soil Survey of the Future. The task forces were challenged to present ideas of where the NCSS efforts should be going. Those recommendations are what I consider the New Challenges for NCSS, and I am pleased to report that many of the issues laid before the conference are already being addressed.

First and foremost, and it addresses many of the issues from the conference, is that the entire soil survey program has made a significant change in its philosophy of operation. The soil survey program is no longer a program designed solely to produce a soil survey report. It is now a program designed to support the collection, management, and maintenance of soil survey information and to provide that information in the formats appropriate to address the needs of the clients.

The Soil Survey database and software development initiative being directed by Dave Anderson is addressing the needs of Users of Soil Survey information. It is looking at ways of managing soils information, to include entering all primary soils data into the data base, and using that data to provide information reflecting the accuracy and reliability of the soils information in the system.

In addressing the needs of users of soils information one theme comes back again and again, and that is the needs are in constant change and evolution. Recent examples of this are reflected in the information being added to the Soils Interpretation Records. This includes items such as CEC, bulk density, organic matter content etc. New uses include determining the effect of soils on the infiltration of pesticides into the ground water, identification of highly erodible lands, identification of wetlands, and the impact of soils on low input sustainable agriculture. Again, Dave Andersons' group is addressing ways to make the new National Soils Information System (NASIS) adaptable to changes in information inventoried as well as the ways that information may be interpreted. The National Soil Survey Interpretations staff headed by Mauri Mausbach, meanwhile, is looking at ways to generate new interpretations and is determining the soil properties needed to support those interpretations.

The soil survey staffs in the states of Colorado, Kansas, Oklahoma, and New Mexico are cooperating in an effort to update soil surveys on a regional basis. In this case the effort is to update the soil surveys in MLRA 77. This project is not exactly the same as that recommended by the

Task Force on Model Soil Surveys, but it does provide a forum to try new approaches to soil surveying. This approach will lead to the development of uniform legends and provide better descriptions of soils, as they will be looked at across their entire range of occurrence instead of only on that part that occurs within some political (state or county) delineation. This concept also includes an effort to design map units on natural landscape units. All of these features lend themselves to use in a G.I.S.

Gary Muckel from the SCS West NTC is helping organize a symposium for the ASA meetings this fall on soil quality standards. This information will be helpful as we begin to address some of the issues of low input sustainable agriculture. The National Soil Survey Center is also working on developing concepts for soil quality standards in base saturation, erosion rates (improving on the concepts of T), and is building on the Forest Service work with bulk density.

Soil Survey publication formats are being modified. Now Publications are now being developed in standard, tabular, and semi-tabular formats(including color inside and outside), and a task force has been established to develop the two volume publication format recommended by the Task Force on the Adequacy of Soil Survey Delivery Systems.

All of these efforts are being conducted in an atmosphere of awareness of increasing needs by an increasing number of clients, both public and private, for more information that is more accurate and more reliable.

I couldn't be more excited about the future of the National Cooperative Soil Survey. For the first time since I have been attending these meetings I can see the Soil Survey aggressively responding to a broad spectrum of the issues identified by both regional and national conferences. These issues are also reflected in the 4 major objectives being used to guide the direction of the Soil Conservation Soil Survey Division: 1. Improve methods and products to meet expanding user needs 2. Provide new knowledge, procedures, concepts, data sets, and relationships to support the use of soil information 3. Provide technical soil services (support in the application of soil survey information), and train users of soils information and 4. Implement, support, and maintain soil survey activities.

Status Report

1. STATSGO: Most States are competing their maps and attribute data sets. They are to keep STATSGO as a high priority for getting it operational. Dennis

Lytle has and will soon distribute a new status map showing the states progress.

2. GPS: Global Positioning technology is being tested by Jimmy Doolittle of the National Soil Investigations staff. One unit is being tested in Massachusetts and New Hampshire in cooperation with the Mass. D.O.T. It is being tested as a tool to help soil surveyors locate themselves in areas with a dense canopy cover, to locate significant landscape breaks, and to locate pedon sites. It has the capability of providing locations by latitude and longitude, and it is using the LORAN C technology which presently helps in the landing of aircraft.

3.

Total Acres in the United States	2,281,717,165
Total Acres mapped at the end of FY-90	1,625,545,146

Approximately 70% of the U.S. is covered by soils maps. Mapping is progressing at a rate of about 40,000,000 acres per year.

4.

Total Acres of Private lands in the U.S.	1,570,934,614
Total Acres mapped at the end of FY-90	1,362,382,794
Acres remaining to be mapped	208,551,820

Approximately 87% of the private land in the U.S. is covered by soil maps.
Mapping is progressing at a rate of about 31,000,000 acres per year.

5.

Total Acres of Federal Lands in the U.S.	644,774,495
Total Acres mapped at the end of FY-90	376,492,047
Acres remaining to be napped	268,282,448

Approximately 58% of the Federal Land in the U.S. is covered by soil maps.
Mapping is progressing at a rate of about 6,367,000 acres per year.

6.

Total Acres of Cropland in the U.S.	431,198,338
Total Acres mapped at the end of FY-86	372,701,539
Acres remaining to map at the end of FY-86	58,496,892
Acres mapped in FY-87	17,821,979
Acres mapped in FY-88	21,085,225
Acres mapped in FY-89	18,864,151
Acres mapped in FY-90	1,379,864

7. Total Acres mapped by SCS per year:

1984	42.7 million
1985	40.7 million
1986	41.3 million
1987	37.0 million
1988	38.8 million
1989	36.0 million
1990	39.3 million

Beginning in 1986 the emphasis for SCS was shifted to mapping cropland. The following figures show the percentage of the acres mapped by SCS that were cropland:

1986	27%
1987	48%
1988	54%
1989	52%
1990	4%

The decrease in numbers of total acres mapped during the 1987-1989 period reflect the inefficiencies in mapping cropland only. Inefficiencies primarily were 1. not block mapping, and 2. detailing soil scientists into areas where they had no previous mapping experience.

8. SCS Soil Survey Funding:

1984	53.4 million	a 1.6% increase over a
1985	54.8 million	three year period with
1986	54.3 million	inflation at about 3%
		per year = loss of 7.4%
1987	58.1 million	A 25% increase over a
1988	67.7 million	4 year period with
1989	68.0 million	inflation at about 3%
1990	68.0 million	per year = gain of 13%

The funding increases in 1987 and 1988 were provided to cover losses due to inflation, increased operational costs, and for meeting the cropland mapping needs of the 1985 Food Security Act. This funding was used to hire additional soil scientists, contract for mapping, and pay for detailing of soil scientists into states with high cropland mapping workloads.

9. The numbers of SCS soil scientists reflect the status of the soil survey budget. During years 1984-1987 the numbers of soil scientists in SCS declined from 1,341 to 1,155. With the increases in funding for the 1985 Food Security Act the numbers have increased to 1,359.

10. The drop in numbers of soil scientists from 1984 to 1987 was reflected in the drop in the number of acres mapped per year. This trend was accelerated by the emphasis placed on mapping of croplands. The trends for the number of acres

mapped per individual soil scientist, however actually began to increase prior to the Food Security Act cropland mapping initiative. This increase in efficiency by individual soil scientists reflected the implementation of productivity improvement initiatives such as better management of soil survey projects, providing word processing equipment for manuscript development, better availability of field equipment, and a better understanding of the soil mapping process by the individual soil scientists. This trend is expected to continue now that the emphasis is again being placed on project mapping with the croplands completed.

11. The number of soil survey reports published each year increased from 61 in 1984 to 78 in 1986 and 1987. In 1988 the amount of funding for publication was reduced and diverted to cropland mapping. This was reflected in a decline in the number of publications to 70. In 1989 the funding was restored and publications rose to 19. During the period of 1987, 1988, and 1989 manuscript development processes have been improved and desk top publishing equipment has reduced the time and the cost associated with manuscript editing and formatting. At the same time more flexibility in manuscript formatting, color covers, color plates inside the publications, and improvements in paper quality have been achieved. The cost savings are reflected in the number of publications that can be published. Presently we are anticipating about 110 publication this year.

Thomas Calhoun
Asst Director, Soil Surveys
SCS, Washington, D.C.

Concerns and Directions in Soil Interpretations

This year has seen more activity in soil interpretations than the last 10 years combined.

I'll try to relate the various activities, some have been completed, some are ongoing, and some just beginning.

Soil loss tolerance Current activity to provide for a consistent "T" factor began sometime in January 1989. The need was reenforced from quality assurance reviews of the Food Security Act that forced the issue. "T" factor criteria between regions were noted to be significantly different. Four NTC staff heads and the NSSC have been in a negotiating mode to develop criteria that is agreeable to all regions and causes the least changes. The philosophy of "T" probably will never be agreed upon but perhaps by basing "T" on soil properties two soil scientists looking at the same soil will be able to agree on a "T". This spring the resulting changes from these criteria was sent to each state for comment. On the average about 30 percent of the "T" factors in the west will be changed. Some revision is being made to incorporate minor changes being made to the last run. I appreciate your input.

When the criteria is settled "T"s will be assigned by the computer from soil properties. The effort points out the need for very clear procedures and criteria by which we derive nationally significant soil factors.

Hydric soils This soil assignment has had significance to the wetland issues facing many agencies. Each state now maintains a county list of mapping units that contain hydric soils. The national list of hydric soil series requires publication within the Federal Register for changes. The last year has required many consistency checks of soils on the lists to their properties as referenced on the Soil Interpretation Record (SIR). Many hot issues remain to be resolved.

Changes to the SIR Several data elements have been added to the SIR. These are AAT, frost free days, annual PPT, elevation, drainage class, slope, 3 to 10 inch, >10 inch, SAR, CEC, CACO3, gypsum, and wind erodibility index. Many additional changes are being made, many related to WEPP data needs, a rock free K factor is an example. Information related to moisture status, temperature, flooding and ponding by month is increasingly being needed. Documentation of this information would answer many of the differences we have in soil classification as well as enable us to present information and interpretations for different times of the year.

Processing SIRs Electronic input is near, only the policy or procedures for insuring everyone has input and approval remain.

Revisions of interpretation criteria Suggested revisions were sent to states and hopefully to all cooperators for comment on the criteria for current interpretations on the SIR. Other committee activities have also taken place and new approaches to interpretations will be presented at a national soil interpretations workshop next month. It is hoped that we will be able to generate interpretations from representative pedons in the future and not rely on stored interpretations.

Forestry interpretations Ron Bauer of the NSSC is coordinating efforts to prepare forestry interpretations. He has met with many forest service soil scientists and will be following up with NTC and state foresters and soil scientists this fall.

Wildlife interpretations This assignment is being coordinated by George Staidl on the National Soil Range Team. A draft of initial work has been prepared with a team of biologists and soil scientists.

STATSGO This general soil map is nearing completion for the nation. It is a digital product and the GRASS GIS software is being interfaced with this most significant national soil information base. Thank you for your cooperative input into this effort. Mon Yee will provide more information as to status and use later in this meeting.

Field office technical guide This official soil survey delivery document is required in all SCS offices. The SCS is restructuring it to address resources of soil, water, plants, animals and air. The condition of these resources is to be addressed as well as the effect of practice implementation on each resource. This is a big change for SCS and may well change many ways we look at soil survey information. Quality standards for soil and other resources are being established this year. Interpretations for conservation practices has been identified as a high priority by the NSSC interpretations staff.

Soil quality standards The Forest service concept may be close to SCSs activities on soil conditions. A committee here is addressing this item as a follow-up recommendation from the nation work planning conference. A symposium is set up jointly with division 5 and 9 at the Soil Science Society meeting at San Antonio on this concept. Speaking of the ASA or Soil Science Society of America, I encourage a greater participation by the state soil scientists. There is a tremendous amount of applicable information at those meetings.

Technical soil services workshop This past February the WNTC conducted a workshop for the resource soil scientist. This workshop explored their jobs and needs in relation to the close user contact they have. Some items for which they expressed needs are:
- computer disks of published and pre-published manuscripts
- more copies of out of print surveys
- speedier publication process, months not years
- ways to update maps and interpretations
- close relations with private industry and universities
- closer communications with cooperating agencies
- joint and shared training with cooperating agencies
- up and running state soil survey databases at the area level
- supporting climate data
- up to date manuals and handbooks
- training in statistics, remote sensing, computer use, pesticides, water quality, and salinity and alkalinity reclamation
- greater capacity single operating system computers, preferably laptops and field tested software
- suitable and appropriate vehicles
- lab equipment

If anyone wants a copy of the report from this workshop sign the list attached to this copy.

Guide for estimating soil properties We have received several requests for this item and are proceeding in its development. We expect a good outline and draft by the end of August. We appreciate*our contribution to this guide. I say that because we need your help.

Guide for definition and abbreviations for soil descriptions This small handy guide was printed in 1974. The Soil Survey Manual, about to be printed, makes many changes to definitions. Additional entries are also now needed. The WNTC continues to receive almost weekly requests for this outdated western guide so we are proceeding in an update. The NSSC is also interested and we will be working together. Many decisions as to what entries are required have yet to be made. With the anticipated storage electronically of all pedon data, consistency in definitions and abbreviations are more important than ever.

International Soil Management Tour This July 1992 international workshop is well into the active planning stages with a run through of the route and anticipated stops made two weeks ago. SCS, BLM, Agricultural Experiment Stations, and Forest Service are involved. The tour will begin in Portland then south to San Francisco, to Lake Tahoe through Nevada to Ontario, Oregon and back to Portland. This two week workshop will have at least three technical sessions and explore a wide variety of land uses and soil management decisions. Two buses are planned, twenty or thirty of the one hundred participants will be foreign. I would like to thank all the cooperators in the three states for their efforts so far and for their complete support to this undertaking.

100th Anniversary of Soil Survey The anniversary for soil survey is approaching in what I consider to be the near future. The date to celebrate this occasion remains an option but 1999 probably most closely coincides with the 50th celebration held in 1949. In addition Simonson's "Historical Aspects of the Soil Survey and Soil Classification" uses 1899 as a beginning. If some of you are interested in serving on a national committee please let me know. I also encourage each of you to think about possible activities and professional groups that should be involved. Please share these with me as it appears I may be the chairman of this project.

Water Quality soil scientist position The WNTC is going to fill a temporary position on the water quality staff and is looking for candidates. This may be ideal for a sabbatical. I have a copy of the job description with me and would be happy to share it. Inquires on the position should be addressed to Howard Thomas at the WNTC. I mention this because the Director is looking for a strong university contact and PHD level credentials in soil chemistry and water relations.

As I mentioned there are a lot of things going on. This is the result of the changed role of the WNTC soils staff and of the NSSC staffing up the soil interpretations staff. The emphasis is growing in the area of applications of soil survey information.

Presented by Gary B. Muckel at the Western Regional Work Planning Conference June 1990.

Concerns in Soil Correlation[1]/
Western Regional Soil Survey Work
Planning Conference
Fairbanks, Alaska
June 17-22, 1990

I appreciate the opportunity to participate in your Western Regional Soil Survey Work Planning Conference. This morning I would like to share with you some of the activities pertaining to soil correlation in the National Soil Survey Center with emphasis on those of the Quality Assurance Staff.

The soil scientists on the Quality Assurance Staff are assigned responsibility for soil correlation and assistance to states largely on the basis of Major Land Resource Areas (MLRA). Most of you are familiar with the three broad regions in which we have made staffing assignments. These are the West, Central and East Regions. Roger Haberman was recently selected to be our supervisory soil scientist for the West Region and Larry Ratliff has the responsibility for the Central Region. Berman Hudson, who had been the supervisory soil scientist for the West Region, is now responsible for supervising soil correlation and related activities in the East Region.

Roger was an active member of the West Region Soil Correlation Staff at Portland, Oregon, for a number of years prior to moving to Lincoln, Nebraska. He has an excellent knowledge of the principle8 of soil correlation and a keen sense of the soil correlation concerns in the Western United States.

Excellent progress is being made to have a modern soil survey for all lands in the United States. There are a number of factors which collectively contribute to the complexity of soil correlation in the West Region. Some of these include: (1) complex soil and geology patterns, (2) wide range of elevations and associated temperature zones, (3) large acreage soil survey areas, (4) extensive acreages of land owned and managed by several different clientele (i.e., private land and public land managed by several federal agencies), and (5) lack the availability of older soils information on which to build on and improve. Many areas are having soil surveys made for the first time.

Soil correlation is the process Of maintaining consistency in classifying, naming, and interpreting kinds of soils and the unit8 delineated on maps. The purpose of soil correlation is to ensure that the soils in a survey area are accurately and uniformly defined, classified, named, and interpreted according to standard. These standards are included in the guidelines of the National Cooperative Soil Survey (NCSS).

[1]/ Jim Culver, National Leader, National Soil Survey Quality Assurance Staff, National Soil Survey Center, SCS, Lincoln, Nebraska.

Soil correlation is dependent on data gathered in the field and laboratory. The accuracy and completeness of a correlation reflects this data. It can be no better than the information on which it is based.

Soil correlation involves (1) the classification and naming of taxonomic units and (2) the naming of map units. A taxonomic unit is a kind of soil. Taxonomic units are defined in terms of soil characteristics that can be seen and measured in the field or laboratory.

Map units are areas of soil. They are designed to provide significant soil interpretations. Each map unit differs in some respect from all other map units in the survey area. Interpretations for the intended land uses are made within existing guidelines, which reflect the present knowledge about soil response. Each map unit provides some unique interpretation.

The soil correlation process usually begins before the first acre is mapped and continues after the last acre is mapped.

The Quality Assurance Staff is involved in a number of activities directly or indirectly related to the progressive correlation of a soil survey area. Significant input includes the following items:

1. Review Memorandum of Understanding
2. Participate in initial or early progress field review
3. Review new and revised series
4. Review field review reports
5. Participate in final field review
6. Review draft of correlations memorandum
7. Technical review and edit of manuscript
8. Training

Soil correlation as part of the National Cooperative Soil Survey is largely a function and responsibility of each Soil Survey party, SCS state office, cooperating universities, and other federal agencies. The SCS state soil scientists provide direction, guidance, and are responsible for preparation of the final soil correlation document. The Soil Survey Quality Assurance Staff is responsible for providing direct assistance on special problems and field reviews and as consultants in providing review of the documents prepared in the soil correlation process.

Comments on Progressive Correlation

Progressive correlation starts with the definition'of the survey objectives in the memorandum of understanding (MOU). The MOU sets the standards for map scale, minimum size of map delineation, kinds of map units, and amount of inclusions in map units. Progressive correlation enables the classification of taxonomic units and naming of map units to keep pace with mapping.

Some of the key elements of progressive correlation are:

1. Decisions made on each review for soils mapped to date
2. Soil survey is "finished" when all tasks are completed
   a. mapping
   b. manuscript
   c. correlation
   d. compilation

The soil survey party leader and party members are key players in progressive correlation. The final correlation of a survey area reflects their day-by-day decisions.

The following are the major correlation responsibilities of the survey party:

1. Describe and classify soils
   a. prepare accurate pedon descriptions
   b. test descriptions against standards (Soil Taxonomy, series descriptions)
   c. recommend revisions in series concepts
   d. propose new series
   e. make correlation recommendations
2. Design and describe map units
   a. determine map unit composition
   b. prepare map unit descriptions
3. Collect data
   a. sample for laboratory analysis
   b. gather yield data
   c. make special studies
4. Prepare, test, and revise soil interpretations
   a. test interpretations throughout the survey
   b. prepare standards for new interpretations
   c. revise standards for interpretations

5. Ensure technical accuracy of soil maps

   a. develop and maintain an accurate descriptive legend

   b. field check for accuracy

6. Prepare the soil survey manuscript

Area conservationists and their support staff play a very important part in facilitating progressive soil correlation. I strongly support the participation of our area conservationists and other disciplines such as range conservationists. district conservationists, and foresters on soil survey field reviews. This provides them with an opportunity to have an appreciation for the amount of time and resources required for the documentation needed in production of quality soil surveys. It also enables the area conservationist to assist in scheduling other specialists (range, forestry. agronomy, etc.) to assist the party leader in testing design of map units and soil interpretations.

Design and Naming of Mapping Units
One of the challenges in soil correlation process involves those soil survey areas having a large acreage of private land and Federal land managed by two or more Federal agencies. The design of consistent soil mapping units throughout these kind of soil survey areas requires coordination and timely involvement of all agencies. Where these soil surveys are made over a period of years or with a multiple level of soil map unit designs, the issues of soil correlation often become complex.

Where feasible and adequate documentation of designed soil map units permit, we concur in use of soil series as names of soil map units. This enables us to provide additional information to current users and projected users. The use of map unit names at levels above the soil series have a definite place in the correlation of selected map units. It would appear the correlation of most map units at the series level with selected map units correlated at levels above soil series would provide the level of soil interpretations most users desire.

Documentation for Correlation
One of our major concerns in soil correlation through the years is adequate documentation of the map units used to express soil patterns on our soil maps. This is true not only for current project soil surveys but for those older soil surveys in the process of being modernized or updated.

There has been excellent progress in recent months, including a number of intense committee sessions, on design of documentation needed for map unit identification and correlation within the National Soil Survey Center. Documentation, including transects, is needed as base data to facilitate a progessive soil correlation process. Berman Hudson, supervisory soil scientist, recently participated in the California State meeting of soil scientists and discussed the various successful transect methods currently being used to document soil map units.

I feel adequate documentation on the components of each soil mapping unit will become an important part of our future state soil survey database (3SD). We will certainly support any needs you may have to ensure there is the desired level of documentation needed for quality soil correlation.

Field Review

One of the major quality assurance activities of our staff in terms of time and travel are field reviews. These include initial, progress and final field reviews. Our staff has participated or plans to participate in (1) nine initial field reviews, (2) 32 progress field reviews, and (3) 78 final field reviews during FY 90. We have made some mid-year adjustments to participate in previously scheduled reviews. We have reduced our involvement in a number of initial field reviews and final field reviews due to largely limited available staff and revised dates requested by states.

Presently, several soil scientists on our staff have more than 15 reviews scheduled during this year. This amounts to 75 days field time plus about one week office review of manuscript and data per review, or another 75 days. The 150 days on reviews out of a normal 230 working days in a year result in a high percent of our available staff time assisting with reviews.

We appreciate the excellent manner in which your state staffs and party leader are providing our office documentation prior to scheduled reviews. This enables our soil scientist to make appropriate reviews and be aware of potential soil correlation or classification concerns prior to going to the field.

Soil Moisture and Temperature

Phil Camp, soil scientist on our staff, will be on the program later to review with you a soil moisture-temperature map of the Western United States. This has been an ongoing project involving a member of SCS and university personnel. We plan to give this project high priority in FY91.

A preliminary look at the STATSGO joins between states indicates good progress is being made by some states to resolve potential inconsistencies. Consistent naming of soils between survey areas within the state and between states is a concern of not only those in soil survey but is needed by those who use soil survey data over multi-state and in Geographic Information Systems (GIS).

I feel a well designed, coordinated map of soil moisture and temperature will significantly contribute to resolving a good number of the soil correlation issues between soil survey areas.

Keys to Soil Taxonomy—Andisol Order

Most of you by now have received the new version of Keys to Soil Taxonomy. The addition of the Andisols Order will require the reclassification and evaluation of a number of soil series in some states. The greatest impact appears to be in Oregon, Washington, California, Nevada, Alaska, and Hawaii. A working session is planned this November between states involved and National Soil Survey Center staff at Portland. This work group plans to study involved soil series and make recommendations for needed changes in the classification of present soil series.

The Andisol Order will help us to more accurately classify our soils but will result in some update in older soil correlations and establishment of some new soil series.

Correlation and Classification of Laboratory Data

One area where the National Cooperative Soil Survey needs your assistance is in the classification and correlation of pedons sampled and submitted to the Soil Survey Laboratory at the National Survey Center.

As of May 1990. various kinds of laboratory data for 16.563 pedons exist at our Lincoln soils laboratory. There are 6,188 data sets that are pre-1978 and 10.375 data sets since 1978. At the present time only 34 percent or 5,589 pedons have been described and 19 percent or 3,083 pedons have been correlated.

The western states have a total of 6,611 pedons with laboratory data. This includes 2,849 data sets pre-1978 and 3,762 data sets since 1978. About 1,966 pedons or 30 percent have descriptions and 472 or 7 percent have been correlated.

Official Soil Series Description (OSEDS)

The processing of all soil series with OSEDS (Official Series Description) on a national basis would be most helpful in providing a database to readily use in our soil correlation process.

The processing of all soil series descriptions into OSEDS continues to be a high priority with the Soil Survey Quality Assurance Staff. The availability of all soil series descriptions in OSEDS will enable each state to make timely needed revisions and will make available, in a database, information readily accessible to all members of the National Cooperative Soil Survey for use in correlation and in making soil interpretations.

We are making excellent progress during the current year to update the soil series you use with OSED. The record as of May 30, 1990, lists 10,294 soil series being used in the West National Technical Center Region. This is a high percent of the 18,000 soil series being used in our National Cooperative Soil Survey Program. Since October 1, 1989, we collectively have input 1.222 of these soil series descriptions in the Western Region into OSEDS. Present records show that there are 2,559 soil series descriptions that need to be input into OSEDS. This amounts to a substantial workload for a number of states. The number of series remaining to be added to OSEDS by states in the West Region range from 10 to 761, with most states having less than 150 to input.

During recent months we have begun to use a scanner to move the series descriptions in our file to OSEDS for a number of states. This has transferred the series descriptions to a useable database suitable to making needed revisions or updates with a minimum amount of time. All series being scanned into OSEDS are identified as "scanned, and not currently revised."

I am looking forward to the continued excellent effort by all of us during the next year to have essentially all the soil series we use in OSEDS.

Quality Assurance - · urvey Interpretations Records

A January 1990 summary shows that on a national basis we are using over 30,000 Soils-5's in our cooperative soil survey program. A summary of the number of Soil-5's being used in each NTC area is as follows:

NTC	Number of Soils-5's
NENTC	1,845
SNTC	3,705
MWNTC	5,090
WNTC	20,797

The Soils-5's as presently used are an integral part of the data gathering and delivery system. The information on the Soils-5's is being used by a wide variety of customers.

There is continued need at all levels, i.e.. field, area, state, NTC, and NSSC, to be cognizant of the values on each Soils-S. Recent personal experience with changes on the Soils-S's related to hydric soil criteria, soil drainage classes, and coordination with the soil series description clearly demonstrates that a continued effort by each of us is needed to maintain quality Soils-5 data. Recent review of selected Soils-5's and soil series descriptions by the Fish and Wildlife Service has indicated some inconsistencies in our preparation of soil correlations and soil interpretations.

We, in the Quality Assurance Staff, will be looking forward to working with each state as we begin to develop our schedule of soil survey activities for this next fiscal year. I feel good positive communications between all parties involved in the soil correlation process will resolve most identification issues. We will welcome your comments or expressions which will contribute to a more efficient way of doing a project or to improving the quality of our product. Please feel free to contract our office to formally or informally discuss issues of soil correlation or of soil survey quality assurance concern.

WESTERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE
FAIRBANKS, ALASKA

Alternative Formats for Published Soil Surveys[1/]

I appreciate the opportunity to review with you some ongoing activity and concern on alternative formats of published soil surveys. Currently, the dominant form of modem soil survey information is in the soil survey report published on an area. county, or multicounty basis. A soil survey report is designed as a multipurpose report to be used by a wide variety of users. The emphasis has been to provide some information for most all users in a generally standardized format. This presentation has been satisfactory for most of our users. A soil survey report is occasionally viewed by some users as the final or end product. However, current technology is demanding an increasing variety of soil interpretive data for use in models and in addressing complex soil-land use issues. The kinds of formats used in published soils surveys is somewhat like the signs and symbols used in soil correlation. Most of us have varying degrees of experience, and all of us have a definite opinion of how certain parts should be done.

During this past year there has been an increasing interest and concern about how we present our soil survey information to our expanding list of users. This concern is currently being addressed in national and regional Cooperative Soil Survey Conference committee activity.

This afternoon, I would like to share with you some of the activities pertaining to alternative formats for published soil surveys.

The Department of Agriculture and cooperating state agencies have been publishing soil surveys since the early 1900's. The national listing of published soil surveys dated November 9, 1988, shows there have been a total of about 3,800 soil surveys published in the United States.

Some soil survey areas have had several soil surveys published over almost a span of 100 years. For example, the National Soil Survey Center in Lincoln is located in Lancaster County in Nebraska. This area had a soil survey published in 1906 with 4 soil map units, in 1938 with 33 soil map units, and in 1977 with 67 soil map units. Each of these three soil survey reports presents soils information in a distinctly different manner.

I would like to review three broad areas of soil survey manuscript formats. These include: (1) where we have been, (2) where we are now, and (3) what we are planning for the future.

The format of published soil surveys has changed immensely since the early 1900's. However, when looking at the variation in the format of published soil surveys during a specific time interval, we find the general format is surprisingly quite similar.

1/ Jim Culver, National Leader, National Soil Survey Quality Assurance Staff, National Soil Survey Center, Lincoln. Nebraska

The major changes in format of published soil surveys closely follow the major kinds of soil surveys made during the past 75 years. These changes include soil surveys made: (1) using the plane table, (2) using aerial photography prior to adoption of Soil Taxonomy, (3) using aerial photography after adoption of Soil Taxonomy, and (4) applying modernization and maintenance techniques (updates).

The format of soil survey reports made with plane table gave emphasis to agriculture uses and contained broadly defined soil map units. The soil map was commonly a colored line map.

In soil surveys published since the late 1950'6, aerial photography has largely been used as a base map. There have been several basic formats used during the past 30 to 40 years or so. Some of these are as follows:

Format 1

a. General series description and brief map unit description with limited interpretations

b. Separate technical series description

c. Most interpretations by groups, i.e., range, forestry, capability unit

Format 2

a. Technical series description and map unit description with limited interpretations

b. Most interpretations by groups, i.e., range, capability, forestry

Format 3

a. Most interpretations in map unit description

b. Separate technical series description

Format 4--Semitabular Format

a. Most interpretations in map unit description

b. Separate technical series description

During this past year, there has been considerable activity in evaluation of how and in what formats we need to present soil survey information to our increasing variety of users. Most of us in recent years have received an increasing number of different kinds of requests for soils information in a variety of formats.

The 1989 National Cooperative Soil Survey Conference held July 24-28 in Lincoln, Nebraska, committee activity centered on 10 task force issues. The task force entitled "The Needs of the Users of Soil Survey Information: Reliability and Methods of Presentation" discussed the format of soil surveys. Members of this task force included: G. E. Warrington, chairperson, soil scientist, Forest Service: S. G. Leonard, range conservationist. National Soils Range Team, Soil Conservation Service; D. Moos, soil scientist, North Dakota Public Service Commission; C. Osen, soil scientist, International Paper Co.; W. E. Russell, soil scientist, Forest Service; and E. Sautter, soil scientist, Soil Conservation Service. An excellent report of this task force is included in the recently distributed proceedings of the conference.

Some of the highlights of this report are:

- The current soil survey report tries to be an all-encompassing document. It is intended to satisfy everyone's needs at the same time; but in striving to do so, we may have actually detracted from its perceived reliability.

- Soil survey reports should be available in both paper and electronic formats.

- Soil survey data reports should be separate from interpretations.

- Paper (hard copy) reports should probably be in a fixed format for general reference.

- Graphics, such as cross-sectional diagrams, should be used.

- Hard copy interpretative reports should be loose-leaf in order to allow easy updates of individual sections based on new information or technology.

- "Dynamic" reports are needed instead of "static" reports.

- Computer databases have numerous advantages and maybe a few disadvantages. Some of the advantages and disadvantages are as follows:

    1. Computer databases are easy to update.

    2. Computer databases are not available to all users and probably will not replace all parts of a published soil survey.

    3. Computer programs tend to see data only in black and white. Interpretations of soil properties and landscapes are often gray.

    4. Expert systems offer a way to capture logic, thus providing a means of automating professional judgment.

The task force recommended that soil surveys (whether paper or electronic) include sections on:

1. Data compilation reports

    a. Pedon descriptions and locations of those descriptions

    b. Laboratory data

c. Field note summaries

d. Form-5 information for each soil and soil phase

2. Interpretative reports keyed to users and kinds of uses

3. Maps

4. Associate databases and resource report reference

A second task force report at the National Cooperative Soil Survey Conference, "Adequacy of Soil Survey Delivery Systems," chaired by T.J. Bicki, University of Illinois, provided excellent recommendations on soil survey report format.

Recommendations in the executive summary include:

1. Soil survey reports should be redesigned so that each report contains two volumes.

a. Technical data and maps should be in one volume.

b. Interpretations should be in a second volume.

2. More technical data should be included in published reports.

3. More graphic elements are needed.

4. The NCSS should take the lead in use and development of electronic-interactive technology.

During the North Central Soil Survey Conference at Ames, Iowa, two weeks ago. had one committee discussed some aspects of soil survey publication format.

Committee 1, "Soil Survey in the 1990's," chaired by Sy Ekart, state soil scientist, North Dakota, and Neil Smeck, Ohio State University, discussed several issues on updating soil surveys and the format of future soil surveys. There was a unanimous decision that the future soil survey format should not be one of either text or electronic data alone but should be a combination of both. A number of additional kinds of information that should be included in updates or future soil survey reports were identified. Some of these are:

1. Water quality

2. Urban expansion concerns

3. Better characterization and description of soil landscapes

4. Special forestry needs

5. Map unit composition

6. Additional data elements, i.e., water movement measurements

The optional two-part published soil survey was also discussed during the spring meeting of state soil scientists at Kansas City, Missouri.

There is currently a group of four state soil scientists (Sy Ekart, North Dakota; Arville Touchet, Louisiana; Jim Carley, Washington; and Steve Hundley, New Hampshire) and NSSC personnel reviewing the present format of soil survey manuscripts. One of the major considerations is to have the soil survey manuscript presented as two separate documents: (1) maps and (2) interpretations. The soil interpretations section in a published soil survey is the first section that becomes out of date because of technology changes.

A questionnaire dealing with how approximately 70 components or sections in a published soil survey may be handled has been sent to all state soil scientists. This questionnaire on format includes items such as How to Use This Survey, the cover picture, General Nature of the County, General Soil Map Units, Yields Per Acre, Wildlife Habitat, Engineering, and Soil Series and Their Morphology. The major issue in this questionnaire is if the various sections should be in Part I, Part II, or both parts.

This advisory group is scheduled to meet in July 1990 at Lincoln, Nebraska, to discuss soil survey formats and to make recommendations. We plan to have these proposals reviewed by the National Cooperative Soil Survey participants this calendar year. This will allow us to proceed with any major format changes the first part of 1991.

I would now like to share with you some of the activity in the National Soil Survey Center pertaining to our current involvement in publication of soil surveys.

Technical Review of Soil Survey Manuscripts

The results of the excellent state-accelerated soil mapping programs and the shifting priorities in the Food Security Act (FSA) are about to have a tremendous impact on production of soil survey manuscripts. Your schedules indicate the Soil Survey Quality Assurance Staff will be receiving 100 manuscripts for technical review in 1990, 107 in 1991, 134 in 1992, 77 in 1993, and 72 in 1994. By the end of 1998, indications are that we will have received 630 soil survey manuscripts for technical review and edit in a 9-year period.

We provided technical review of 50 manuscripts in FY 89. We have completed technical reviews of 45 manuscripts during the current fiscal year and have 14 manuscripts in the process of being assigned for technical review. The distribution of these technical reviews by staffs is as follows: completed--east, 26; central, 10; and west, 9; and ready for review--east. 2; central, 4; and west-g. We are presently contracting out the technical edit for some manuscripts in the west.

Soil survey manuscript workshops have been conducted in Colorado, Oregon, Missouri, and Texas during the current fiscal year. Assistance has been provided to four states on the development of manuscript formats.

Our technical review of manuscripts is limited to only a portion of the soil series in the survey area. The following guidelines are used in making these technical reviews. Where the “umber of soil map units is less than 50, a 20 percent review of all series is made; where there are 50 to 100 map units. a 15 percent review of series is made; and in survey areas with more than 100 map units, a 10 percent review of series is made. For each series reviewed, all map units, general soil map descriptions, and tables associated with the selected series are technically reviewed.

We have slightly modified our procedure for technical review of manuscripts. All technical reviews are presently coordinated by Bill Braker, soil scientist in charge of manuscripts. We feel this procedure will assist in providing a consistent, timely technical review of the manuscripts submitted to our office.

Soil Surv Publication

A summary of the national schedule of soil surveys by state and survey area shows 236 soil survey manuscripts in the system. This number includes manuscripts in some stage of review, edit, or publication. Soil maps for 181 of the 236 manuscripts have been submitted to the National Cartographic Center.

Current projections indicate that we will edit about 60 to 65 soil survey manuscripts in FY 90. This total is possible because we are presently using contract proofreading and contract editing. We anticipate that this use of contractors will allow us to edit a” additional 10 soil survey manuscripts during the fiscal year.

We currently have about 45 soil survey manuscripts on the shelf ready for edit. Soil maps for 20 of these soil survey areas have been submitted to the National Cartographic Center. The soil survey manuscripts that have soil maps already submitted to the National Cartographic Center will have high priority for editing.

Current projections suggest that there is potential for about 100 to 110 soil surveys to be published this year. This is contingent in part on three contracts, covering about 17 soil surveys each, that GPO has with private industry for printing services. We now have the authorization to use color for cover pictures of soil surveys and for soil profiles.

Desktop publishing is effectively being used by the NSSQA Staff to reduce the cost of producing and to reduce staff time in preparing material for soil survey publication. The system was set up in July 1988. The software, MAGNATYPE, is used on a” AT&T 6386 computer. Typically, the publication cost for a soil survey was $16.000 to $17,000 in 1988. In 1989, with the desktop publishing system, it was only $13,000. This is a savings of $3.000 to $4,000 per survey. In addition, the system saves about 3 months of editorial staff time per survey. A brief handout on the desktop publishing system by Paige E. Mitchell, editor on our staff, gives an excellent overview of this system.

There are two areas we are presently developing to enhance our editing capability.

They are as follows:

1. Tables in soil survey manuscripts are presently generated using the SOILS-6 file and the SOILS-5 database at Ames, Iowa. Adjustments to the

tables (i.e., crop yield tables) are made in pencil by the state and submitted to our office for editing. This requires our office to manually make all recommended corrections on each table. By the end of this fall, we plan to have a system, in operation whereby each state will have the opportunity to make these needed adjustments in their state soil survey database (3SD). Each state will submit a disk of the tables which are essentially ready for publication, to NSSQA.

2. The pedon description program is currently being reviewed in order to make it consistent with the new National Soil Survey Manual. The pedon program also needs to be in agreement with the editing style used in soil surveys. Once the revised program is operational, the soil survey project leader could use the pedon program to describe pedons in manuscripts. This procedure would result in a very minimum amount of editing and would significantly reduce potential errors.

Recent data elements added to the soil interpretation record are (1) annual air temperature, (2) frost-free days, (3) annual precipitation, and (4) elevation. The plan is to include these data elements as a separate table referenced in the climatic features section of soil survey manuscripts. The data element on drainage class will be included in table K on soil and water features.

National Databases for SCS Soils Information

There are several national databases used in developing material in published soil surveys. These include:

1. Official Soil Series Descriptions

2. Soil Classification Files

3. Soil Interpretation Records (SCS-SOI-5)

4. Map Unit Use Files (SCS-SOI-6)

5. Soil Laboratory Data (SCS-SOI-8)

Currently, we are using about 18,000 soil series and have about 210,000 map units in our Map Unit Use Files (MUUF).

Modernization and Maintenance of Soil Surveys by Major Land Resource Areas (MLRA)

There has been an increased interest in modernizing and maintaining soil surveys on a major land resource concept. Our staff has coordinated two separate sessions during the past 3 months to discuss modernization on the MLRA concept.

A meeting was held at Stillwater, Oklahoma, during the week of March 5-8, 1990, to evaluate modernization of MLRA 77, Southern High Plains. This area. about the size of the state of New York, includes parts of Texas, Oklahoma, Kansas, New Mexico. and Colorado and involves three NTC areas (SNTC, MNTC, and WNTC). In attendance at this session were personnel from the NSSC, MNTC. SNTC. WNTC, NHQ, Oklahoma, Kansas, Texas, New Mexico. and

Oklahoma State University. A considerable amount of work and planning has been done during the past 10 years to identify the concerns in modernizing the soils and their interpretation for MLRA 77.

A second session was held on May 8. 1990. at Cedar Rapids, Iowa. It was conducted to evaluate modernization of MLRA 105. Northern Mississippi Valley Loess Hills. Participants included NSSC staff members; state soil scientists from Iowa, Minnesota. Wisconsin, and Illinois; and Iowa resource soil scientists. MLRA 105 includes all or parts of about 41 counties in Iowa, Illinois, Minnesota, and Wisconsin.

Some significant items pertaining to the projected publication or format of soil survey information discussed during these two sessions were:

1. An update for the entire MLRA

2. One report for the entire MLRA

3. One legend for the entire MLRA

4. Subsets of data by county

5. A digitized soil map

6. A. recommendation for soil survey project leaders to work within MLRA's rather than within state and county boundaries

7. A multiple layer project with specific completion data for various phases

The concepts of modernization and maintenance of soil surveys by MLRA has been well received during planning sessions with regional directors and Washington technology staff of the Soil Conservation Service.

Summary

The published soil survey has been a popular document for most users. Our history of soil survey publications through the past 100 years has been "dynamic" to meet the needs of most users and technology enhancement.

We are again at another technology crossroads. We need to provide users with effective and timely soils information. Congress and the public will demand that we provide our soils information in several formats. Each of us will have a certain preference on how we would like the format or methods of presentation modernized.

Current activities by Dave Anderson and his staff in data systems will allow us flexibility in electronic storage and presentation of our soils information.

One comment by a committee member addressing soil survey formats is of interest. His comment is as follows: "While it would be nice to think that we would all be willing to call up soils information on a computer, not many will. Most people (students, too) prefer a 'hard copy,' I think. Hard copies can be made from data in a computer , so I would suggest we keep it on disks and provide hard copies for those who want to practice 'information retrieved' by reading a book as we have done successfully for generations."

Personally, I feel we currently have the technology and resources to reformat or enhance our presentation and delivery of soil survey information to users. The present activities to evaluate our presentation of soil survey information will be challenging. The committee studying soil survey manuscript format will need our support and recommendations as we develop multiple methods to deliver soil survey information to user8 in an effective and timely manner.

WEST REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

FAIRBANKS, ALASKA
June 1990

☆☆☆☆☆

Reference Handouts
Jim Culver, National Leader
Soil Survey Quality Assurance
National Soil Survey Center
Lincoln, Nebraska.

NATIONAL SOIL SURVEY CENTER

TECHNOLOGY TIDBITS

December 12, 1989

DESKTOP PUBLISHING SYSTEM

Paige E. Mitchell
Editor, NSSQA Staff

As one of the newest additions to the Quality Assurance Staff, the desktop publishing system is the only staff member who isn't on a salary, doesn't drink coffee, and never asks for a promotion. What the system does for the Soil Conservation Service is lower the costs of producing and publishing soil surveys and save the editorial staff a great deal of time.

After the system was set up in July 1988, the editors spent nearly 5 weeks training on the equipment and setting up the formats needed for each section of the survey. The software program, MAGNATYPE, is used on an AT&T 6386 computer. Basically, the standard survey codes, such as $101 and $133, are converted to typesetting codes using a swap program. The $101 code, for example, is translated into a string of 6 typesetting format codes that govern spacing, paragraph indentation, letter point size, column width, hanging indentation, and font selection. This conversion allows the state offices and regional technical centers to use the same codes and formats they have always used in conjunction with the new desktop system. The typeset pages are composed on a state-of-the-art Printware 720 IQ laser printer, which prints 1,200 dots per inch.

The desktop publishing system has been operational for approximately 1 year. In September 1988, five surveys were typeset on the new system. In fiscal year 1989, 54 surveys were typeset and sent to National Headquarters. The average survey cost in fiscal year 1988 was $20,000. This figure is unusually high because many of the surveys published that year were exceptionally large. Typically, the average cost ranged from 516,000 to $17,000. The average cost in fiscal year 1989 using the desktop publishing equipment was only $13,000. This is a savings of $3,000-$4,000 per survey. Placing the section "How To Use This Soil Survey" on page 1 instead of on the back of the cover resulted in a savings of $300-$500 per survey. The overall savings was realized despite the additional cost of using higher quality paper and of incorporating color cover photographs and soil profiles. For example, the color cover for Leon County, Texas, added 30 cents to the cost of each copy, and the 13 color profiles added 62 cents. Together, they added $3,000 to the total cost of the survey.

The cost of publishing three surveys through the Government Printing Office (GPO) is about 551,000. Using the desktop publishing system, four surveys can be produced at a cost of about $52,000. This adds up to one free survey for every three published.

In addition to saving money, the desktop publishing system saves a considerable amount of time and paperwork. The editorial staff estimates that it saves at least 3 months time on each survey. Previously, when GPO composed survey page proofs, one minor coding error could affect the entire layout of the survey and render the page proof virtually useless. The page proof would be returned to the National Technical Center, the error would be fond and corrected, a new 9-track tape would be run for the entire manuscript, the whole package would be sent back to GPO, and another page proof would be typeset. If a coding error occurs now, it can be detected and corrected by an editor in a matter of seconds. In September 1988, five surveys were typsct on the new system. The editoral staff estimates that the desktop system saves at least three months time on each survey.

The desktop publishing system displays the page layout in actual size on the monitor. At this stage, the size of headings, the amount of extra leading, the placement and alignment of margins and gutters, text that is bold-faced or italicized, misspellings, and typographical errors can be checked by an editor before the page proof is even printed. The quality of type is comparable to that of the GPO typeset surveys, and the editoral staff is allowed more artistic freedom to make each page visually attractive.

Nearly all the editors and editorial assistants have worked with the system and are experienced in typesetting soil surveys. The staff has also used the desktop system to develop individual swap programs that create templates for use in semitabular survey formats for many state offices. The templates, which serve as a pattern or guide for the semitabular format, are transferred onto diskettes and distnbuted from the state offices to party leaders. Once a template is created, the specific survey data need only be inserted, because all the codes necessary for typesetting are imbedded in the template. These templates reduce not only the amount of time spent coding the document, but also the margin of error in coding.

The desktop publishing equipment has proved to be a sound investment for the Soil Survey Quality Assurance Staff. As new software programs and typesetting technology become available, the productivity, efficiency, and quality of soil survey publication will continue to improve.

SERIES STATUS FOR STATES IN THE WEST NTC REGION

Number of OSEDS - Result: 10,294 SERIES
OSEDS updated since 10/1/89 - Result: 1222 SERIES

Hawaii - Result: 283 SERIES
OSEDS Missing = 149

Washington - Result: 1196 SERIES
OSEDS Missing = 10

Oregon - Result: 958 SERIES
OSEDS Missing = 17

California - Result: 1514 SERIES
OSEDS Missing = 761

Arizona - Result: 399 SERIES
OSEDS Missing = 80

New Mexico - Result: 648 SERIES
OSEDS Missing = 138

Utah - Result: 780 SERIES
OSEDS Missing = 323

Nevada - Result: 1314 SERIES
OSEDS Missing = 185

Colorado - Result: 774 SERIES
OSEDS Missing = 162

Wyoming - Result: 539 SERIES
OSEDS Missing = 153

Idaho - Result: 997 SERIES
OSEDS Missing = 283

Montana - Result: 610 SERIES
OSEDS Missing = 298

TOTAL MISSING SERIES FROM ALL WESTERN STATES = 2555.

Alaska - Result: 282 SERIES
OSEDS Missing = 76

NATIONAL SOIL SURVEY QUALITY ASSURANCE STAFF
Soil Survey Manuscript Technical Reviews
Progress for Fiscal Year 1990

Technical Reviews completed:

East Staff	26
Central Staff	10
West Staff	9
Total	45

Manuscripts awaiting Technical Review:

East Staff	2
Central Staff	4
West Staff	8
Total	14

*** NSSL DATABASE ***
PEDON COUNTS
01/May/90

** WESTERN STATES • *

STATE	TOTAL	PRE1978	<----- 1978 & UP				----->
			1978-UP	W/TAX	NO TAX	DESCRIPTION	CORRELATED
ALASKA	344	80	264	29	235	207	28
ARIZONA	581	295	286	38	248	198	38
CALIFORNIA	1193	529	664	116	548	341	74
COLORADO	482	212	270	8	262	143	8
HAWAII	42	7	35	17	18	21	17
IDAHO	554	129	425	189	236	199	59
GUAM	20	0	20	19	1	16	19
MONTANA	538	296	242	72	170	95	53
NEW MEXICO	368	137	231	94	137	104	72
NEVADA	600	261	339	14	325	1.81	14
OREGON	470	285	193	1	192	68	18
TRUST PACIFIC ISLAND	37	0	37	35	2	27	36
UTAH	458	265	193	4	189	122	1
WASHINGTON	504	162	342	25	317	151	25
WYOMING	412	191	221	9	212	93	10
GRAND TOTALS ------>	6611	2849	3762	670	3092	1966	472

TOTAL . . . . All of the pedons in the NSSL Database.
PRE1978....... Pedons sampled prior to 1978 by the NSSL and it's predecessor laboratories.
1978-UP . . . . . Pedons sampled by NSSL beginning in 1978.
W/TAX.. Pedons classified by states or TSC's on NSSL Soil-8 forms returned to NSSL.
NO TAX.. Pedons not classified by states or TSC's.
DESCRIPTION .. Profile descriptions currently stored in the NSSL Database.
CORRELATED .. Pedons with a correlated series name shown on NSSL Soil-8 form returned to NSSL.

Ongoing Soil Surveys - WE Region 1990-1999
From Soil Survey Schedule

State ID	Survey Area	Percent Complete	FFR Scheduled
AZ623	SHIVWITS AREA, ARIZONA	64	10/90
AZ625	MOHAVE COUNTY AREA, ARIZONA, NORTHEASTERN PART, AND PART OF COCONINO COUNTY	100	06/90
AZ627	MOHAVE COUNTY, ARIZONA, SOUTHERN PART	100	12/90
AZ647	LUKE AIR FORCE RANGE, ARIZONA, PARTS OF MARICOPA, PIMA AND YUMA COUNTIES		10/96
AZ648	ORGAN PIPE CACTUS-CABEZA PRIETA AREA, ARIZONA, PARTS OF PIMA AND YUMA COUNTIES		10/96
AZ657	YUMA COUNTY, ARIZONA, NORTHERN PART		10/96
AZ661	EASTERN PINAL AND SOUTHERN GILA COUNTIES, ARIZONA		10/94
A2666	COCHISE COUNTY, ARIZONA, NORTHWESTERN PART		10/96
AZ671	COCHISE COUNTY, ARIZONA, DOUGLAS-TOMBSTONE PART	82	01/91
AZ673	GRAHAM COUNTY, ARIZONA, SOUTHWESTERN PART		06/93
AZ697	MOHAVE COUNTY, ARIZONA, CENTRAL PART	21	12/92
AZ699	HUALAPAI - HAVASUPAI AREA, ARIZONA, PARTS OF COCONINO, MOHAVE AND YUMA COUNTIES	69	09/90
AZ703	TOHONO O'ODHAN INDIAN RESERVATION, ARIZONA, PARTS OF MARICOPA, PIMA, AND PINAL COUNTIES	75	11/90
AZ707	LITTLE COLORADO RIVER AREA, ARIZONA, PARTS OF COCONINO AND NAVAJO COUNTIES	3	10/95
AZ711	NAVAJO MOUNTAIN AREA, ARIZONA, PARTS OF APACHE, COCONINO AND NAVAJO COUNTIES		04/97
AZ713	CHINLE AREA, PARTS OF APACHE AND NAVAJO COUNTIES, ARIZONA, AND SAN JUAN COUNTY, NEW MEXICO	0	04/96
AZ715	FT. DEFIANCE AREA, PARTS OF APACHE AN NAVAJO COUNTIES, ARIZONA, AND McKINLEY AND SAN JUAN COUNTIES, NEW MEXICO	65	09/91
CA011	Colusa County	23	09/91
CA608	SUSANVILLE AREA	100	03/91
CA653	FRESNO COUNTY, CALIFORNIA, WESTERN PART	57	09/90
CA659	TULARE COUNTY WESTERN PART	28	03/95
CA667	SAN LUIS OBISPO COUNTY, CARRIZO PLAIN AREA SSA 667	75	06/91
CA668	Kern County Northeast Part	31	08/96
CA691	Kern County Southwest Part	9	12/93
CA802	Benton Owens Valley	94	09/90
coo23	COSTILLA COUNTY AREA, COLORADO	62	09/93
CO063	KIT CARSON COUNTY, COLORADO	89	09/92
coo73	LINCOLN COUNTY, COLORADO	54	11/94
CO628	LAS ANIMAS COUNTY AREA, COLORADO PARTS OF LAS	67	10/95
CO634	SANGRE DE CRISTO AREA, PARTS OF ALAMOSA, CUST	100	07/90
CO638	TELLER-PARK AREA, PARTS OF TELLER AND PARK CO	34	10/95
CO647	ROUTT NATIONAL FOREST AREA, PARTS OF GRAND, J	81	09/92
CO648	ROUTT COUNTY AREA, COLORADO	54	10/93
CO657	PIKE AND SAN ISABEL NF-NORTHERN PART: PARTS.0	100	10/93
CO668	ARCHULETA COUNTY AREA, COLORADO	48	09/91
CO671	CORTEZ AREA, COLORADO, PARTS OF DOLORES AND M	78	09/92
CO672	ANIMAS-DOLORES AREA, PARTS OF ARCHULETA, DOLO	91	01/91
CO677	RIDGWAY AREA, COLORADO PARTS OF DELTA, GUNNIS	44	I0/93
CO686	MOFFAT COUNTY AREA, COLORADO	93	06/90
CO660	GRAND MESA-WEST ELK AREA	100	03/90

CO654	HOLY CROSS AREA	29	10/93
CO636	WET MOUNTAIN AND SPANISH PEAKS AREA	32	10/91
CO642	INDIAN PEAKS AREA	3	09/92
CO645	RED FEATHER AREA	4	09/92
CO650	WILLOW CREEK PASS AREA	90	10/93
CO653	GEORGETOWN AREA	1	09/92
CO663	COCHETOPA AREA	27	10/92
CO691	GRAND JUNCTION AREA	39	11/91
ID608	ST.JOE AREA, IDAHO, PARTS OF SHOSHONE AND BENEWAH COUNTIES	74	04/92
ID611	LEWIS AND NEZ PERCE COUNTIES, IDAHO	90	06/91
ID612	CLEARWATER AREA, IDAHO, PARTS OF CLEARWATER AND LATAH COUNTIES	21	10/95
ID656	ADAMS-WASHINGTON AREA, IDAHO PARTS OF ADAMS AND WASHINGTON COUNTIES	100	02/90
ID675	OWYHEE COUNTY AREA, IDAHO	10	07/90
ID681	WOOD RIVER AREA, IDAHO, GOODING COUNTY AND PARTS OF BLAINE, LINCOLN AND MINIDOKA COUNTIES	61	05/93
ID704	JEROME AND PART OF TWIN FALLS COUNTY, IDAHO	86	06/90
ID712	BEAR LAKE-CARIBOU COUNTIES AREA, IDAHO, PARTS OF	45	09/94
	BEAR LAKE AND CARIBOU COUNTIES	45	
ID714	FRANKLIN COUNTY AREA, IDAHO	91	07/92
ID715	ONEIDA COUNTY AREA, IDAHO		04/91
ID752	CUSTER LEMHI AREA IDAHO, PARTS OF BLAINE, CUSTER,	83	01/91
	AND LEMHI COUNTIES	45	
ID763	BUTTE COUNTY AREA, IDAHO	83	11/93
MT011	CARTER COUNTY, MONTANA		04/91
MT017	CUSTER COUNTY, MONTANA	67	12/92
MT025	FALLON COUNTY, MONTANA	10	10/90
MT041	HILL COUNTY, MONTANA	76	10/91
MT051	LIBERTY COUNTY, MONTANA	23	08/90
MT065	MUSSELSHELL COUNTY, MONTANA	82	10/94
MT101	TOOLE COUNTY, MONTANA		07/90
MT615	CHOUTEAU COUNTY AREA, MONTANA	85	10/90
MT622	GALLATIN COUNTY AREA, MONTANA	46	09/92
MT627	JEFFERSON COUNTY AREA AND PART OF SILVER BOW COUNTY, MONTANA	55	09/92
MT630	LEWIS AND CLARK COUNTY AREA, MONTANA	100	05/90
MT639	SWEET GRASS COUNTY AREA, MONTANA	38	10/94
MT641	PHILLIPS COUNTY AREA, MONTANA	31	10/96
MT644	UPPER CLARK FORK RIVER AREA--PARTS OF POWELL,, GRANITE, AND DEER LODGE COUNTIES, MONTANA	74	01/90
MT651	SANDERS COUNTY AREA AND PARTS OF FLATHEAD AND LINCOLN COUNTIES, MONTANA	52	12/92
MT670	SILVER BOW COUNTY AREA AND PARTS OF JEFFERSON AND BEAVERHEAD COUNTIES, MONTANA	8	10/93
MT033	GARFIELD COUNTY, MONTANA	20	10/95
MT604	BEAVERHEAD COUNTY AREA, MONTANA	2:	10/95
MT666	GOLDEN VALLEY AREA, MONTANA		10/96
MT637	MEAGHER COUNTY AREA, MONTANA	16	10/96
MT624	WHEATLAND COUNTY AREA, MONTANA	29	10/93
MT618	FLATHEAD COUNTY AREA AND PART OF LINCOLN COUNTY, MONTANA		10/96
MT647	BITTERROOT NATIONAL FOREST AREA, MONTANA	0	09/90
NM669	CURRY COUNTY AND SOUTHWEST PART OF QUAY COUNTY	0	04/92
NM692	MCKINLEY COUNTY AREA		08/91

NM698	JICARILLA APACHE AREA, PARTS OF RIO ARRIBA AND SANDOVAL COUNTIES		06/91
NM715	FT. DEFIANCE AREA. PART OF APACHE AND NAVAJO COUNTIES ARIZONA AND MCKINLEY AND SAN JUAN COUNTIES, NEW MEXICO		04/90
NM717	SHIPROCK AREA, PARTS OF SAN JUAN CO., NM AND APACHE CO., AZ		09/90
NV754	LINCOLN COUNTY, NEVADA, SOUTH PART	76	07/90
NV755	CLARK COUNTY, AREA, NEVADA		09/94
NV759	WASHOE COUNTY, NEVADA, NORTH PART	85	09/90
NV760	HUMBOLDT COUNTY, NEVADA, WEST PART	16	06/95
NV766	ELKO COUNTY, NEVADA, SOUTHEAST PART	61	05/91
NV770	CHURCHILL COUNTY, AREA, NEVADA, PARTS OF CHURCHILL AND LYON COUNTIES	100	05/90
NV777	HUMBOLDT COUNTY, NEVADA, EAST PART	79	09/91
NV779	WHITE PINE COUNTY, NEVADA, EAST PART	39	06/91
NV781	NYE COUNTY, NEVADA, NORTHWEST PART	11	05/95
NV783	NYE COUNTY, NEVADA, NORTHEAST PART	90	05/90
NV704	LINCOLN COUNTY, NEVADA, NORTH PART	0	09/94
NV785	NYE COUNTY, NEVADA, SOUTHWEST PART	100	09/90
OR015	CURRY COUNTY, OREGON	24	08/95
OR055	SHERMAN COUNTY, OREGON	100	09/91
OR620	UPPER DESCHUTES RIVER AREA, OREGON	94	04/91
OR628	HARNEY COUNTY AREA, OREGON	72	09/94
OR649	DOUGLAS COUNTY AREA, OREGON	79	04/92
OR670	WALLOWA COUNTY AREA, OREGON	24	07/93
OR674	WARM SPRINGS INDIAN RESERVATION, OREGON	35	09/92
UT013	DUCHESNE AREA,UTAH -PARTS OF DUCHESNE,SUMMIT & WASATCH COUNTIES	21	03/95
UT047	UINTAH AREA UTAH - PARTS OF UINTAH, GRAND AND DAGGETT COUNTIES	71	04/91
UT617	Millard - Juab Area,Utah,Western Parts of Millard and Juab Counties	100	01/90
UT623	EMERY AREA,UTAH - PARTS OF EMERY & SEVIER COUNTIES	42	03/91
UT628	SEVIER COUNTY	4	10/92
UT642	KANE COUNTY,Utah	44	11/94
UT645	MANTI-LASAL NATL.FOREST,MANTI DIVISION - PARTS OF SANPETE & EMERY COUNTIES	34	11/92
UT646	DIXIE NATL. POREST:PARTS OF GARFIELD,WASHINGTON,IRON,KANE & WAYNE COUNTIES	29	12/90
UT647	WASATCH NATL.FOREST-SUMMIT,CACHE.DAVIS,DUCHESNE & WASATCH COUNTIES	12	05/97
UT651	FISHLAKE NATL.FOREST EASTPORTION - PARTS OF SEVIER,PIUTE & WAYNE COUNTIES	36	08/93
WA017	DOUGLAS COUNTY, WASHINGTON	26	10/94
WA021	FRANKLIN COUNTY, WASHINGTON	74	04/92
WA8600	CASHMERE MTN. PARTS OF CHELAN AND OKANOGAN COUNTIES	100	04/96
WA8632	OLYMPIC NATIONAL FOREST	30	09/92
WA8637	KITTITAS COUNTY	70	04/93
WA8639	KLICKITAT COUNTY AREA, WASHINGTON	79	04/92
WA8680	WENATCHEE NATIONAL FOREST NACHES AREA		09/93
WA0681	YAKIMA FIRING CENTER, PARTS OF KITTITAS AND		05/90
WY027	NIOBRARA COUNTY, WYOMING	63	11/90
WY031	PLATTE COUNTY SOIL SURVEY	45	06/93

SOILNAME	MLRA	ACRES_IN_MLRA
ALDERWOOD	1	408
	2	653.782
. . ..*.*....*.*. •	*..	-------------
sum		954,190
AMARILLO	70	2.139
	7,	1.053.747
...•••••••••••••	••••	------------
sum		1,055,886
ANDIC CRYOCHREP TS		527,952
	3	70,689
	43	620,110
	6	35.290
.....••••••••••	•...	------------
sum		1,254,041
ANDIC DYSTROCHR EPTS		399,317
	43	1,103,472
•• • ....•	••••-	-------------
sum		1,502,789
ASCALON		109,125
	46	2,482
	49	12,928
	58	3,206
	58A	1,187
	58B	13,984
	61	870
	67	902,267
	69	
	72	102,163
....••••••••••••	••••	-------------
sum		1,148,212
ATHENA	8	54,885
	9	539.492
....l.	....	-------------
sum		594 ,347
BACA		13.021
	44	
	49B	
	67	401.464
	69	218.60,
• be..**.*...,.*	....	-------------
sum		633.092
BADLAND		28,538

SOILNAME	MLRA	ACRES_IN_MLRA
BADLAND	10	5.089
	11	26,261
	15	65,856
	159	2.002
	164	1.782
	165	4,806
	166	1,989
	17	5.210
	20	52,490
	200	2.797
	201	392
	21	
	23	31,638
	25	366
	26	6.376
	27	31.298
	28A	20.268
	28B	7.765
	29	34.62,
	3	1,000
	30	293,177
	32	23.305
	34	130,868
	35	491.649
	36	94.929
	37	309.982
	39	6,371
	40	21.560
	42	47.079
	44	754
	46	4.550
	47	22.061
	48	21,915
	48A	1,458
	52	
	534	15.280
	58A	378.696
	58B	25.585
	6	4.673
	67	30,002
	7	606
	70	59,713
	8	1,928
***************	****	-------------
sum		2,316,691
BAINVILLE	54	93.142
	58A	368,290
	67	6.944
***************	****	-------------
sum		468.376
BAKEOVEN	10	123,767

SOILNAME	MLRA	ACRES_IN_MLRA
BAKEOVEN	22	5,099
	7	71 ,699
	8	648.295
	S	2.755
. . . .l...	. ..*	-------------
sum		851,615
BARKERVILLE	39	527.265
	41	29.692
**************	****	-------------
sum		556.957
BERINO	42	661.452
• *..**.***....*	. . . .	-------------
sum		661.452
BLUEPOINT	30	20.512
	41	30.099
	42	625.955
******************		-------------
sum		576,559
	1	
BOHANNON	3	456.20,
		220
• . . ..*..*......	****	-------------
sum		456.421
BRESSER		272,310
	49	85,792
	67	64.03,
**************	****	-------------
sum		422.139
CABBA	46	65.530
	4,	50.256
	48A	3.46.
	52	6,995
	53A	102,898
	54	
	58A	490.960
....l...	....	-------------
sum		720,103
CABBART	44	8,628
	46	
	52	26,388
	58A	653.065
**************	****	-------------
sum		688,081
CABEZON	35	150,114
	3539	9.036
	36	150.83,

SOILNAME	MLRA	ACRES_IN_MLRA
CABEZON	39	132.106
	4,	10,581
***************	....	-------------
sum		452,676
CAJON	17	59.911
	30	601,595
***************	....	-------------
sum		661,506
CHERRY	53A	114,709
	54	7.217
	58A	350.314
***************	....	-------------
sum		472.240
CIENEBA	15	176.067
	18	106,170
	20	421.960
	22	397
***************	....	-------------
sum		706.614
CLOVIS	35	32.907
	36	534.73,
	70	226.126
	77	271.956
***************	****	-------------
sum		1,065.722
COLBY	58A	58,834
	67	446.330
	69	181,731
	72	179,569
***************	....	-------------
sum		666.464
DEAMA	3539	9,928
	36	33.477
	39	211,671
	42	465
	70	1,139,298
. ...*......**.*	****	-------------
sum		1,394,859
DELPOINT	46	
	52	930
	58A	399,965
. . ..**.....*..*	****	____________
sum		400.695
DONA ANA	30-3	
	40-3	

SOILNAME	MLRA	ACRES_IN_MLRA
DONA ANA	41	25.050
	42	424.659
***************	* ***	
sum		449.709
DUNE LAND		1.202
	1	26,035
	11	3,193
	13	23,629
	14	32.626
	163	1,806
	17	1.769
	19	184
	2	90
	23	
	26	4,336
	27	5.402
	28A	22.997
	266	644
	29	321
	30	16,879
	34	1,272
	35	2.100
	36	715
	37	3.66,
	42	274.965
	43	290
	464	121
	5,	9.966
	58B	1,430
	67	18,011
	69	21.230
	7	12.025
	77	41,532
	6	754
..............l	.***	
sum		529,827
ECTOR	42	127,177
	70	939.076
. . . .*.*...	****	
sum		,,066,255
ELLOAM	52	405,998
	58A	3,642
....	****	
sum		409.640
ELSO	58A	617,811
***************	****	-------------
sum		617.81,
GILMAN	30	156.205

SOILNAME	MLRA	ACRES_IN_MLRA
GILMAN	3,	92. 176
	40	154,611
***************	* ***	-------------
sum		404.992
GYPSUM LAND	26	269
	36	6.532
	42	378.673
	48A	23.66,
	70	6.646
***************	****	-------------
sum		416,001
HANFORD	14	'3,676
	17	227.502
	19	96. 105
	29	96.940
	30	600
. . . . ..*........	****	-------------
sum		437.025
HARVEY	32	7.620
	36	51,586
	58A	36.996
	67	27.690
	69	101. 170
	70	462.631
***************	....	-------------
sum		706.095
HILAND	34	205.627
	566	257.315
• .**.*.*...*...	****	-------------
sum		463.142
HISTIC PERGELIC CRYAQUEPTS	W170	
	176	651.666
***************	****	-------------
sum		6511.666
JOSEPHINE	15	722
	42	142,518
	5	193.224 65.914
a...........	. ..*	-------------
sum		402.376
KIM		7.160
	36	12.433
	46	1,361
	49	15.029

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SOILNAME	MLRA	ACRES_IN_MLRA
KIM	58	17,645
	58A	6,532
	58B	21,284
	61	9,894
	67	234,996
	69	128,471
	7 K	
	70	90.525
	72	1,500
	77	9.039
sum		555,869
KIMBROUGH	41	16,427
	42	29,616
	70	15,117
	77	873,609
sum		934,769
LAMBERT	53A	105,372
	58A	792.366
sum		697,760
LATOM	70	425,168
	77	5.562
sum		430.730
LAVA FLOWS	10	66.710
	11	101.603
	13	3.536
	161	1,031,881
	166	9.030
	21	14,411
	22	38,246
	23	
	26	f.595
	28A	7.650
	30	2.135
	35	1.675
	36	96.466
	42	66.925
	47	263
	6	271
	70	33.024
sum		1,497,645
LEHMANS	36	4.676
	39	15.646
	40	79.617

SOILNAME	MLRA	ACRES_IN_MLRA
LEHMANS	41	49,246
	42	355.235
sum		504.620
LICKSKILLET	10	143,790
	43	7.769
	6.6	27.174
	6	469.661
sum		666,364
LISAM	46	3.960
	52	103,649
	58A	322.764
sum		430.373
LONTI	34	
	35	1.660
	36	213,681
	39	6,356
	40	221,008
sum		442.905
LOZIER	42	626.639
	70	5,068
sum		633,707
MANVEL		2.612
	67	22,020
	69	506.645
sum		611,477
MANZANO	36	151.449
	49	1, 172
	51	22,565
	70	249.163
	77	12.302
sum		436.65,
MAYMEN	15	231.219
	18	3.203
	20	40.314
	22	76.06,
	5	146.433
sum		497.236

SOILNAME	MLRA	ACRES_IN_MLRA
MIDWAY		29.910
	46	4.909
	46	2,366
	49	2.964
	58A	970.195
	67	39,633
	69	46.676
	72	750
sum		,,099,847
MILLSHOLM	15	417.770
	17	3,699
	20	170.334
	5	1,678
sum		593.471
MOENKOPIE	34	4.975
	35	413.974
	39	5,657
sum		424.606
MOHAVE	30	1,335
	40	173,198
	42	412,010
sum		586,543
NELDORE	34	18,180
	52	
	58A	569,143
	60B	
sum		567.323
NICKEL	30	26.670
	40	55.226
	41	21.770
	42	957.319
sum		1,062,985
NUNN		72.066
	49	176,822
	58A	39,666
	61	16.651
	67	332.965
	69	735
	72	95
sum		641,244

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SOILNAME	MLRA	ACRES_IN_MLRA
OLNEY		89,112
	32	9,394
	49	12,015
	58A	4.360
	67	390.066
	69	237.649
***************	****	
sum		742.636
OTERO		15,571
	35	4.52,
	36	4.973
	49	10.260
	58B	2,817
	67	257,318
	69	93.91,
	70	57.61,
	72	
	77	26.646
* **************	****	
		472.746
PALINOR	28B	421.932
***************	****	
		421.932
PALOUSE	43	20.353
	8	29.486
	9	444. 120
***************	****	
sum		493,959
PASTURA	29	13,496
	35	14,515
	36	725
	39	134,342
	40	1,894
	70	502.20,
	77	646
***************	****	
sum		667,821
PENISTAJA	35	90.725
	36	314.202
	70	246,611
***************	****	
sum		651,538
PERSAYO		4,920
	32	139,932
	34	133,872
	35	6,142

SOILNAME	MLRA	ACRES_IN_MLRA
PERSAYO	36	39,773
	37	92.456
	43	32.806
	70	3.594
**************	****	------------
sum		453,495
PHILLIPS	52	779.544
**************	****	------------
sum		779.544
PINTURA	30	26.302
	42	412,829
..************	****	------------
sum		441,131
PLATNER	49	3.239
	67	399,633
	69	
	72	234.096
. *************	****	------------
sum		636.970
PLAYAS	10	336
	17	1.992
	23	31,300
	24	24,518
	26	9.014
	27	536,110
	28A	744.972
	28B	98,998
	29	82.235
	30	46.644
	35	1.050
	4,	36.475
	42	28,187
	46	530
	47	1,195
	67	6.356
	77	17,488
**************	• .**	------------
sum		1,669,402
PULLMAN	77	524.264
. . . .*..*.**	****	------------
sum		524,284
QUINCY	10	16,285
	11	73,125
	21	456
	25	
	28A	479
	7	474,129

SOILNAME	MLRA	ACRES_IN_MLRA
QUINCY	8	24.710
**************	. ..*	------------
sum		599.164
REAGAN	42	264.752
	70	153.486
....***********	. ..*	------------
sum		436.236
REDONA	70	456.964
**************	****	------------
sum		456.964
RENOHILL		10,124
	32	3,112
	34	11,092
	49	17,888
	58	1.135
	58A	6.621
	58B	127,141
	60A	44.289
	67	238.993
• .*...*****t.*.	• **.	------------
sum		460.395
RENSLOW	9	409.623
**************	• ..*	------------
sum		409.623
RENTSAC	34	48.825
	44	28,329
	46	9.730
	48	394.839
	48A	13.009
	49	10,370
	52	7.610
	56.	tO0.95,
**************	....	------------
sum		613,663
RITZVILLE	6	2.546
	7	38.446
	8	1,189,129
....***********	....	------------
sum		1,230,121
RIVERWASH		2,972
		2.677
	W168	3.554
	W170	
	W171	1,527
	X174	11,025
	,	2.946

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SOILNAME	MLRA	ACRES_IN_MLRA
RIVERWASH	1,3	343
	10	7,147
	11	10.249
	14	49.047
	15	507
	163	902
	17	62,895
	176	350
	18	3,799
	19	46.693
	2	31,256
	20	5,171
	21	5.338
	22	5.415
	23	1,071
	24	
	26	862
	28A	1,837
	3	2.074
	3.6	1,060
	30	45.740
	30-1	
	30-3	
	31	4.375
	32	1.252
	34	1.440
	35	20.920
	36	18,143
	37	29,514
	39	4,112
	4	1.440
	40	13.692
	41	5.963
	42	32.312
	43	6.686
	44	6.084
	46	600
	47	5.996
	48A	44,
	49	4.060
	5	5.479
	53A	3.590
	58A	17,548
	58B	
	6	5.063
	61	3.426
	67	693
	69	2.516
	7	1,813
	70	25.662
	77	9.058
	8	11,206
	9	2.766
**************	****	------------
sum		552,455
RIZNO	35	446.065
	39	212.603
**************	****	------------
sum		658.668
ROCK LAND		10.469
	1	49
	10	38
	13	2.036
	15	69.314
	161	29.534
	164	10.182
	166	58.306
	18	33.499
	2	2.810
	20	11,122
	22	4.623
	28A	60.076
	29	663
	3	1.160
	30	73.047
	35	28.730
	39	286.46,
	40	107,597
	41	196.689
	42	40.453
	43	7.803
	46	22.866
	47	47.22,
	5	20.772
	58A	11.529
	70	81,167
	8	362
**************	****	------------
sum		1,220,788
ROCK OUTCROP		450.944
	39	2.215
	A3·	612
	ULTI	,.428
	W168	39.76,
	1	58.129
	10	111,019
	11	212,088
	12	544
	13	130,787
	14	1,348
	15	358.363
	151	354
	157	2.062
ROCK OUTCROP	158	3,089
	159	2,756
	160	11.543
	161	84,142
	164	4 9 . 2 3 ,
	166	30.732
	167	463
	17	1,360
	176	21.600
	18	524.423
	193	715
	194	300
		3.418
	196	3,837
	197	1.07,
	199	7.584
	2	40.665
	2.3	7.663
	20	45,,938
	200	2.506
	20,	6,218
	202	480
	203	1,908
	2,	94.958
	22	1,218,251
	23	49,860
	24	46.903
	25	71,410
	26	93,549
	27	62.021
	28	4.012
	28A	92.225
	28B	128,397
	29	222.920
	3	157. ‘64
	3.6	11,683
	30	319.179
	30-1	
	30-3	
	30-4	
	32	218,070
	33	27.563
	34	630.662
	34B	
	35	1.937.123
	3539	15.032
	36	1,208,526
	37	91.548
	39	260.366
	39-4	
	4	
	40	220. 151
	40-3	

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SOILNAME	MLRA	ACRES_IN_MLRA
ROCK OUTCROP	41	308,753
	42	792,236
	43	1,683,623
	44	61,555
	45	35,818
	46	155,291
	46A	3.604
	47	444.428
	48	347.037
	48 T	
	48A	1,005,006
	48B	35,419
	49	109,590
	5	123,430
	51	19,996
	52	8,057
	53A	6.651
	54	935
	58A	676.903
	58B	174,088
	583	1.769
	6	599.054
	6,7,	2.854
	60A	13,534
	609	
	61	29,539
	62	34.544
	64	
	67	83,171
	69	71.207
	7	50.382
	70	1,456,161
	72	13,086
	77	4,293
	8	325,111
	9	116,288
***************	****	-------------
sum		18,617,482
ROSITAS	30	149.029
	30-1	
	3,	313,709
	40	4.736
***************	....	-------------
sum		467,474
ROUGH BROKEN LAND	W170	7.320
	14	30.116
	15	9.900
	159	27.392
	162	5.784

SOILNAME	MLRA	ACRES_IN_MLRA
ROUGH BROKEN LAND	164	55,332
	166	15,776
	19	17,710
	19,2	19.046
	2	2.572
	20	4.520
	26	3.976
	28A	4.100
	3	6.478
	30	26.155
	35	3.140
	36	29.077
	39	75.312
	40	9.09,
	4,	(67.530
	42	39.92,
	47	3.160
	67	2.090
	69	'3.734
	77	10,094
***************	****	-------------
sum		588,116
RUBBLE LAND		20.476
	W170	
	10	20.390
	11	29.041
	13	1.830
	164	925
	176	600
	190	42
	192	62
	193	429
	21	63.422
	22	3,.598
	23	48,880
	24	4,264
	25	24,959
	26	15,434
	27	13.133
	28A	8.430
	28B	8.007
	3	25.957
	30	14,727
	30-3	
	34	13.964
	35	18,915
	42	29.715
	43	134,436
	44	1,895
	45	39.584

SOILNAME	MLRA	ACRES_IN_MLRA
RUBBLE LAND	46	2.452
	4,	14,485
	48	819
	48A	255,212
	5	854
	6	78.351
	7	9.645
	70	86,088
	8	26.726
***************	****	-------------
sum		1,045,666
SAN JOAQUIN		6.695
	17	439.924
.....**********	****	-------------
sum		446.509
SCOBEY	46	796
	52	441,068
***************	****	-------------
sum		441,864
SHANO	11	51,431
	7	589,267
	7 8	6.544
	7.8	1.195
	8	
***************	****	-------------
sum		648.427
SHEPPARD	34	6.542
	35	452.042
	36	91.422
	37	323,337
	42	53,733
***************	. ..*	-------------
sum		927.076
SHINGLE		8,005
	32	63.498
	34	77.254
	36	6.437
	46	7,494
	49	4,440
	59	94,929
	58B	545,049
	60A	42.620
	6,	9.079
	67	63.89,
	69	40.354
. . . .*..	****	
sum		963,039

Tue May 29

SOILNAME	MLRA	ACRES_IN_MLRA
SIMONA	42	530,251
sum		530,251
SPRINGERVILLE		11,419
	35	49,659
	3539	75,285
	39	364,224
sum		500,597
STELLAR	41	14,061
	42	435,557
sum		449,618
STONEHAM		23,170
	46	1,094
	49	770
	58	6.343
	58B	46,660
	67	3.96. 104
	69	111,544
	72	1.500
sum		578,185
TENCEE	30	15,150
	42	479.027
	70	12.320
sum		506,497
THEDALUND	34	127.268
	49	4,094
	58A	219,655
	58B	1,032
	60A	19,202
	6,	4.260
	67	40,995
sum		416,506
THUNDERBIRD	35	3,704
	3539	99.452
	36	33,666
	39	451,048
	39-4	
	40	175
	70	16.625
sum		603.470

SOILNAME	MLRA	ACRES_IN_MLRA
TIVOLI	67	40,024
	69	111,131
	70	492
	77	277.240
sum		428,887
TORRIORTHENTS		126.350
	11	1,384
	13	26,072
	15	1,010
	17	13,558
	23	1,536
	28A	
	29	25,774
	30	30.111
	30-1	
	34	367.246
	35	142.975
	36	32.692
	37	13,003
	40	3.216
	40-3	
	41	35.401
	42	62.563
	48	63.705
	48A	43.620
	51	
	58B	27.729
	6.7	3.053
	7	639
	70	30,908
	77	14.010
	8	606
sum		1,109,461
TORTUGAS	29	13.764
	30	10,370
	39	192.672
	4,	29.651
	70	222.936
sum		465,593
TRAVESSILLA		5,425
	32	17,089
	34	66.622
	35	74.662
	36	163,026
	37	1,457
	39	9.442
	49	90.597

SOILNAME	MLRA	ACRES_IN_MLRA
TRAVESSILLA	58A	178,491
	58B	5,894
	60B	5.594
	67	67.252
	69	116.907
	70	622.701
	77	1.004
sum		1,326,053
TRES HERMANOS	40	31.166
	41	151.386
	42	292; 324
sum		464,876
TYPIC CRYOCHREPTS		4.212
	176	219,645
	43	499.230
sum		723.067
UPTON	42	656.664
	70	49.340
sum		706.204
URBAN LAND	W170	259
	X176	969
	1	634
	10	1.729
	11	9,425
	14	64,720
	15	30.875
	16	455
	17	81,583
	18	44,
	19	59.627
	190	290
	191	37
	192	676
	193	334
	194	3,
	195	232
	196	792
	199	7.600
	2	94.610
	20	7,814
	200	, ,669
	201	293
	202	1.498

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SOILNAME	MLRA	ACRES_IN_MLRA
URBAN LAND	26	4,075
	30	6.578
	4	168
	42	1.110
	44	6.230
	49	12.506
	5	552
	58B	7.570
	7	475
	8	6.367
**************	****	------------
sum		412,060
USTIC TORRIORTH ENTS		
	34	21,952
	35	176,151
	36	35.245
	39	19.9.3
	44	7,110
	46	1.807
	48A	
	49	92.633
	58A	112,319
	58B	12.229
	60B	
	67	18,776
	70	663
	72	
..........******	****	------------
sum		499,028
VALENT		72.710
	599	3,769
	67	766,765
	69	61,411
	72	620.642
	7,	9,114
**************	....	------------
sum		1,754,410
VIDA	52	149,098
	531	377,610
...........*...	****	------------
sum		526.706
VONA		46.296
	58A	20.966
	58B	6,259
	6,	570.289
	69	270,800
	72	14.63,

SOILNAME	MLRA	ACRES_IN_MLRA
**************	****	------------
sum		929,249
WALLA WALLA	8	906,255
**************	****	------------
sum		906.255
WARDEN	7	340.360
	7,8	88,014
	8	1,716
**************	****	------------
sum		430.110
WATER		490.147
	25	2.54,
	£47	523
	M	40.635
	WATE	30
	W168	17,205
	"170	12.535
	X174	70.973
	X176	2.291
	1	90.290
	1.3	1.266
	10	21.524
	11	76.120
	13	55.337
	14	75.672
	15	209.120
	17	113.994
	174	8.250
	176	1.500
	16	16.942
	19	6.643
	2	125.196
	20	7.422
	200	198
	21	85,461
	22	36,056
	24	1.331
	25	4,620
	26	43,919
	2,	65.966
	26	3.679
	28A	699,399
	266	232
	3	29.365
	30	9,188
	31	19.096
	34	24,106
	35	49.016
	36	14,618
	41	2.050

SOILNAME	MLRA	ACRES_IN_MLRA
WATER	42	45,068
	43	129,574
	44	22.691
	4,	7.256
	46	3.781
	48A	15.040
	48B	4.761
	5	23.540
	51	5,174
	52	4.304
	53A	19.775
	58A	34,111
	6	36.701
	604	12,776
	6,	49.740
	69	32.506
	7	36.767
	70	20.606
	6	30.56,
	9	19.057
• ****.*..***,.*	****	------------
sum		3,118,713
WELD		27.500
	67	668,167
	69	7.396
	72	1.410
• **.**.*......	****	------------
sum		704.473
WILEY		26.779
	49	4.660
	6,	749.623
	69	550.955
• *.*.***.***.**	****	------------
sum		1.334.437
WILLIAMS	46	351
	52	183,580
	53A	1,083,897
	54	1,260
. . ...*......*..	....	------------
5""		1,269,088
WINK	42	509.466
....	. ..*	------------
sum		509,466
WINONA	35	757,767
	36	35.996
	39	14.646
	70	40,136
. . ..**...*.*.*.	****	------------

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Tue May 29

Soils Whose Acreage Exceeds 400,000 Acres in the Western NTC

SOILNAME	MLRA	ACRES_IN_MLRA
sum		848,547
WITT	35	3,653
	36	9,481
	39	83,774
	48A	
	70	314,714
sum		411,622
YAMAC	46	
	48	17,977
	52	13,295
	58A	461,427
sum		492,699
ZAHILL	52	79,609
	53A	1,092,779
sum		1,172,388

926 records selected.

National Soil Survey Laboratory
Activities Report
June 1990

Since our last conference, Dr. Ellis Knox became the Head of The National Soil Survey Laboratory and in that capacity is the SCS National Leader for Soil Survey Investigations. Dr. Carolyn Olson is the head of the new Field Investigations staff that was added a year and a half ago. New liaison assignments to states and other personnel changes those are reflected on our current staff listing. Those are available to those of you who want them.

We have received the OPM vacancy announcement for a GS-11 research soil scientist to work primarily with our datasystems. This will draw from all sources and hence will not be on the familiar SCS "green sheets". We will soon announce another research soil scientist vacancy, likely for emphasis in soil chemistry. So, if you know of qualified candidates, please have them contact Dr. Xnox or one of the Laboratory Staff members.

Analytical Activities

The number of samples that we receive has increased each year for the last several years. Last year we received about 260 projects with about 8,600 samples on which nearly 190,000 analyses were completed.

A new Soil Survey Laboratory methods is being written and is complete except for final in-house editing. We can provide it as a draft document to NCSS cooperators on request before the end of this calendar year. We plan for it to replace Soil Survey Investigations Report No. 1 after being subjected to a more formal editorial review.

To provide more software uniformity between our analytical instruments and our data storage units we are in the process of purchasing, a Laboratory Information Management System **(LIMS).** We expect this system to automatically provide some analytical laboratory management tools that we currently lack or have to maintain manually. We anticipate that this will further improve analytical efficiency.

Data Bases and **Records**

As in the past, as soon as analyses are complete and stored in the mainframe computer, they are electronically available to you using the INTERACT program to access the National Soil Survey Laboratory Database.

Use of the NSSL database is limited by the lack of classification of many of the pedons. We are modifying the instructions for the Soil-8 forms to separate the family classification of the pedon itself from the correlation procedure. The classification of the pedon based on the field description and laboratory data can be made as soon as the data are available. We know that the classification of the pedon is likely to differ from the classification of the series identified at final correlation, so there is no need to wait for completion of the survey or for final correlation to force a match with the family of the correlated series. We would like to have the classification of the pedon determined by the states, but if classification is separated from correlation issues, then any competent, informed soil scientist can classify.

The National Soil Characterization Data Base development is moving closer to reality with the location of Ellis Benham at the Soil Survey Laboratory. Ellis is an Auburn University Ph.D. candidate employed by Texas A&M University. This database will incorporate data from all NCCS contributing laboratories. The associated committee has experiment station representatives from each region in addition to the SCS members. Analytical data and descriptions with software for manipulation of the data will be distributed periodically on CD ROM to make it available to the SCS and other participants in the National Cooperative Soil Survey.

Training

A great deal of our staff time is spent training other soil scientists. Warren Lynn continues to serve as technical coordinator for lab data courses with three or four sessions taught in Lincoln and usually in one or two other locations each year. Most of the staff helps with these courses. Warren represented NSSL in the joint effort with the NSSQA staff to pilot two sessions of a new soil survey course this year. NSSL staff members also teach at the Soil Science Institute, the soil salinity course, and soil correlation courses.

For the third year, our staff had a well-received presentation at the National Science Teacher's Conference.

Research and Development

Since the list of research activities in which our staff is involved is quite long, permit me to highlight some representative ones.

Study	Leadership
N.C. Mountain Soils Study and Tour	Lynn
Int'l Soil Correlation Meetings	Kimble
Humic Substances Characterization	Sobecki, Kaisaki
Saline Seeps	Reinsch
Drainmod parameters from S-5 data	Baumer
Particle size by transducer	Reinsch, Baumer
Soil Data Interrelationships	Brasher
Soil Geomorphology SSIRs	Gamble
Soil Climate	Paetzold
Statistical Techniques for Soil Variability	Paetzold
MLRA Projects	Brasher, Olson, Nettleton
Wisconsin Soil Moisture Study	Yeck, Baumer, Olson, Paetzold, Gamble
Soil surface and ephemeral properties	Grossman
Water dispersible clay	Burt
Reconstructed bulk density for Ap horizons	Grossman
Illinois - Till plain study	Olson, Nettleton
Missouri Ozarks	Gamble
New England Bedrock study	Doolittle
Great Plains projects	Field Investigations Staff, Brasher, Nettleton
Oklahoma Panhandle	Olson, Brasher

Looking Ahead

We believe that the use of the data we have now and what we collect in the foreseeable future will be much more heavily concerned with soil survey interpretations. Those will include concerns on which we are already working such as water quality and some just coming onto the horizon such as global warming.

Priorities and protocols for getting additional data may change somewhat from our current ways of operating. Perhaps we will need to consider sampling representative soils in an MLRA instead of a county or group of counties. A proposed sampling protocol for MLRA updates is being written and reviewed by our staff. Some have suggested that the benchmark soils concept may again be a viable way to approach sampling. We may also find that our staff liaison assignments may need to be made in a different way. If you have some thoughts about these topics, please tell me your ideas.

RONALD D. YECK

*** N S S L D A T A B A S E ***
P E D O N C O U N T S
01/May/90

STATE	TOTAL	PRE1978	<---- 1978-UP	1978 & UP W/TAX	NO TAX	DESCRIPTION	CORRELATED ---->
NOT IDENTIFIED	35	2	33	0	33	0	0
ALASKA	344	80’	264	29	235	207	28
ALABAMA	104	19	85	72	13	35	71
AMERICAN SAMOA	25	10	15	15	0	15	15
ARKANSAS	70	27	43	14	29	26	14
ARIZONA	581	295	286	38	248	198	38
CALIFORNIA	1193	529	664	116	548	341	74
COLORADO	482	212	270	8	262	143	8
CONNECTICUT	23	8	15	15	0	11	15
DISTRICT OF COLUMBIA	3	3	0	0	0	0	0
DELAWARE	24	15	9	0	9	3	0
FLORIDA	155	94	61	4	57	13	4
FOREIGN NATION	894	3	891	566	325	652	560
GEORGIA	244	54	190	69	121	101	64
GUAM	20	0	20	19	1	16	19
HAWAII	42	7	35	17	18	21	17
IOWA	780	146	634	443	191	543	409
IDAHO	554	129	425	189	236	199	59
ILLINOIS	479	142	337	90	247	197	101
INDIANA	319	9	310	94	216	70	84
KANSAS	346	111	235	126	109	126	126
KENTUCKY	244	85	159	70	89	100	71
LOUISIANA	230	124	106	71	35	32	37
MASSACHUSETTS	89	69	20	4	16	5	4
MARYLAND	150	17	133	0	133	96	0
MAINE	121	63	58	14	44	18	7
MICHIGAN	173	90	83	31	52	34	31
MINNESOTA	151	108	43	26	17	38	27
MISSOURI	327	82	245	100	145	93	99
MISSISSIPPI	163	123	40	30	10	29	29
MONTANA	538	296	242	72	170	95	53
NORTH CAROLINA	268	59	209	51	158	86	51
NORTH DAKOTA	424	171	253	173	80	53	172
NEBRASKA	752	292	460	159	301	224	105
NEW HAMPSHIRE	107	70	37	2	35	30	2
NEW JERSEY	86	54	32	29	3	26	29
NATIONAL LABORATORY	79	0	79	0	79	0	0
NEW MEXICO	368	137	231	94	137	104	72
NEVADA	600	261	339	14	325	181	14
NEW YORK	279	75	204	46	158	84	19
OHIO	32	6	26	18	8	22	18
OKLAHOMA	163	68	95	10	85	69	8
OREGON	478	285	193	1	192	68	18
PENNSYLVANIA	57	40	17	2	15	0	2
PUERTO RICO	188	100	88	1	87	58	0
SOUTH CAROLINA	85	30	55	14	41	21	11
SOUTH DAKOTA	412	198	214	3 3	181	111	33
TENNESSEE	228	168	60	15	45	52	1 5
TRUST PACIFIC ISLAND	37	0	37	35	2	27	36
TEXAS	706	273	433	240	193	255	229
UTAH	458	265	193	4	189	122	1
VIRGINIA	76	13	63	0	63	19	0

.65

*** NSSL DATABASE ***
PEDON COUNTS
01/May/90

STATE	TOTAL	PRE1978	<----- 1978-UP	1978 & UP W/TAX	NO TAX	DESCRIPTION	CORRELATED ----->
VIRGIN ISLANDS	12	8	4	0	4	4	0
VERMONT	175	73	102	39	63	67	39
WASHINGTON							
WISCONSIN	515 / 504	178 / 162	337 / 342	139 / 25	198 / 317	134 / 131	59 / 23
WEST VIRGINIA	159	59	100	51	49	71	51
WVOMING	412	191	221	9	212	93	10
GRAND TOTALS ------>	16563	6188	10375	3546	6829	5589	3083

TOTAL .... All of the pedons in the NSSL Database.
PRE1978 .... Pedons sampled prior to 1978 by the NSSL end it's predecessor laboratories.
1978-UP ...... Pedons sampled by NSSL beginning in 1978.
W/TAX .... Pedons classified by states or TSC's on NSSL Soil-8 forms returned to NSSL.
NO TAX .... Pedons not classified by states or TSC's.
DESCRIPTION Profile descriptions currently stored in the NSSL Database.
CORRELATED ... Pedons with a correlated series name shown on NSSL Soil-8 form returned to NSSL.

*** NSSL DATABASE ***
PEDON COUNTS
01/May/90

** WESTERN STATES **

STATE	TOTAL	PRE1978	<---- 1978 & UP ----> 1978-UP	W/TAX	NO TAX	DESCRIPTION	CORRELATED
ALASKA	344	80	264	29	235	207	28
ARIZONA	581	295	286	38	248	198	38
CALIFORNIA	1193	529	664	116	548	341	74
COLORADO	482	212	270	a	262	143	8
HAWAII	42	7	35	17	18	21	17
IDAHO	554	129	425	189	236	199	59
GUAM	20	0	20	19	1	16	19
MONTANA	538	296	242	72	170	95	53
NEW MEXICO	368	137	231	94	137	104	72
NEVADA	600	261	339	14	325	181	14
OREGON	478	285	193	1	192	60	18
TRUST PACIFIC ISLAND	37	0	37	35	2	27	36
UTAH	458	265	193	4	189	122	1
WASHINGTON	504	162	342	25	317	151	25
WYOMING	412	191	221	9	212	93	10
GRAND TOTALS ------>	6611	2849	3762	670	3092	1966	472

TOTAL........All of the pedons in the NSSL Database.
PRE1978......Pedons sampled prior to 1978 by the NSSL and it's predecessor laboratories.
1978-UP....Pedons sampled by NSSL beginning in 1978.
W/TAX.Pedons classified by states or TSC's on NSSL Soil-8 forms returned to NSSL.
NO TAX.Pedons not classified by states or TSC's.
DESCRIPTION .Profile descriptions currently stored in the NSSL Database.
CORRELATED . Pedons with a correlated series name shown on NSSL Soil-8 form returned to NSSL.

LIAISON ASSIGNMENTS 6/90

Area and States	Scientist
Pacific Northwest (WA, OR, ID)	Rebecca Burt/Fred M. Kaisaki
Montana	Richard L. Pullman
Lake States, Alaska (MN, WI, MI, AK)	Ronald R. Yeck
New England (ME, NH, VT, WA, CT, RI)	Laurence E. Brown
Lower Northeast (NY, NJ, PA, MD, DE, DC, WV, VA) and Northern Plains (NE, ND, SD)	Robert B. Grossman
Hawaii	Leo C. Klameth
Southwest (CA, NV, AZ, NM)	Otto W. Baumer
Intermountain (UT, CO)	Thomas G. Reinsch
Central Corn Belt and Central Plains (IA, IL, IN, OH, MO, KS, WY)	W. Dennis Nettleton
South Central (OK, TX, IA, AR)	Benny R. Brasher
Southeast and Puerto Rico (KY, TN, NC, SC, GA, MS, AL, FL, PR)	Warren C. Lynn

REGIONAL LIAISON

Midwest National Technical Center	W. Dennis Nettleton
Northeast National Technical Center	Robert B. Grossman
South National Technical Center	Warren C. Lynn
West National Technical Center	Otto W. Baumer

Updating Soil Surveys by MLRA
Soil Survey Investigations, Services and Perspectives
June 1990
(BRB)

1. Collect and summarize existing investigations data for the MLRA

   1.1 NSSL

   1.2 Universities

   1.3 Other Agencies

   1.4 Literature

2. Help develop MLRA map unit definitions

   2.1 Prepare or coordinate prepartion
       2.1.1 Surficial materials map - May need university help
       2.1.2 Geomorphic Surfaces map - May need university help

3. Plot information

   3.1 Location of sampling sites by county centriod

   3.2 Exact location of sample sites if coordinates are known

   3.3 Geographic Distributions of data and data relationships

4. Make field investigations

   4.1 Characterize series
       4.1.1 Over geographical range
       4.1.2 Over morphological range
       4.1.3 Both

   4.2 Determine modal concepts
       4.2.1 Classify series
       4.2.2 RV's (Representative value(s) for modellers)

   4.3 Determine Soil - Geomorphic relationships and soil genesis to help develop map unit definitions

   4.4 Characterize MLRA for regional and national planning

   4.5 Special or non-traditional investigations
       4.5.1 Water quality - surface runoff and deep leaching
       4.5.2 Erosion predictions
       4.5.3 Global change evidence
       4.5.4 Detect or quantify amounts of toxic elements (heavy metals - selenium, etc.)
       4.5.5 Long term monitoring of temporal properties - soil moisture, temperature, surface characteristics

5. What soils are chosen for sampling

   5.1 Most extensive in descending order.
       5.1.1 MUFF file
       5.1.2 Where do we stop - 50% of area - 75%?

   5.2 Potential new series

5.3 Those needed to determine Soil - Geomorphic Relationships

5.4 Fill gaps in Data Base
- 5.4.1 Need MLRA SOIL-8's completed to select soils

5.5 Those requested by States or QA staff

5.6 Those needed to study special problems

6. Sampling Protocol

6.1 Variable sampling patterns and number of sites depending on purpose and soil or landscape characteristics
- 6.1.1 Transects
- 6.1.2 Sample both ends of the range and the modal
- 6.1.3 If bimodal, characterize both distributions
- 6.1.4 Need a procedure.to determine sampling patterns

6.2 How do we determine and express the reliability of our sampling distribution and results

6.3 Dig sampling pit to at least 2 m if possible - auger deeper
- 6.3.1 Soil genesis and stratigraphy
- 6.3.2 Characterize for deep leaching of N, etc.

6.4 Sample all horizons, bulk samples and clods

6.5 Sample to characterize surface and near surface layers

7. Administrative Concerns

7.1 Determine a long range Investigations plan for the MLRA
- 7.1.1 NSSIV to try to accommodate special objectives when sampling for other purposes
- 7.1.2 NSSIV and other NSSC staffs agree on the long range plan
- 7.1.3 Clear long range plan with states and others
- 7.1.4 Incorporate or reference long range plan in M.O.U.

7.2 Cooperation with universities and other agencies.
- 7.2.1 University or agency appoint a representative
- 7.2.2 Procedure to share responsibility and activities
- 7.2.3 Fiscal support of graduate students
- 7.2.4 Joint publications

7.3 Responsibility
- 7.3.1 NSSIV to appoint a Coordinator for all NSSIV activities in the MLRA. May be several liaisons for a multi-state MLRA
- 7.3.2 One person on QA staff to have central responsibilty
- 7.3.3 There may be a local MLRA manager

7.4 Soil Survey Investigations Staffing
- 7.4.1 Additional staff may be required to handle field work

Canada's National Soil Data Base and Some Related Laud Evaluation and Interpretation Activities

C.A.S. Smith[1] and K.B. MacDonald[2]

LRRC Contribution No. 90-59

INTRODUCTION

The role of soil survey is changing from that of simply drawing and publishing soil maps to that of managing an ever increasing volume of soil related information. Temporal and spatial databases act as the fuel for land evaluation models and GIS. Users are as interested in the soil data bases as the printed map products.

The Canadian Soil Information System (CanSIS) is 8 soil geographic information system developed and supported by the Land Resource Research Centre of Agriculture Canada which, amongst other activities, develops and manages the National Soil Data Base which contains the location, attributes and biological productivity of major soils of Canada.

In this paper we describe some of the structures and levels of detail found in the National Soil Data Base. Some of the uses and interpretive products generated from this data source are given and where possible, comparisons are made with soil data bases developed by the USDA-SCS.

COMPONENTS OF THE NATIONAL SOILS DATA BASE

In many instances when dealing with spatial questions the cost in time money end expertise of collecting all the data required for every question is prohibitive. It is the philosophy of the Canadian Soil Information System (CanSIS) that general data bases at three levels of soil detail be maintained for baseline soil properties. The result is the National Soil Data Base (NSDB), a group of vector-based, thematic_ data bases operating on a commercial ARC/INFO GIS. Each of these has a defined and consistent format for associated attributes and a significant portion of Canada's land resource has been characterized within them (MacDonald, 1990).

Individual projects in land evaluation (defined here as studies integrating biophysical, climatic and socio-economic factors), and those requiring specialized interpretations can add attributes onto these general data bases as needed.

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National Level (1:5,000,000)

This data base supports the present Soils of Canada map. It contains information on climate normals, soil great group, land use and modeled yield data for five major crop types. This extensive series of attributes has been compiled and stored in the Land Potential Data Base. The map polygons cover large regional physiographic areas somewhat analogous to the USDA-SCS Major Land Resource Areas (MLRA's). One map sheet covers the entire country.

Pest risk assessment studies have been carried out using climate and soils data from the national level data base. For certain assessments it has been necessary to collect climate data from weather stations rather than using the general area estimates.

Regional Level (1:1,000,000)

This level incorporates Agriculture Canada's soil landscape series. In areas where detailed mapping exists, these maps are the products of generalization. Where no previous mapping exists (i.e. much of northern Canada) Landsat imagery or small scale aerial photography is used to delineate landscape polygons. The area of these landscape delineations varies considerably. Nationally, polygon sizes vary from 1,000 to 100,000 hectares with most falling into the range of 20,000 to 80,000 hectares. Two data bases, one for dominant soil and associated landscape properties and the second of subdominant soils, are linked to each polygon on the 26 maps that are being prepared for national coverage at this scale.

These data bases serve a similar function to the USDA-SCS STATSGO files. In addition to soil taxa and attributes they include information on geologic parent materials, vegetation cover, physiographic characteristics, drainage and water bodies. In some cases linkages to detailed level files are provided. These data have been used as a basis for a series of interpretive maps covering regional soil degradation problems. The soil landscape maps and associated interpretive maps help to answer questions of regional and national scope.

Detailed level (1:10,000 to 1:126,000)

A set of relational data files that contain information about the soil map unit, the soil name (series or association) and the individual horizons within the soil are linked to the detailed soil maps within CanSIS. The process of compiling this information from existing soil survey reports, laboratory records and expert estimates is an ongoing project. Over 1300 detailed maps reside within CanSIS but presently only a small number of these have the completed soil attribute files linked to them. These files are similar in nature and use to the USDA-SCS SSURGO data base although their structures differ.

A description of what makes up a complete digital soil map and the elements of that map have been outlined by MacDonald (1989). The relationship between the cartographic bases, the non-soil thematic information and the soil attribute files is shown in Figure 1. The symbolized soil theme is linked to a soil map unit file (SMUF). This lists the soil names and their abundance within the polygon of interest. Information about the soils is found in the soil names file (SNF) which are ordered by province. The soil layer file (SLF) contains the soil chemical and physical properties.

SOME LAND EVALUATION AND SOIL INTERPRETATION ACTIVITIES

These activities are occurring both at the Land Resource Research Centre headquarters in Ottawa and at the eleven soil survey units which are located in each province and the Yukon territory. Some projects involve the direct utilization of NSDB files and in other cases involve the creation and manipulation of regionally distinct databases.

Soil Landscape Degradation Maps

A series of interpretive soil degradation maps based on the regional (soil landscape) data base have been prepared or are in preparation. These data are augmented as necessary to make interpretations. A list of these interpretive maps are given in Table 1. Examples of two of these interpretive products are outlined below.

Table 1. Interpretive soil degradation maps and the provinces covered.

Map type	coverage
Wind erosion risk	Alta, Sask, Man, southern Ont
Water erosion risk	all provinces
Salinity	Man, Sask, and Alta
Acidification	BC, southern Ont, Que, Atlantic provinces

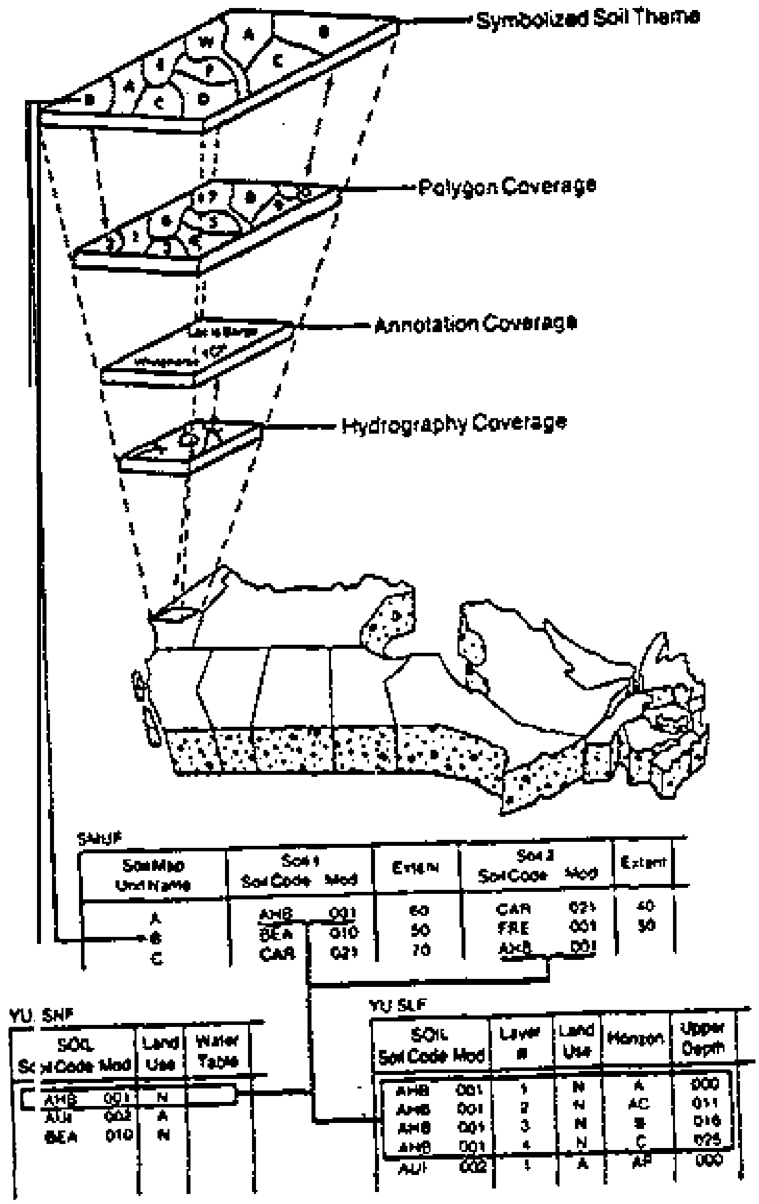
The classification of the risk of wind erosion (LRRC, 1987) is derived from data from the soil landscape data bases, climate data supplied by the Atmospheric Environment Service of Environment Canada and on a model for wind erosion that incorporates physical soil properties. Further interpretations are made about the degree of protection provided by the usual crop management practices within the soil landscape polygon. This incorporates crop and land use data from files of Statistics Canada.

The classification of soil salinity (LRRC, 1988) is achieved for surface and subsurface soils using soil attributes from the soil landscape map series and additional observations and laboratory values of soil electrical conductivity. Information about the extent and landscape position of salinity in map polygons is provided.

For the soil degradation map series a data base composed of relevant attributes is given in extended legend format accompanying the printed map and is available digitally.

FIGURE 1:

ELEMENTS OF A COMPLETE DIGITAL SOIL MAP:
Relationships



Agronomic Interpretations

An application of the NSDB to agronomic interpretations involves the computerized calculation of land capability classification for arable agriculture. The classification system was developed in Alberta (Pettapiece 1986) as an update of the Canada Land Inventory, Soil Capability Classification for Agriculture (Environment Canada 1965). The system employs point deductions to calculate a capability rating within a seven class system. While agricultural capability class systems do not have much favor within the USDA-SCS, they still have use in land use planning and land zoning in many parts of Canada.

There are three components to the classification; landscape, soil and climate. Each is rated separately and a final integrated rating is expressed related to the most limiting factor of each component. Economics are explicitly excluded from the rating system. Socio-Economic factors can be included in most comprehensive land evaluation models. Readers wishing details of the rating system are directed to Pettapiece (1986).

The landscape component of the system includes slope length, steepness, stoniness and landscape pattern. These may be measured directly in the field or obtained from NSDB data bases and topographic maps.

Climate factors include a moisture component and an energy component. Moisture is calculated as the difference between precipitation and potential evapotranspiration weighted for each month of the growing season and expressed as an index. The energy component is a calculation of the effective growing degree days. The system also incorporates a daylength factor. This factor effectively increases the growing degree-day value for regions between 50° and 65° N latitude to better reflect the productive realities of northern agriculture. In some parts of the country, agroclimatic maps display these values. Otherwise, calculations are based on the nearest long-term weather station normals.

The third component is soil. Factors for both organic and mineral soils have been defined. Surface factors for mineral soils (top 20 cm) include texture, structure, organic matter content, depth of topsoil, pH, salinity, sodicity and calcareousness. Subsurface factors are texture, structure, depth to non-conforming layer, acidity, salinity and sodicity. Drainage is another soil factor. All of these data are listed with the SNF and SLF of the detailed level of the NSDB. A CanSIS research effort has been to prepare programs to utilize detailed NSDB data records and generate agricultural capability ratings directly. It is anticipated that once fully functional these important interpretive maps could be generated quickly and consistently.

Land Evaluation Projects

There are many land evaluation projects being carried out in Canada by both government agencies and university departments. Described below are a few representative projects being undertaken by the Land Resource Research Centre.

The Prairie. Land Evaluation Project represents a project to carry out land evaluation on a regional basis. The model draws on data from national and regional levels of the NSDB. It also requires climate data and farming systems information. Modeled data on climate and crop indices and yield are created (MacDonald, 1990). Evaluations are based on agroecological resource areas (Pettapiece, 1989), areas within which common soil, landform and climatic conditions exist. The CanSIS research effort has been directed to developing a data model which allows for the organization, storage and integration of these diverse types of data.

A land analysis and decision support system (LANDS system) has been developed by staff LRRC staff in British Columbia (Moon et al., 1990). Originally developed for applications in Malaysia, this land evaluation tool has been applied at a detailed level in northern B.C. The LANDS system integrates GIS applications with relational data base management. Programs and procedures are used to construct a mathematical program to match crop systems to land types. The resulting land use plan maximizes net farm income for the region of study. The LARDS system uses a GIS module to define land management units. The various components of the LANDS shell are shown in Figure 2.

SUMMARY

The NSDB contains information stored in a variety of data base structures at three levels of detail. Parallel, but somewhat differently structured soil data bases are maintained by the USDA-SCS. The objectives of the soil landscape (regional) maps and data base series are similar to those of the STATSGO project. Within Agriculture. Canada work continues on linking over 1300 detailed maps within CanSIS to detailed soil map unit, soil name and soil layer files which act as storage and retrieval mechanisms for information similar to that in the SSURGO data base.

There is a range of active research and development applications using NSDB data. Within the federal soil survey these are related to soil degradation mapping, agricultural land capability assessment and land evaluation projects at varying level of detail. Research_ efforts not only lead to a clearer understanding of the uses and limitations of the NSDB but also knowledge of other data available and an increased supply of data for future uses.

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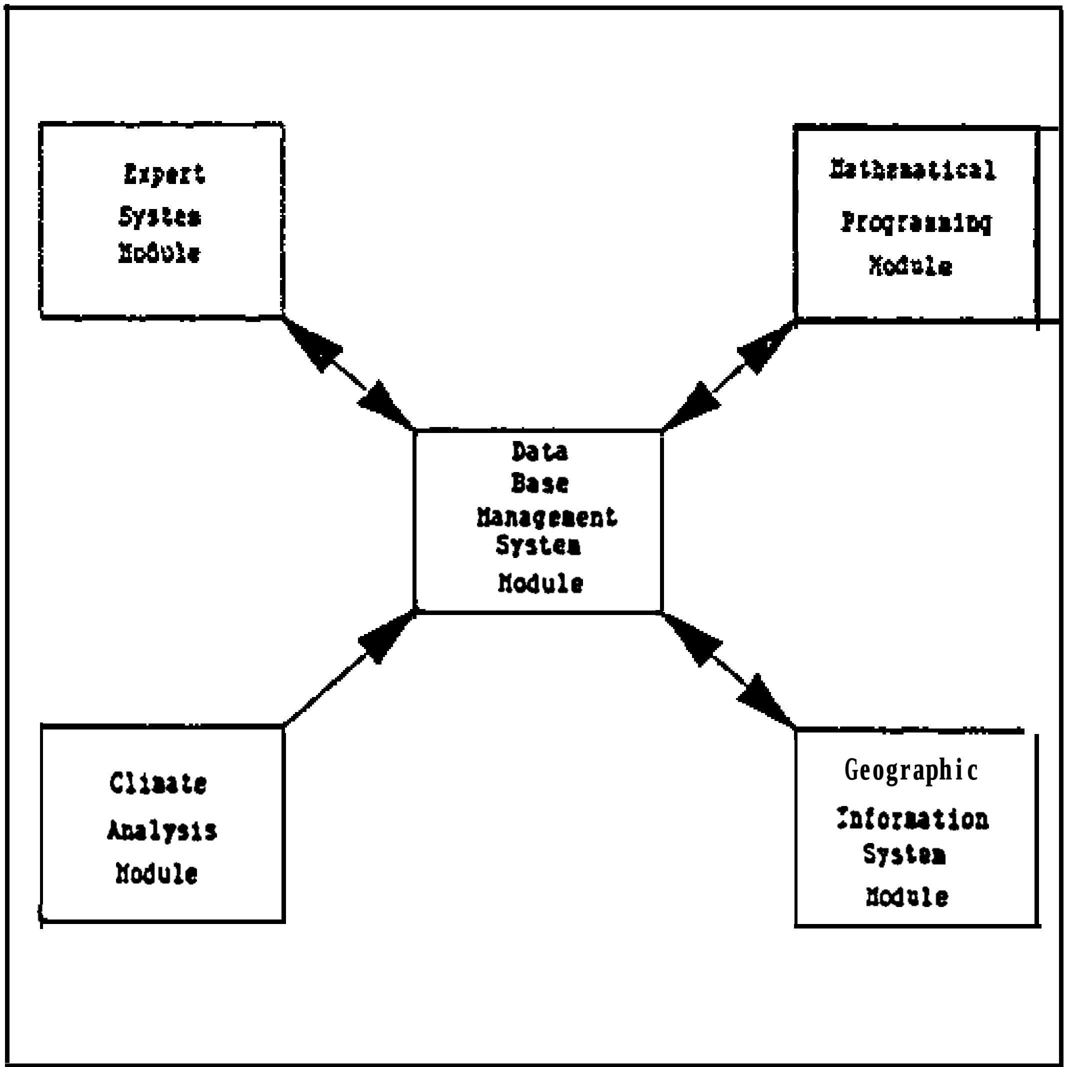

Figure 2. The LANDS shell outlining the components of a land evaluation system in B.C.

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SOIL INVENTORY AND MANAGEMENT

IN THE ALASKA REGION, USDA FOREST SERVICE

Earl B. Alexander

Regional Soil Scientist, Juneau, AK

The Forest Service manages 22.4 million acres of land in Alaska - 5.68 million on the Chugach National Forest in south-central Alaska and 16.75 million on the Tongass National Forest in southeast Alaska (Fig. 1). The Tongass National Forest has bee" divided into 3 adiministrative Areas, each larger than any Forest in any other Region. Timber, wildlife, fisheries, mining, and recreation are the main resource management concerns. The Forest Service practices integrated resource management, which means that no resource is managed without considering the others.

Physiography

Both Forests of the Alaska Region are in the Pacific Coast and Mountain System (Wahrhaftig, 1965). The mountains in the Alaska portion of this system are constructed of allochthonous terranes, a series of fault-bound disjunct crustal fragments that have accreted to the North America" continent during subduction of the Pacific plate (Robert Thorson in Muhs et al., 1987). Mostly, they are weakly-metamorphosed volcanic sedimentary assemblages and many plutonic bodies. The coastal plain around the Gulf of Alaska is "arrow, discontinuous, with 5,490 m Mt. St. Elias within 33 km and 4,660 m Mt. Fairweather within 15 km of the present coastline.

Practically all of the Region was covered by ice during the Pleistocene (Coulter et al., 1965). Extensive ice fields remain along the crests of the higher mountains along the coast. These contribute ice to numerous glaciers, including the largest piedmont glaciers in North America. Some glaciers flow into the sea, where ice is harvested commercially.

The present climate is cool and wet. Most of the Region is perhumid. Nearly all of the soils have cryic temperature and perudic moisture (Patric and Black. 1968; Patric and Stephens, 1968) regimes. Few of them freeze, due to thick snow accumulations. Soils at the lowest latitudes and altitudes, where snow cover is often discontinuous through the winter, freeze most frequently.

Spruce-hemlock forests have migrated northward during the Holocene (Heusser, 1985) to occupy, along with muskeg, most of the land below timberline. Timberline is about 800 m in the south (Stevens, 1965) to about 300 m above sea level around the northern margin of the Gulf of Alaska. The muskeg vegetation is primarily sedges, rushes, and mosses, commonly with sparse scrubby trees.

Weathering is rapid, based on chemical denudation rates (Stednick, 1981), due to the wet climate. Little clay is formed, however, due to the predominance of dissolution over precipitation and crystallization, although biotite is altered to vermiculite eve" in alpine environments (Thor" et al., 1984). Spodosols mature in a few hundred years and become predominant in forested areas (Alexander et al., 1990), although both well- and poorly-drained organic soils (Folists and Lithic and Terric Cryosaprists) are common. All muskeg soils are organic (Fibrists, Hemists, and Saprists). The soils of the Alaska Region are sinks for organic carbon fixed from carbon-dioxide by photosynthesis (Alexander et al., 1989).

Currently, mass wasting and stream cutting are the main processes of erosion (Swanston, 1969). There is little particulate erosion by the overland flow of water in most of the Region.

Soil Inventory

All of the Tongass National Forest, except National Monuments and Wilderness Areas, has been mapped at order 3 or 4 levels of detail (Table 1). Correlation of these inventories on the 3 Areas (Table 1) of the Forest should be completed within 2 years. Soil map units are complexes and associations of series for order 3 and higher taxa or combinations of series and higher taxa for order 4 inventory. Map unit composition was determined by traverse. mostly between helicopter drops.

Table 1. Soil inventory in the Alaska Region of the Forest Service: area (acre) mapped and being correlated to conform to NCSS standards.

Forest/Area	Order Of Detail		No NCSS	Total
	3	4	Mapping*	(acres)
Chugach	327,000	0	5,357,000	5,684,000
Tongass				
Chatham	2,600,000	2,559,000	2,786,000	7,945,000
Ketchikan	2,785,100	492,450	1,889,150	5,166,700
Stikine	3,392,500	275,500	0	3,668,000

* A few million acres mapped on the Chugach N.F. have never been correlated to NCSS standards.

Only 327,000 acres on the Chugach National Forest have been mapped to National Cooperative Soil Survey (NCSS) standards; correlation is scheduled for completion this year. An ecological classification and inventory program has been initiated on the Chugach National Forest. Soil data collected in this inventory will be utilized to revise mapping already done, but not correlated, and bring the inventory of millions of acres to NCSS standards.

Soil Management

The major incentive driving field mapping of the Tongass National Forest to completion was the realization by land managers that soil maps are basic natural resource information, essential for good Forest land management planning. Because landform boundaries were considered to be soil map unit boundaries, landform maps can be generated from the soil data in the GIS. Plant associations were described and identified at pedon locations; thus maps of potential natural vegetation can also be generated from soil data in the GIS.

Soil map information in the GIS has been utilized to develop wetlands maps and many different kinds of interpretive maps. Many of our interpretations, such as slope stabilty or mass failure hazard, might be considered the domain of another discipline, but soil scientists are the ones making the interpretations because they are the ones who have obtained the geographic data. We still make on-site investigations in the planning of timber sales and other management activities. In the future, we will be doing more monitoring of the effects of management activities on soils and the cover that protects them from erosion. We have best management practices (BMPs) and soil quality standards (SQSs) to guide management and support monitoring in our activity areas.

Acknowledgements. Forest soil scientists of the Alaska Region have been very helpful in supplying and verifying information in this article: Dean Davidson, Chugach National Forest, and on the Tongass National Forest, Everett Kissinger, Stikine Area, David Loggy, Ketchikan Area. and Randolph West, Chatham Area.

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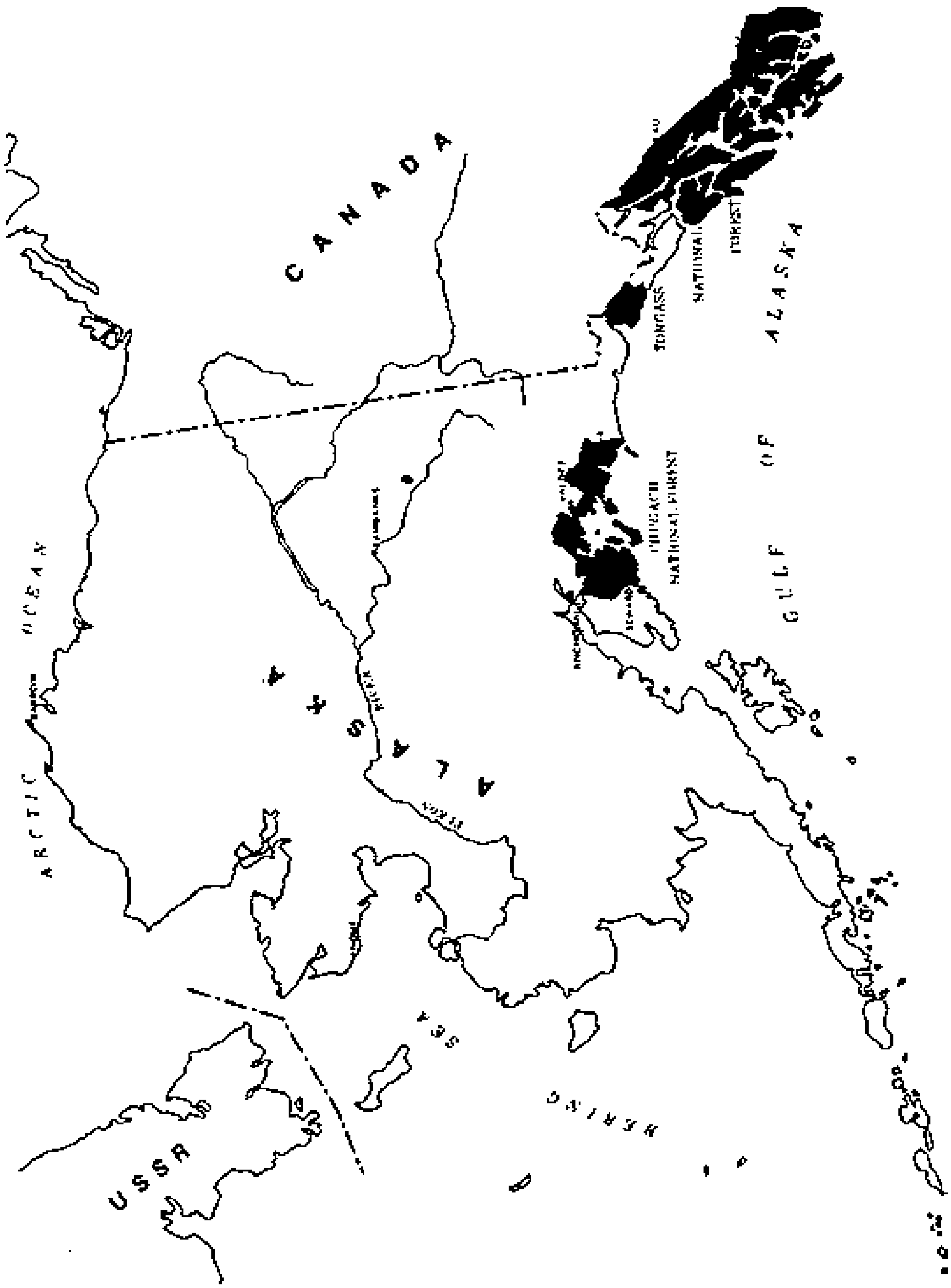


Figure 1. Locations of the Chugach and Tongass National Forests (solid black areas on map) in the Alaska Region.

CLIMATE AND TERRAIN CHALLENGES TO SOIL SURVEY IN ALASKA

Hayes C. Dye, State Soil Scientist/
State Resource Conservationist

Anchorage, Alaska

I will briefly discuss three topics. The first is to aquaint you with the Alaska SCS program and its employees (see attachments 1, 2, and 3); the second, a bit of history in the Alaska soil survey program which began with Hugh H. Bennett and Thomas D. Rice in June 1914; and lastly, a broad overview of Alaska's regions, climate, native people as well as some trivia about Alaska's land, mountains, lakes, and tides.

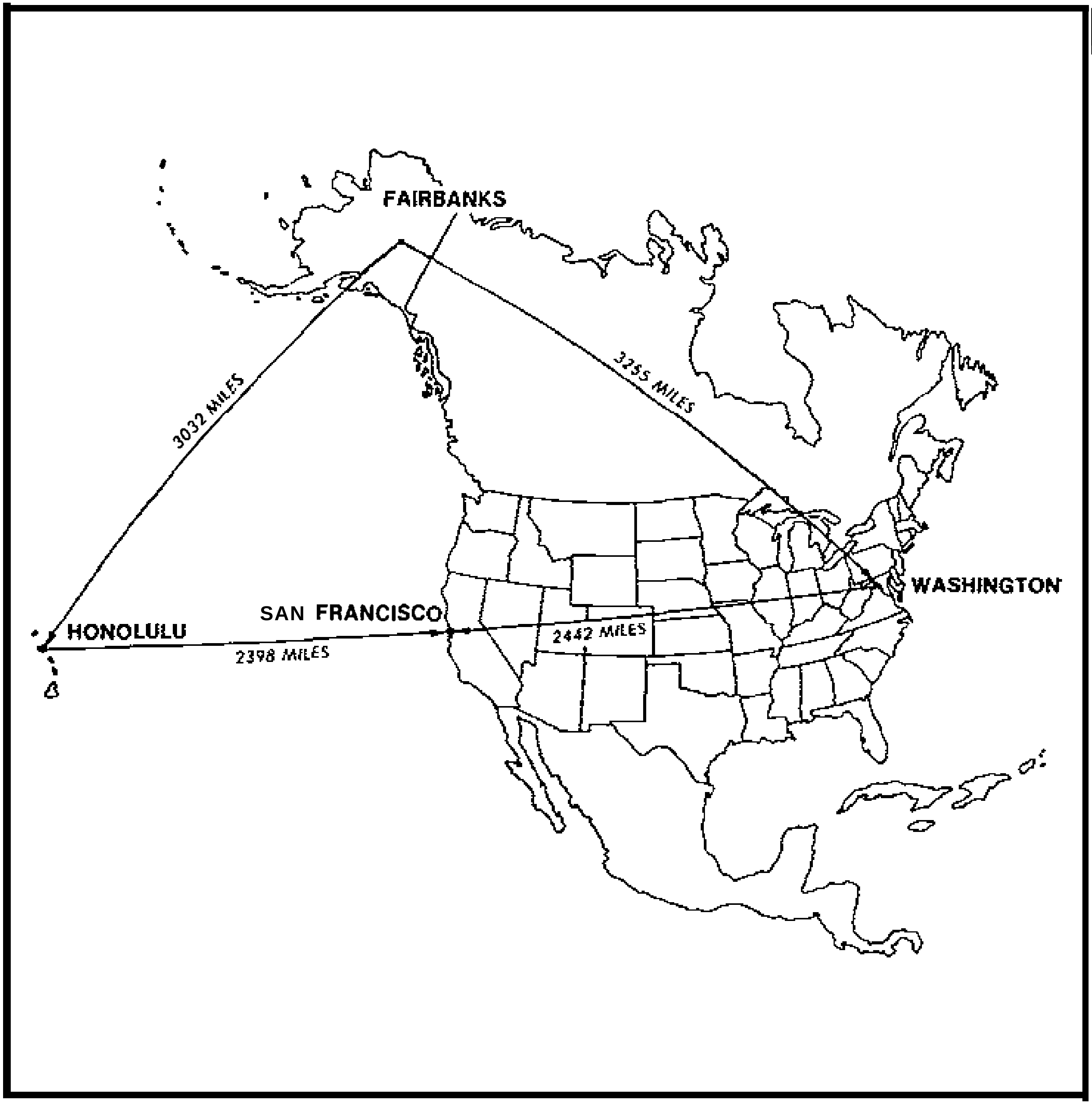
I also have a few slides from the archives that'll let us reminisce about field camps, vehicles, weather and perhaps a few hazards to Alaska soil surveyers.

Although Alaska Is a young state, her history in soil surveys is long. Dr. Sam Rieger, the first State Soil Scientist for Alaska, will be discussing the history of the *Exploratory* ***Soil Survey of Alaska*** with us today. But even before the exploratory. Hugh H. Bennett had a charge beginning In June 1914 to come to Alaska, then a territory. and Investigate several areas.

The letter of transmittal and introduction are particularly important to Alaska and to me, the third State Soil Scientist for Alaska (see attachments 4 and 5).

Alaska is divided into six regions (see attachment 6).

Southeast- Southeast, Alaska's panhandle. stretches approximately 500 miles from Icy Bay, northwest of Yakutot, to Dixon Entrance at the United States-Canada border beyond the southern tip of Prince of Wales Island. Massive ice fields, glacier-scoured peaks and steep valleys, more than a thousand named islands, and numerous unnamed islets and reefs characterize this vertical world where few flat expanses break the steepness, Spruce, hemlock and cedar, basis for the region's timber industry. cover many of the mountain-sides.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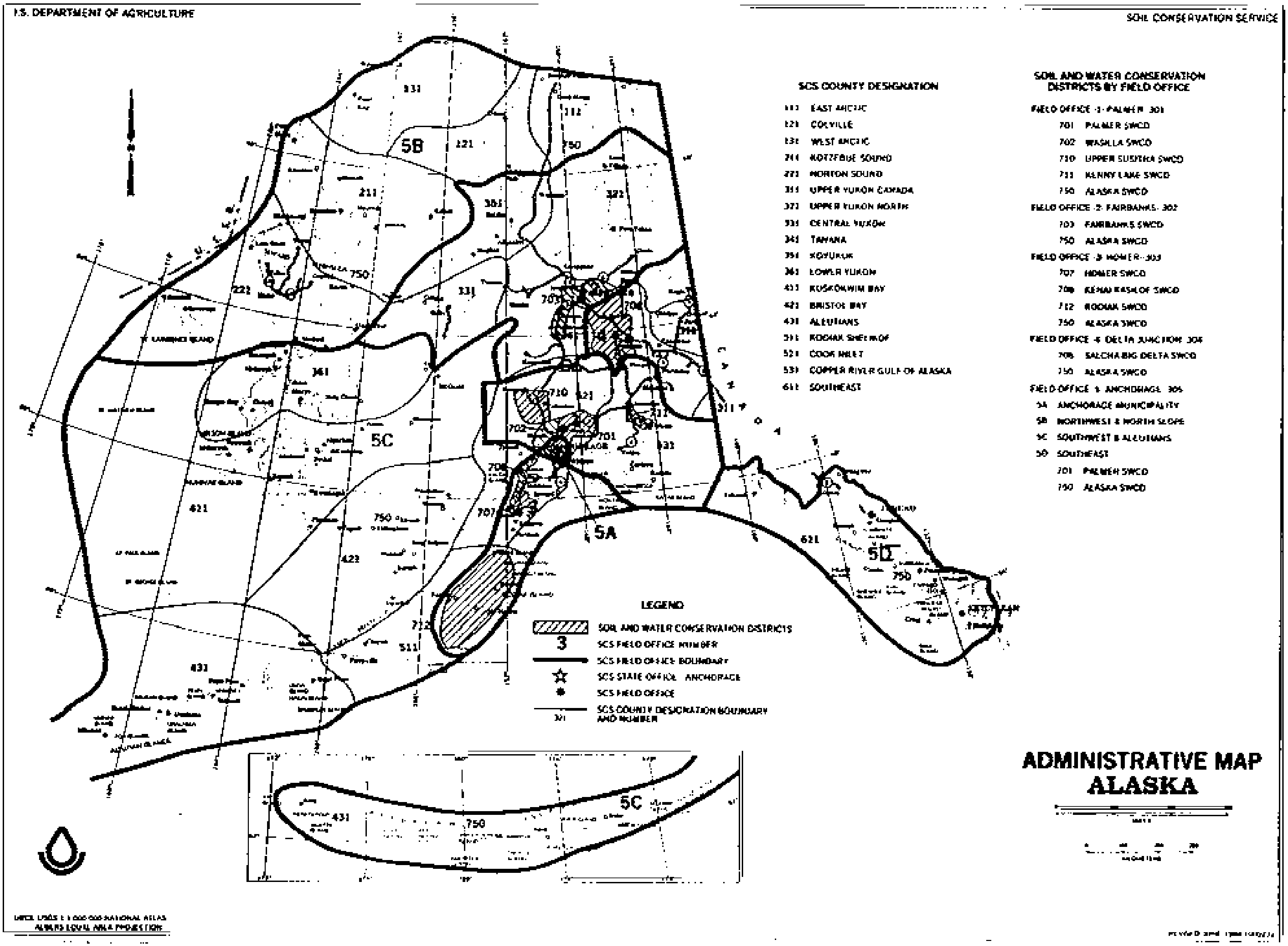
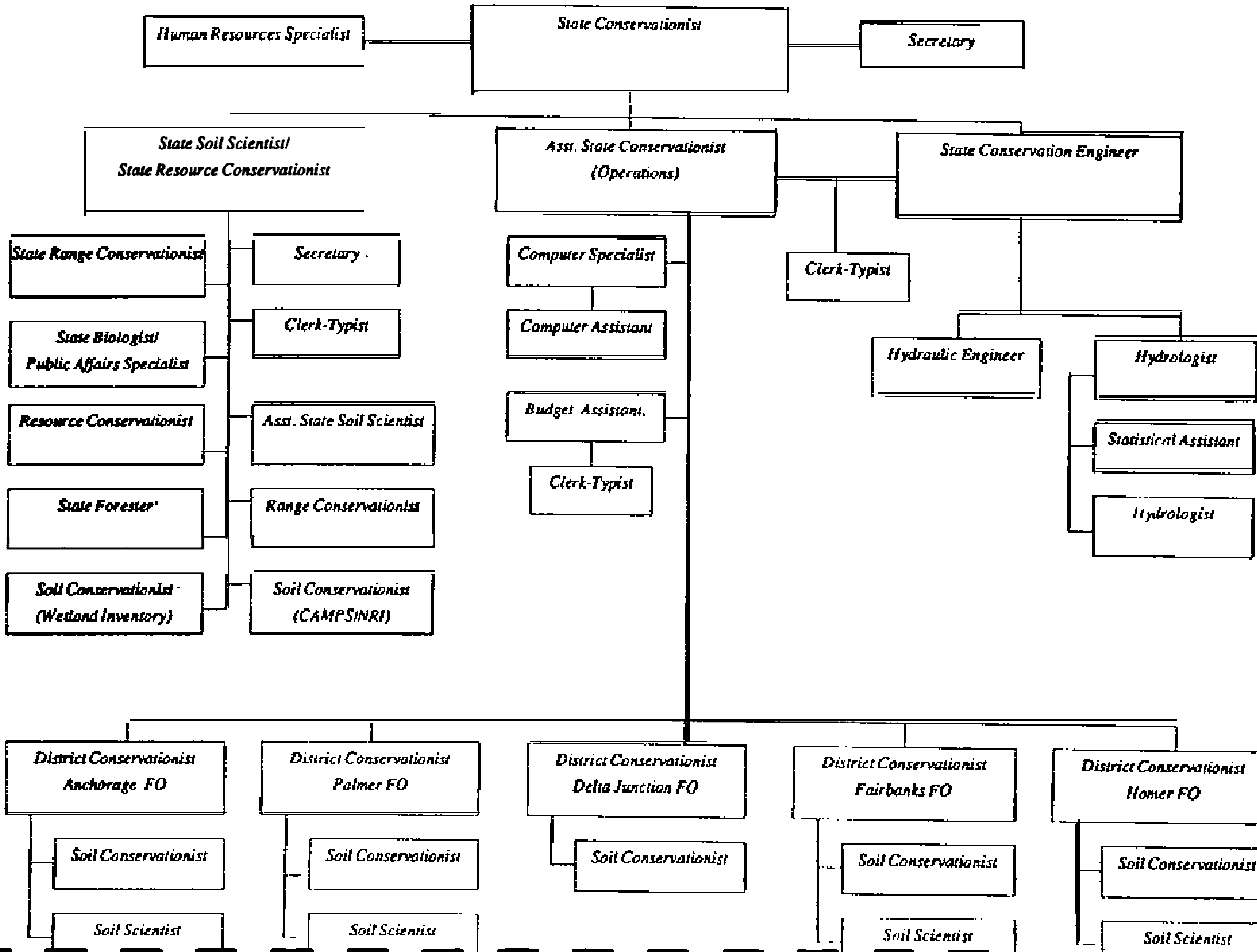
3032 MILES
3255 MILES
HONOLULU
SAN FRANCISCO
2398 MILES
2442 MILES
WASHINGTON

Atch 1

3 85


U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SCS COUNTY DESIGNATION
111 EAST ARCTIC
121 COLVILLE
131 WEST ARCTIC
211 KOTZEBUE SOUND
221 NORTON SOUND
311 UPPER YUKON CANADA
321 UPPER YUKON NORTH
331 CENTRAL YUKON
341 TANANA
351 KOYUKUK
361 LOWER YUKON
411 KUSKOKWIM BAY
421 BRISTOL BAY
431 ALEUTIANS
511 KODIAK SHELIKOF
521 COOK INLET
531 COPPER RIVER GULF OF ALASKA
611 SOUTHEAST
SOIL AND WATER CONSERVATION DISTRICTS BY FIELD OFFICE
FIELD OFFICE -1- PALMER 301
701 PALMER SWCD
702 WASILLA SWCD
710 UPPER SUSITNA SWCD
711 KENNY LAKE SWCD
750 ALASKA SWCD
FIELD OFFICE -2- FAIRBANKS 302
703 FAIRBANKS SWCD
750 ALASKA SWCD
FIELD OFFICE -3- HOMER 303
707 HOMER SWCD
708 KENAI KASILOF SWCD
712 KODIAK SWCD
750 ALASKA SWCD
FIELD OFFICE -4- DELTA JUNCTION 304
706 SALCHA BIG DELTA SWCD
750 ALASKA SWCD
FIELD OFFICE -5- ANCHORAGE 305
5A ANCHORAGE MUNICIPALITY
5B NORTHWEST & NORTH SLOPE
5C SOUTHWEST & ALEUTIANS
5D SOUTHEAST
701 PALMER SWCD
750 ALASKA SWCD
LEGEND
SOIL AND WATER CONSERVATION DISTRICTS
SCS FIELD OFFICE NUMBER
SCS FIELD OFFICE BOUNDARY
SCS STATE OFFICE ANCHORAGE
SCS FIELD OFFICE
SCS COUNTY DESIGNATION BOUNDARY AND NUMBER
5A
5B
5C
5D
ADMINISTRATIVE MAP
ALASKA

Atch 2


State Conservationist
Human Resources Specialist
Secretary
State Soil Scientist/
State Resource Conservationist
Asst. State Conservationist
(Operations)
State Conservation Engineer
State Range Conservationist
Secretary
Clerk-Typist
State Biologist/
Public Affairs Specialist
Resource Conservationist
Asst. State Soil Scientist
State Forester
Range Conservationist
Soil Conservationist
(Wetland Inventory)
Soil Conservationist
(CAMPS/NRI)
Computer Specialist
Computer Assistant
Budget Assistant
Clerk-Typist
Clerk-Typist
Hydraulic Engineer
Hydrologist
Statistical Assistant
Hydrologist
District Conservationist
Anchorage FO
District Conservationist
Palmer FO
District Conservationist
Delta Junction FO
District Conservationist
Fairbanks FO
District Conservationist
Homer FO
Soil Conservationist
Soil Conservationist
Soil Conservationist
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Soil Scientist
Soil Scientist
Soil Scientist
Soil Scientist

Atch 3

Att. h 4

Issued September 20, 1915.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL RECONNOISSANCE IN ALASKA, WITH AN ESTIMATE OF THE AGRICULTURAL POSSIBILITIES.

PART I. COOK INLET-SUSITNA REGION.
PART II. YUKON-TANANA REGION.
PART III. COPPER RIVER REGIONS.
PART IV. COMPARISON OF ALASKA WITH FINLAND AND PARTS OF SIBERIA.

BY

HUGH H. BENNETT AND THOMAS D. RICE.

[Advance Sheets—Field Operations of the Bureau of Soils, 1914.]

1-3

87

Atch 5

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., February 11, 1915.

SIR: In the spring of 1914 the Department of Agriculture received a request from the honorable the Secretary of the Interior that an expert of the Department of Agriculture be appointed to investigate and report upon the possibilities of agriculture in certain portions of Alaska. These regions were being considered as possible routes for the construction of a railroad, which the President was authorized by Congress to build.

In June, 1914, Messrs. Hugh H. Bennett and Thomas D. Rice, of the Bureau of Soils, proceeded at your direction to Alaska for the purpose of studying the climate, soils, crops, and other conditions bearing upon the possibilities of agricultural development in these several parts of the Territory. Three months were spent in the field making reconnoissance soil surveys and gathering other material for a report.

The results of these investigations are embodied in the accompanying manuscripts and maps, which I have the honor to recommend be published as advance sheets of Field Operations of the Bureau of Soils for 1914, as provided by law.

Very respectfully,

MILTON WHITNEY,
Chief of Bureau.

HON. D. F. HOUSTON,
Secretary of Agriculture.

SOIL RECONNOISSANCE IN ALASKA, WITH AN ESTIMATE OF THE AGRICULTURAL POSSIBILITIES.

By HUGH H. BENNETT and THOMAS D. RICE.

INTRODUCTION.

The existence of a vast mountainous area along the southern coast of Alaska, with numerous lofty, snow-covered peaks and huge glaciers, necessarily unfit for human habitation, is apt to give one unfamiliar with the complexities of the topography and climate of the Territory as a whole the impression that Alaska is a region of inhospitable mountains, glaciers, and snow, without farming possibilities. In a measure this is true, for there are in the Territory immense areas of rugged mountains, including the loftiest peaks upon the North American Continent, and great wastes of snow-clad and precipitous land, 'tide stretches of bleak tundra and mountain skirting the Arctic Ocean, innumerable bodies of water-soaked Muskeg, and many glaciers of almost incredible magnitude. Nevertheless there are millions of acres of relatively low, smooth land and gentle slopes in various parts of the country which are topographically and climatically suited to farming. That this is true is not a matter of conjecture, for many valuable food products both for man and animal are nom being successfully grown. Farming in a region so far north may seem astonishing until one is acquainted with the equable summer climate, the long hours of summer daylight, and the good quality of the soil.

Those n-ho are thinking of going to Alaska for the purpose of engaging in agricultural pursuits should give careful consideration to the conditions--the topography, climate, population, soil, crops, means of travel and transportation, markets, and tendencies of mining development. It would be unwise for the prospective agriculturist to rush into this country without some preliminary knowledge of the true conditions. The same is true of all new regions.

In the regions dealt with in this report it must, be remembered that as yet strictly pioneer conditions obtain, that settlement is largely confined to communities in the vicinity of mining camps, that much of the country is inaccessible owing to the absence of roads and railroads, and that home markets are restricted to the present small population.

Every indication is that agricultural development must be gradual, must grow with the construction of highways and railways, with the development of mining industries and accompanying incrense of population. If large numbers, without. sufficient capital, should "stampede" to these lands with the idea of immediately establishing profitable farms for themselves, it is believed that thero would be only disappointment for many. A careful study of the conditions before undertaking fnrming operations here is therefore urgently advised.

The purpose of this report is to present such available information regarding crops and those characteristics of surface configuration. climate, and soil, and conditions of transportation, markets, mining industries, and settlement as may have important influence upon the agricultural development of the region.[1]

The prospects of success for farming depend, so far as sale of surplus products is concerned, upon finding a local market among a population attracted by mining resources and fishcries. In other words; these regions of Alaska will probably not for some time export agricultural products, at least, not on an important, scale. Exportation of such products must await the building of a system of railways and highways and probably, also, the establishment of cheaper transportation.

A briefer report, with reconnoissnnce soil maps, outlining the apparent possibilities of farming in the several regions visited was submitted in January to the Interior Department for the use of the Alaska Engineering Commission in connection with their report to the President. This commission made preliminary railway-line surveys during the summer of 1914 through several regions, including the Susitna-Brond Pass-Nenana route to Fairbanks, the Copper River-Tanana route, and others. The President, after considering the respective merits of the several possible routes, decided to build a railroad along tha Susitna-Broad Pass-Senana route, the line to begin at Seward, on Resurrection Bay, and to follow the present line of the Alaska Northern Railroad to Cook Inlet, thence up the Susitna Valley, through Broad Pass, and down the Nenana River to the Tanana River. A branch line will tap the Matanuska coal fields and other branch lines and extensions may be built.

The topographic and geologic maps of the U. S. Geological Survey greatly facilitated the field investigations and made possible the construction of reconnoissance soil maps covering much wider area

[1] The act passed by the Sixty-third Congress at its second session, providing for the construction of railroad or railroads in Alaska provides, among other things, that the Resident be empowered "to designate and cause to be located a route or route9 for a line or lines of railroad in the Territory of Alaska * * ●, to be so located as to connect one or more of the open Pacific Ocean harbors on the southern coast of Alaska with the navigable maters in the interior of Alaska, and with a coal field or fields so as best to aid the development of the agricultural and mineral or other resources of Alaska, and the settlement of the public lands therein • * *."

than could possibly have been covered without them. A timber map of Kenai Peninsula made by the Forest Service helped in making the reconnoissance soil map of that. region. The Alaska Engineering Commission paid the expenses of the work and rendered valuable assistance in the prosecution of the field work, supplying boat transportation and camp supplies and granting the privilege of drawing upon the caches of the surrey parties. The members of this commission are William C. Edes, Chairman, Lieut. Frederick Meares, and Thomas Riggs, jr. The valuable work accomplished by the several stations of the Alaska Agricultural Experiment Stations, under the direction of Prof. C. C. Georgeson, of this department, afforded much assistance in studying crop production.

The investigations of this reconnoissnnce were directed specifically toward those areas embracing the largest estent of forming land. It was not possible in the time available to visit a number of localities outside the areas discussed, in which there are agricultural lands and where some crops nre now grown.

The field work was begun at Knik on the 26th of June. A few days were spent in studying the soils and agriculture on both sides of Knik Arm; then Rice, the titer, and a guide, with camp outfit and pack horse, made a trip up the Matanuska Valley to a point about 3 miles above Chickaloon. Returning to Moose Creek, a trail was followed from there to mile 22 on the Willow Creek wagon road, and from there the party crossed the Little Susitnn River on the wagon road, ascended the high benches on the north side of the river. followed thcseseveral miles in a westerly direction, recrossed the Little Susitnn, and returned to Knik by the wagon road.

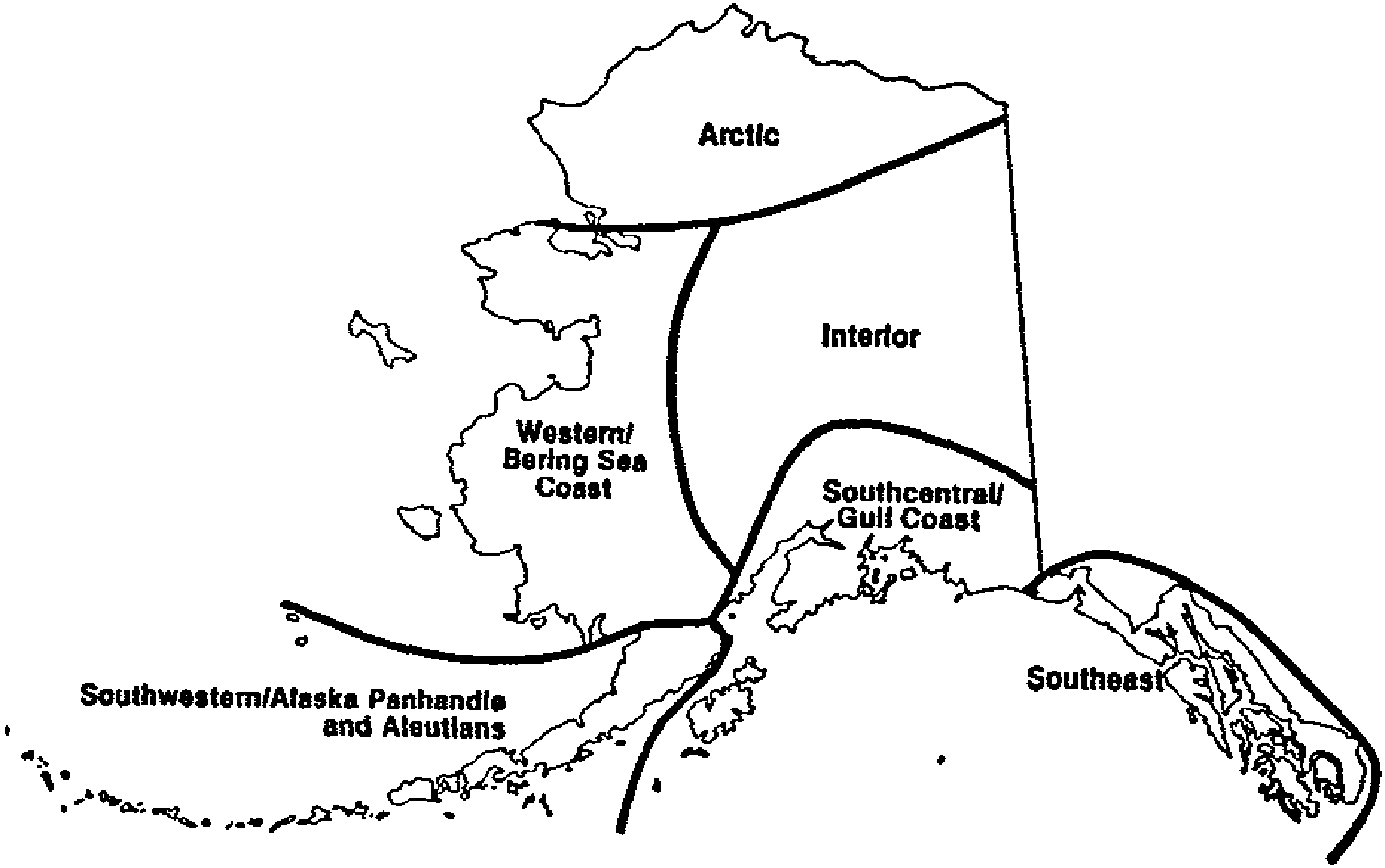
On July 14 Rice, the writer, and two assistants from Knik, Stanton Shafer and W. A. Johnson, left Susitna Station on a stern-wheeler of the Alaska Engineering Commission, carrying an 18-foot rowboat and camping supplies for four weeks, ascending the Susitna River to a point about 3 miles below Indian Creek and 10 miles or more above the area including lnnd of farming possibilities. Descending the river in the rowboat, camps were made at various points along the hanks, from which trips were made across the bottoms, benches, and Muskeg on both sides of the river. Arriving at Susitna the evening of August 5, the party divided two days later, Rice going up the Tentna River with Shafer and Johnson and the writer across the trail to Knik.

Ascending the Tentna by power boat to a point about 15 miles above McDougall, near the confluence with the Skwentna River, Rice proceeded by foot as far as Nugget Creek, a tributary of Cache Creek, lying to the north of Peters Hills. He then returned to Ship Creek, the headquarters of the commission, and later proceeded to various points on Turnagain Arm and Henai Peninsula by boat, and made such examinations of the soils of those section as time permitted. It was not possible to see as much of Kenai Peninsula as was desired, but it is believed that a satisfactory reconnoissance soil map was made of that region through the investigations made, aided by a timber map of the Forest Service.

The writer sailed from Knik Anchorage for Cordova on the 16th of August, and on the 20th went over the Copper River nnd Northwestern Railroad to Chitina. The trip from Chitina to Fairbanks was made by automobile, opportunity being thus afforded to examine the soils in the Copper River Basin and along the bottoms of the Delta and. Tnnana Rivers. The soils and agriculture of the Fairbanks district mere studied both in the bottoms and uplands by nutomobilc and boat trips and on foot. With Fred Date and two pack horses. a trip was made from Fairbanks to Senana by way of the Goldstream Creek Valley and Minto Flats, and from Senana up the Nenana River to the benches above the "thirty-mile" road house. Returning to Nenana a motor boat was secured on which the trip was made down the Tanana to Hot Springs, stops being made at Tolovana and other points. Spending about two days at Hot Springs, the writer took a river steamer to Fort Gibbon, and left that place September 16 on the trip up the Yukon River to Whitehorse. On this trip stops at Rampart, Eagle, Dawson (in Yukon Territory), and other places allowed time for taking samples of the more important soils set along the river. Whitehorse was reached September 29, and on the same day the trip was made over the White Pass & Yukon Railroad to Skagway and an ocean steamer immediately taken there for Seattle.

On returning to Washington, the soil maps were assembled and the report written.[1]

[1] The report was written by Mr. Bennett, who had charge of the expedition.


Arctic
Interior
Western/
Bering Sea
Coast
Southcentral/
Gulf Coast
Southeast
Southwestern/Alaska Panhandle
and Aleutians

Atch 6

Southcentral/Gulf Coast-The Southcentral/gulf coast region curves 650 miles north and west of Southeast to Kodiak Island. About two-thirds of the state's residents live in the arc between the Gulf of Alaska on the south and the Alaska Range on the north, the region commonly called Southcentral. On the region's eastern boundary, only the Copper River valley breaches the mountainous barrier of the Chugach and Saint Elias mountains. On the west rise lofty peaks of the Aleutian Range. Within this mountainous perimeter course the Susitna and Matanuska rivers.

Interior - Great rivers have forged a broad lowland, known as the Interior, in the central part of the state between the Alaska Range on the south and the Brooks Range on the north. The Yukon River carves a swath across the entire state. In the Interior, the Tanana, Porcupine, Koyukuk and several other rivers join with the Yukon to create summer and winter highways. South of the Yukon, the Kuskokwim River rises in the hills of western Interior before beginning its meandering coarse across the Bering Sea coast region.

Arctic - Beyond the Brooks Range, more than 80,000 square miles of tundra Interlaced with meandering rivers and countless ponds spread out along the North Slope. In far northwestern Alaska, the Arctic curves south to take in Kotzebue and other villages of the Kobuk and Noatak river drainages.

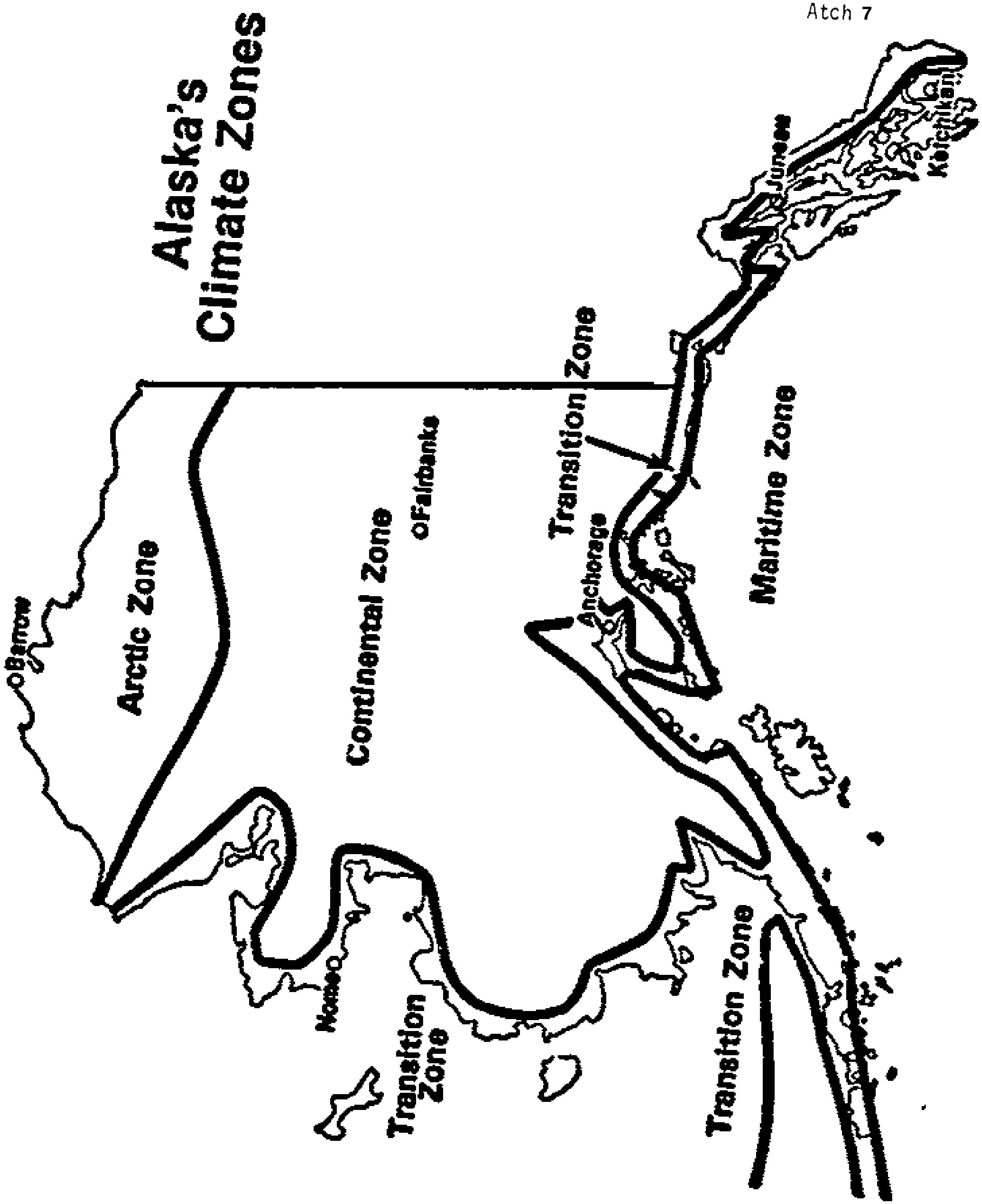
Traditionally the home of the inupiat Eskimos, the Arctic was inhabited by few non-Natives until oil was discovered at Prudhoe Bay in the 1960s. Today the region's economy is focused on Prudhoe Bay and neighboring Kuparuk oil fields. Petroleum-related jobs support most of the region's residents either directly or indirectly. Subsistence hunting and fishing fill any economic holes left by the oil Industry.

Western-Bering Sea Coast - Western Alaska extends along the Bering Sea coast from the Arctic Circle south to where the Alaskan Panhandle joins the mainland near Naknek on Bristol Bay. Home of lnupiat and Yup'ik Eskimos, the region centers around the Immense Yukon-Kuskokwim river delta, the Seward Peninsula to the north and Bristol Bay to the south.

Southwestern/Alaska Peninsula and Aleutians- Southwestern Alaska includes the Alaska Peninsula and Aleutian Islands. The peninsula curves southwest about 500 miles to the first of the more than 200 Aleutian Islands, roughly 5,500 square miles in area. Nearly the entire chain is in the Alaska Maritime National Wildlife Refuge.

According to the Alaska state climatologist, Alaska's climate zones are maritime, transltion, continental and arctic. With the exception of the transition zone along western Alaska, the zones are divided by mountain ranges that form barriers to shallow alr masses and modify those deep enough to cross the ranges (see attachment 7).

Atch 7


Alaska's Climate Zones
Barrow
Arctic Zone
Continental Zone
Fairbanks
Transition Zone
Anchorage
Maritime Zone
Juneau
Ketchikan
Nome
Transition Zone
Transition Zone

The **maritime climate** zone Includes Southeast, the northern gulf coast and the Aleutian Chain. Temperatures are **mild - relatively** warm In the winter and cool in summer. Precipitation is heavy, 50 to 200 inches annually along the coast and up to 400 Inches on mountaln slopes.

The **transition** zone is, in effect, two separate zones. One is the area between the coastal mountains and the Alaska Range, which includes Anchorage and the Matanuska Valley. Summer temperatures are higher than those of the maritime climate zone, with colder wlnter temperatures and less precipitation.

The **continental** climate zone covers the majority of Alaska except the coastal fringes and the arctic slope. It has extreme high and low temperatures and low precipitation.

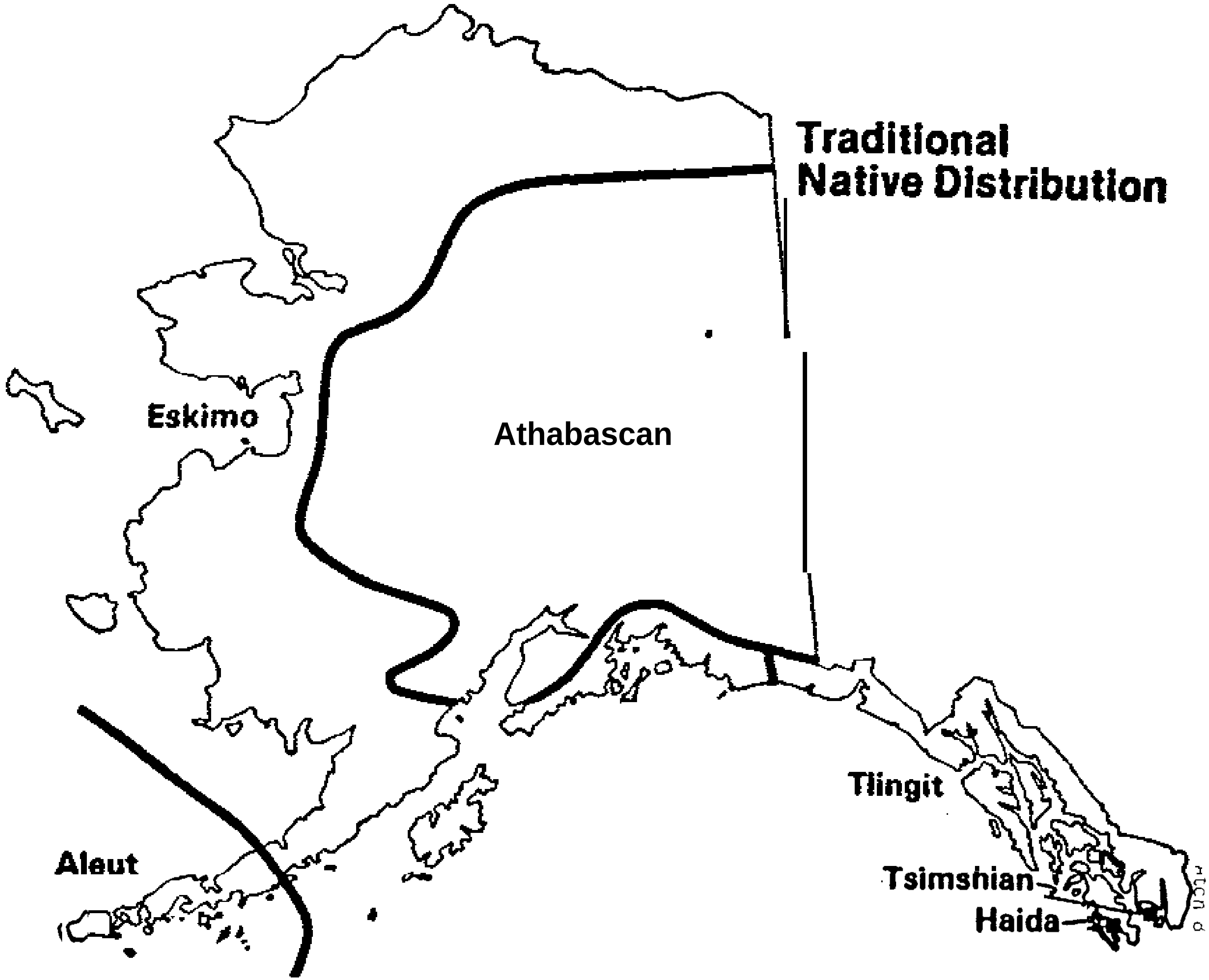
The Arctic, north of the Brooks Range. has cold winters. cool summers and desertlike precipitation. Prevailing winds are from the northeast off the arctic ice pack, which never moves far offshore. Summers are generally cloudy and winters are clear, and cold. The cold air allows little precipitation and inhibits evaporation. Because continuous permafrost prevents the percolation of water into the soil, the area is generally marshy with numerous lakes.

Alaska's 64,000 Native people make up about 13 percent of the state's total population, Of those, roughly 34,000 are Eskimos, 22,000 are Indians and 8,000 are Aleuts. Although many live in widely scattered villages along the coastline and great rivers of Alaska, 9,000 Native persons lived In Anchorage in 1980, and Fairbanks had a Native population of nearly 3,000 (see attachment 8).

At first glance It seems odd that such a hlgh area as Alaska has not been more heavily settled. Thousands of acres of forest and tundra, miles and miles of rivers and streams, hidden valleys, bays, coves and mountains, are spread across an area so vast that it staggers the imagination. Yet, over two-thirds of the population of Alaska remains clustered around two major centers of commerce and survival. Compared to the settlement of the western Lower 48, Alaska is not settled at all.

In comparison to the 365 million acres of land which comprise the total of the state, the settled or altered area currently amounts to less than 1/20th of a percent.

Of the 20 highest mountains In the United States, 17 are In Alaska, which has 19 peaks over 14,000 feet. Alaska has more than 3 million lakes, one of which is lliamna which is approximately 1 ,000 square miles.


Traditional
Native Distribution
Eskimo
Athabascan
Aleut
Tlingit
Tsimshian
Haida

In southeastern Alaska, Prince William Sound, Cook Inlet and Bristol Bay, saltwater undergoes extreme dally fluctuations, creating powerful tidal currents. Some bays may go totally dry at low tide. The second greatest tide range in North America occurs In upper Cook Inlet near Anchorage, where the maximum diurnal range during sprint tides Is 38.9 feet (Nova Scotia's Bay of Fundy has the greatest).

GLOBAL CLIMATE CHANGE AND FORESTRY PRODUCTIVITY

Forest floor chemistry interacts with temperature and moisture to restrict or enhance the supply of nutrients for tree growth. In subarctic forests of interior Alaska, this control of element supply is manifest in dramatically different rates of nutrient cycling among the principal forest types. Slow growing forests developing on cold, wet soils produce organic detritus that is slow to decompose because of its chemical composition. Consequently, element supply is restricted in these ecosystems. Productive forests developing on warm, drier soils produce organic detritus that decays more rapidly because of favorable chemical composition. Element supply is enhanced in these forest ecosystems.

Using the compartment model Linkages, we evaluate several scenarios that propose altered temperature and precipitation regimes for their influence on forest floor chemistry, element supply and the consequence to forest productivity.

Keith Van Cleve, Professor, School of Agriculture and Land Resources Management, UAF, Fairbanks

TRANSPORTATION AND INFRASTRUCTURE: KEYS TO SUCCESSFUL AGRICULTURAL DEVELOPMENT IN ALASKA

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Abstract: Transportation and appropriate infrastructure are keys to the success of agricultural development. Although there are 7,000,000 hectares of land considered croppable in Alaska, only 230,000 are considered economically viable for crops because of the limited transportation system and infrastructure. In the mid 1970s, a substantial planning effort was made to develop an export model based on grain and red meat in hopes of revitalizing the agricultural industry in the state. The model did not come to fruition. Plans called for very rapid development of farms, and virtually no constraints were put on who could purchase land. Most who purchased land had little knowledge of farming or farm management. Failure to complete the necessary infrastructure has made survival difficult for the few who did have the skills necessary for farming large enterprises in the circumpolar north. If there is a real interest in expanding Alaska's agricultural industry in the future, planners would do well to learn from historical experiences.

INTRODUCTION

"Those who can not remember the past, are condemned to repeat it."

George Santayana

Transportation and appropriate infrastructure are not often recognized as significant to successful agricultural development by those having experience where sophisticated agricultural industries are already in place. An obvious key to most, however, is availability of suitable land. Alaska's land mass is approximately 174,141,000 hectares. Four percent (7,000,000 hectares) is considered appropriate for production of crops (Rieger, et.al., 1979). Physical geographic factors: soil type, soil depth, slope and precipitation determine the land's potential for crop production (Rieger, 1974). Temperatures and growing degree days influence the type of crops. These factors limit the physical extent of land designated as croppable to river valleys primarily south of the Brooks Range. The limited extent of the surface transportation network and lack of appropriate infrastructure place a further impediment on lands appropriate for agricultural development in Alaska (Figure 1).

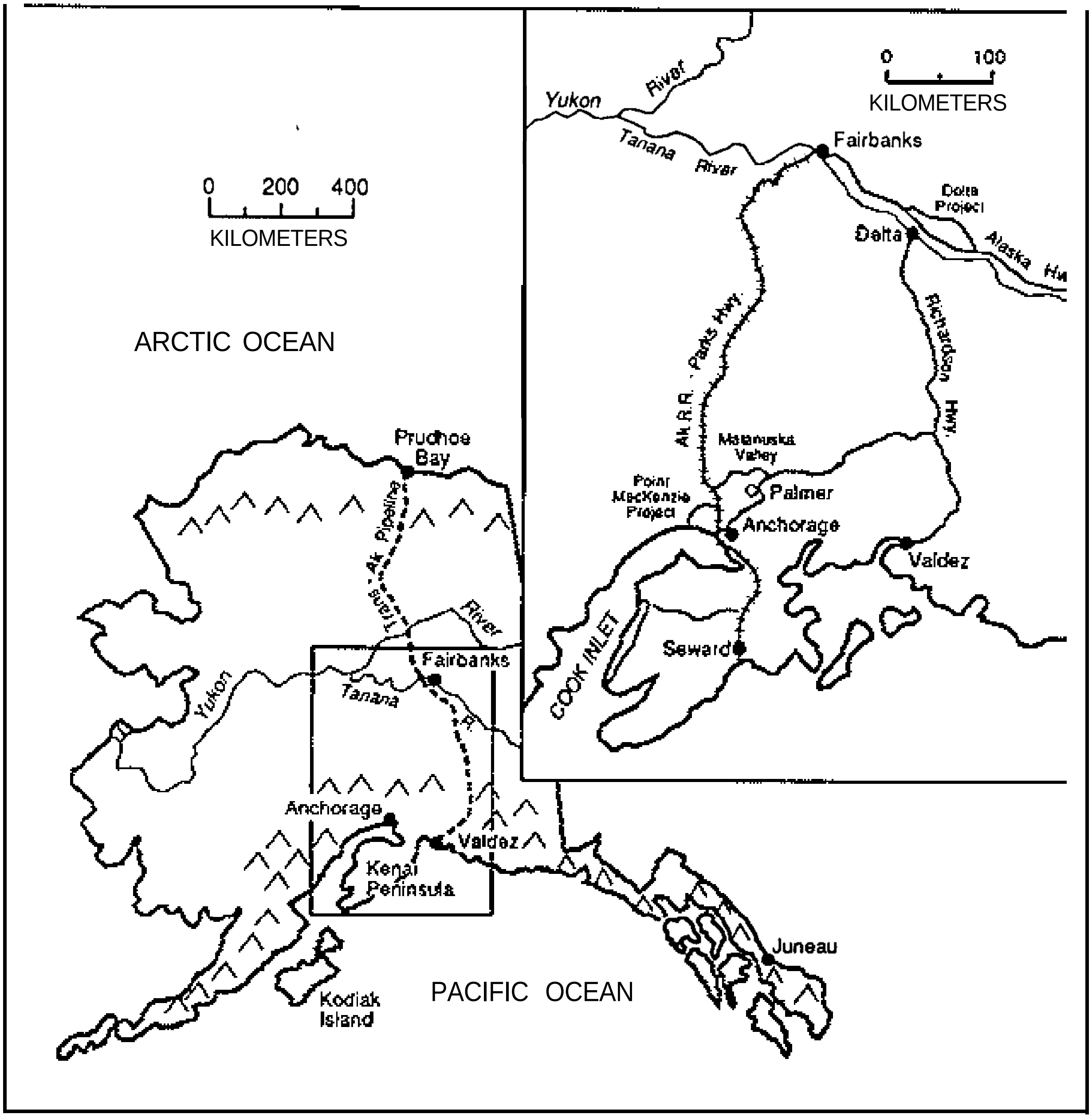

Figure 1. Alaska, featuring mountain ranges, major rivers, and population centers.
From: Pearson and Lewis, 1989.

Kellog and Nygard (1951) made one of the first observations concerning the link between transportation and'infrastructure and successful agricultural development. They stated that although land surveys in Alaska had classified millions of hectares as potentially croppable, only 230,000 were economically viable because of the limited transportation system and infrastructure. During the early 1900s and since statehood, agricultural production has been concentrated in the railbelt with a few production areas in outlying regions (Figure 2). The early beginnings were in coastal areas.

Eighty percent of Alaska's 540,000 residents reside in the railbelt area which constitutes only 20 percent of the state's total area (Lewis and Pearson, 1990). Today, Alaska's agricultural production is concentrated in the Tanana Valley near Fairbanks and Delta Junction (51.8 percent of the total acreage), and in the Matanuska Valley near Anchorage and Palmer (39.2 percent of the total acreage) (Stange, 1990). The farm-gate value of production, however, is 38 percent higher in the Matanuska than in the Tanana Valley because the product mixisprincipally vegetables and milk (Pearson and Lewis, 1990). The total land in farms as defined by Brown (1990) in Alaska Agricultural Statistics was 469,000 hectares in 1989.

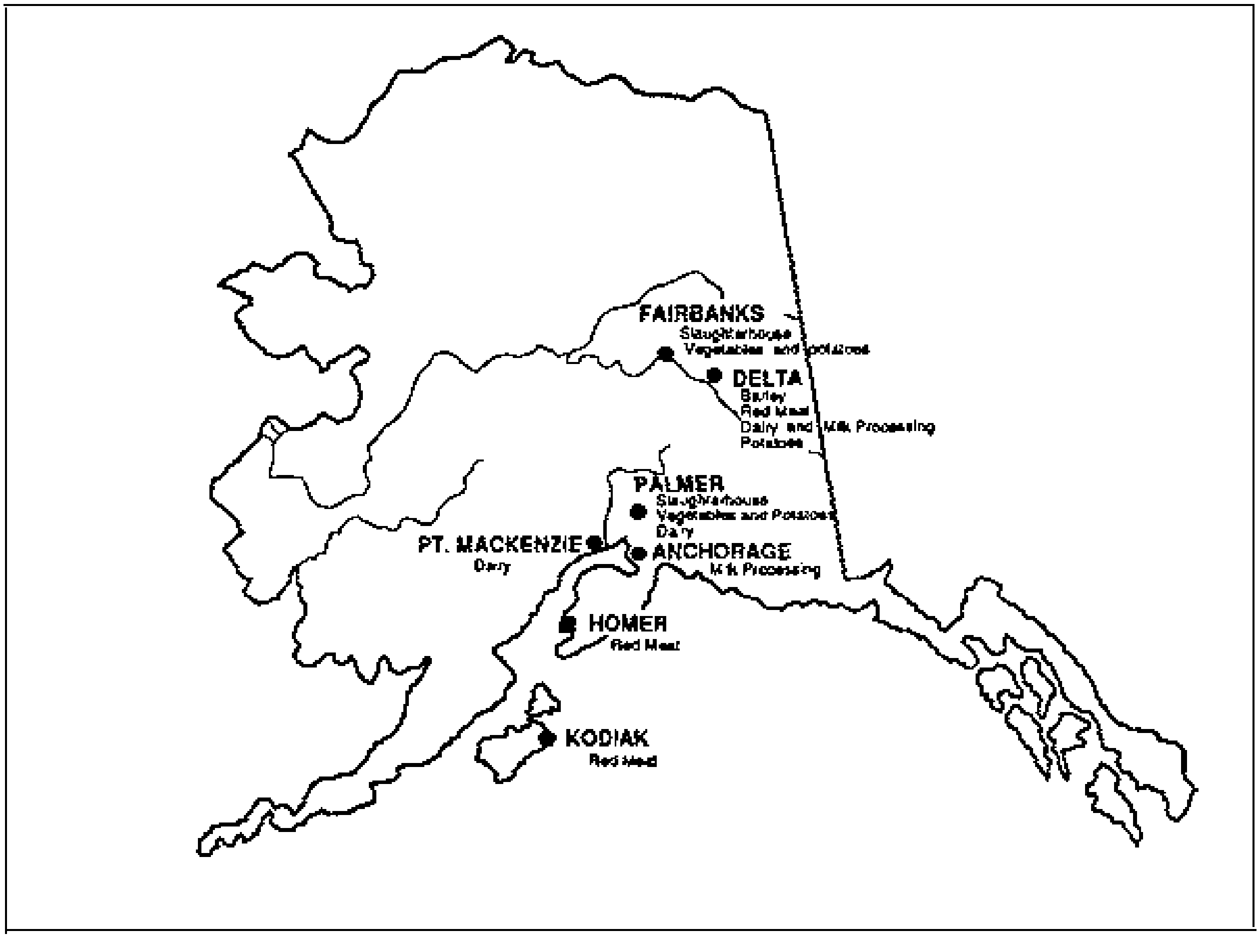

Figure 2. Agricultural centers showing principal products of each region.

The absence of adequate slaughter facilities, port grain terminals, and vegetable processing facilities restrict the amount of raw products which can be produced. The small population of the state limits markets as well. Despite this, there are a wide variety of crops, animals, and manufactured products produced by the agricultural industry in Alaska. The primary raw products are small grams (barley andoats), beef,reindeer, hogs, milk, potatoes, lettuce, cabbage, and carrots. A variety of other vegetables are also produced as are poultry, eggs, mutton, and wool.

ALASKA'S AGRICULTURAL HISTORY

Alaska's agriculture began when Russian fur traders and trappers established settlements. Consideration was given to agriculture when sites were selected. Fresh milk, meat and vegetables were a concern (Burton, 1974). Most important, however, were coastal locations. Little investment was needed to develop harbors, there was little incentive to settle inland away from the sea otter resource, and settlers actually preferred food shipped from their homeland to that produced in the settlements (Pearson and Lewis, 1989). Unfortunately, and unknown to Russian traders, coastal lands are among those designated as having low or no potential for crop production.

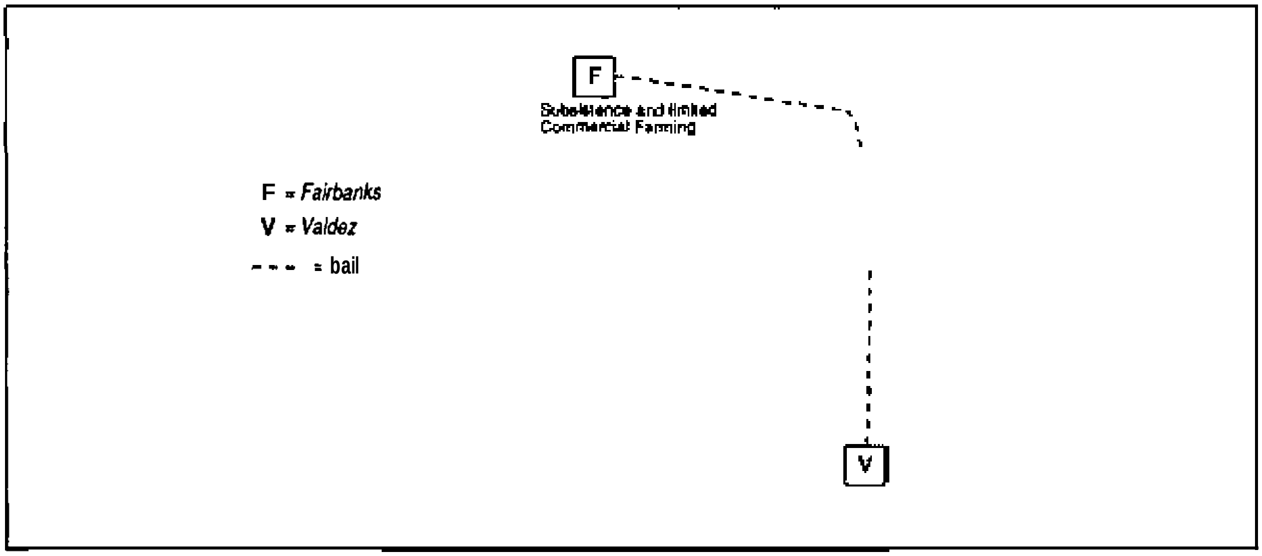

Figure 3. Transportation network and infrastructure from 1898 through 1917.

Although the U.S. government purchased Alaska in 1867, interest in agriculture was not active until 1898 when land surveys in the interior of the territory were begun (National Resources Committee, 1932). Survey reports indicated an extensive potential for production of agricultural crops and raising of animals (Lewis et.al., 1987). By the early 1900s, fundingbecame available for the Valdez Trail linking the port at Valdez to Alaska's interior at Fairbanks (Figure 3). The population of Alaska was approximately 64,000 in 1910 and remained atthatleveluntil the 1940s when military activity increased. Thefirstagricultural area to develop was in the Tanana Valley near Fairbanks to support the gold mining industry (Pearson, et.al., 1990). Grain crops were produced, a flour mill operated in 1917, and a creamery operated into the 1950s. Delta Junction was established as a major freight and passenger transfer point. Next to develop was the Matanuska Valley. Settlers were brought in by the Alaska Railroad in the 1920s, and the Matanuska Valley Colony, made up of farmers from depressed areas in the 48 contiguous s tates, began in 1935 (Stone, 1949).

The transportation networks were expanded between 1917 and 1940 (Figure 4). Anchorage was a growing city and road and rail connected it to Palmer and Fairbanks. The infras truc ture, however, became less diversified though it expanded. The only agricultural product processed was raw milk. Creameries operated in Fairbanks and Palmer. Farming was largely to produce products for personal consumption.

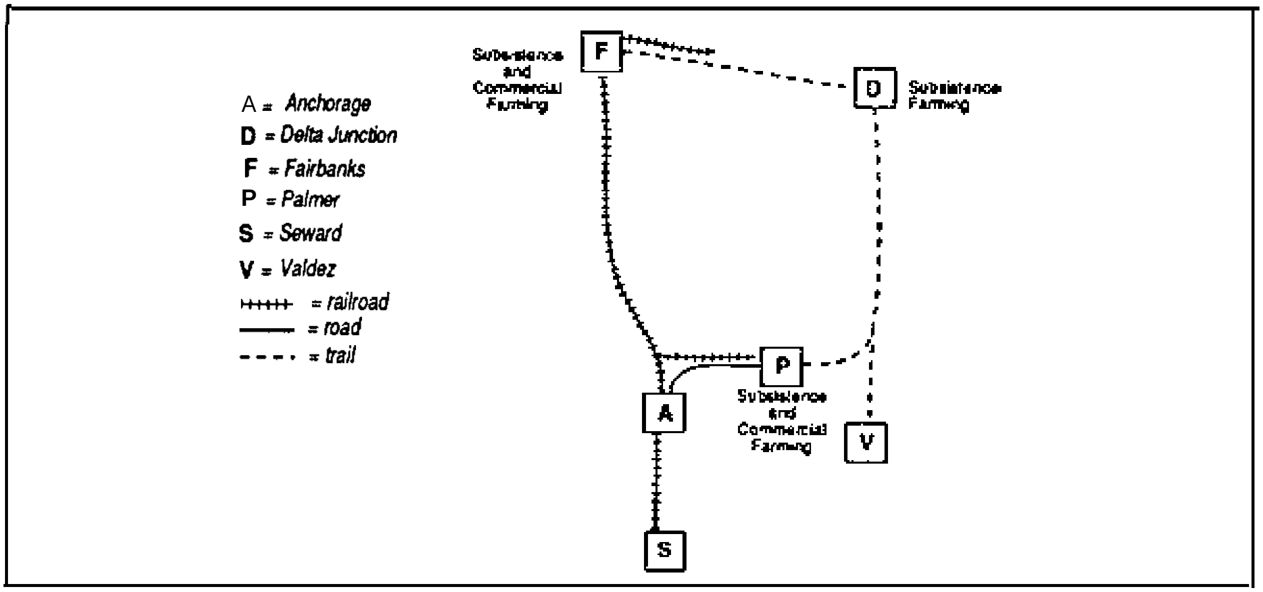

Figure 4. Transportation network and infrastructure from 1917 through 1940.

Specialization of agricultural production occurred in the Tanana and Matanuska Valleys after 1940, and farming became more commercial. In the Tanana Valley, small grains and livestock were the principal products. Availability of federal homestead land in the 1950s brought more farmers to Delta Junction, connected to Fairbanks by an extension of the Valdez Trail renamed the Richardson Highway (Figure 5). In the Matanuska Valley, concentration was on dairying, potatoes, and vegetable crops. Efforts of producers were supported by two agricultural experiment stations, one in Fairbanks and the other in Palmer. However, improvement of the transportation system (to support military expansion) throughout the railbelt area, and particularly from the port at Anchorage to points in the interior of Alaska, made it less expensive to ship food into Alaska than it could be produced on the relatively small, low technology farms prevalent throughout the indus try. Introduction of large aircraft made it possible to ship perishable products into the state (Francis, 1967).

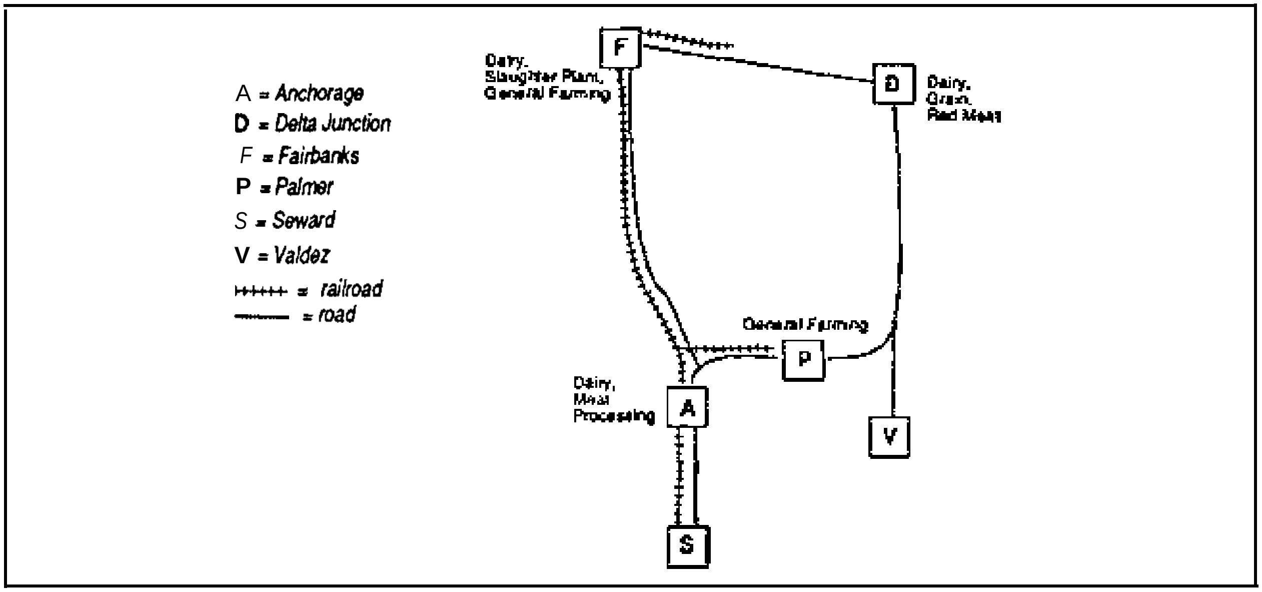

Figure 5. Transportation network and infrastructure from 1940 through 1976.

Investors in the agribusiness industry outside Alaska were not willing to move into what was perceived as a high-risk environmental region where they would face small markets (the population was 72,500 in 1940, and 226,200 in 1960) and high transportation costs into and out of Alaska. Prior to 1959, when Alaska was granted statehood, the federal government had no interest ininjecting capital into Alaska to expand its agriculture. It was not necessary when the U.S. already owned surplus products. With the exception of the Alaska Agricultural Revolving Loan Fund which made loans to farmers considered too high-risk by other institutions, the new state government had little capital to inject. Therefore, no expansion of the infrastructure occurred. Consequently, growth in the industry stagnated in the 1960s.

EXPANSION OF THE AGRICULTURAL INDUSTRY

The discovery of oil at Prudhoe Bay in 1968 led to an increase in the population in urban areas, increased income to the state from oil royalties, and increased personal income. There was an interest in development of resources other than oil by the state, and agricultural lands wereoneresourceconsidered (Lewis, et.al., 1987). Further, there was an interest by people in the state in obtaining locally produced food products, and, by some, in investing in farms and other agricultural enterprises. This interest was supported by state government officials and legislators who realized if any expansion were to occur in the agricultural industry: 1) the industry would have to berevitalized, 2) new lands would have to be put into production, 3) appropriate infrastructure elements would have to be in place, and 4) lands already in production would have to be protected from encroachment by subdivision expansion.

From 1976 through 1979, the state of Alaska sponsored a series of four feasibility studies (Thomas, 1977; Faris and Hildreth, 1977; Thomas, et.al.; 1977; Lewis et.al., 1980). The first study considered the condition of the industry in general. The second two studies addressed the economic feasibility of production of small grains, particularly barley, in Alaska's interior. The fourth gave options for establishing dairy farms in the Point MacKenzie area near Palmer to support the existing dairy processing plant in Anchorage. Dairy farm numbers in Palmer weredecreasingasfarmersrealizedhighcapitalgainswhen farmsweresubdividedandsoldasresidentialoarcels. A fifth study (Fugelstadt et.al., 1985) suggested operating efficiencies for the dairy-processing plant in Anchorage.

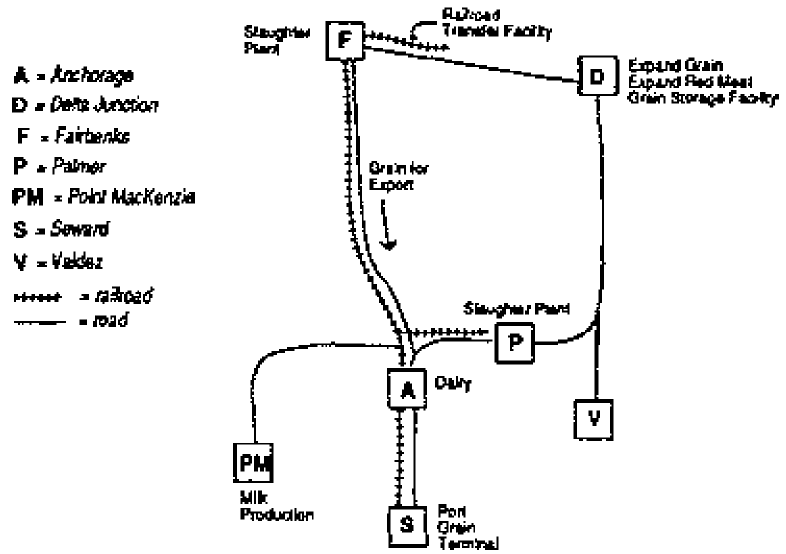

Figure 6. Alaskan agricultural development model.

The development model envision by planners is shown in Figure 6. At the core of the plan, were two agricultural projects (Lewis, et.al., 1980; Lewis and Thomas, 1982). The new lands recommended for production of small grains were near Delta Junction with dairy farms near Point MacKenzie. In 1978 and 1980, two land sales near Delta Junction put 32,500 hectares with farm sizes from 557 to 1250 hectares in private ownership. In 1983, 19 farms with an average size of 186 hectares were sold to expectant dairy farmers (Thomas et.al., 1983). Roads were extended by the state to and within the projects. The state also offered loans to interested entrepreneurs to expand the agricultural infrastructure. Two slaughter facilities were planned for Fairbanks and Palmer. A grain and fertilizer facility was to be built near Fairbanks to facilitate movement of grain and fertilizers from road to rail. An elevator was to be built in Delta Junction to handle grain from farmers not having on-farm storage. Railroad cars were to be purchased by the state to move grain from Delta Junction. Not all grain was to be fed to livestock in Alaska where 87,000 metric tons of feed grain was the estimated amount necessary for 20,000 slaughter cattle (25 percent of the market share), 100,000 market hogs (43 percent of the market share) and 6,000 dairy cattle (75 percent of the milk market share) (Agricultural Task Force, 1983). The excess from a targeted 224,000 metric tons at a yield of 2.35 metric tons per hectare was to be exported through Seward from a port elevator to be constructed by the state and sold to private enterprise with state loan money. A final step by the state of Alaska was to retain agricultural lands already in production. This was not apart of the plan for the agricultural projects, but was considered necessary to enhance the industry. A buy-back plan was suggested Workman et.al., 1980) in which farmers would trade developed agriculturallandfor new lands (with significantly more area). These would have to be improved before production could begin. To date, no farmers have taken advantage of this option.

THE COLLAPSE OF THE DEVELOPMENT MODEL

The model developed for expansion of Alaska's agribusiness industry did not come to fruition. According to some, it was conceived with little attention to what had occurred as the agricultural industry developed in the U.S. (Strange, 1990). This, however, is an irrelevant comparison. The history of the development of U.S. agriculture is one of settlement of a frontier with the subsequent need for food for settlers. These were settlers who had an agrarian background. The federal government subsidized farmers to encourage further opening of frontier lands. Alaskan agricultural development has its roots in the need for food during boom periods such as furs, whales, gold, and oil (Pearson, et.al., 1990). Some people from the boom periods remained and did become food producers. Unfortunately, few had sufficient skills in farming in the circumpolar north to be successful, and thus left the region. The single exception was the Matanuska Colony sponsored by the federal government to resettle farmers severely affected by the depression (Stone, 1949).

There were, and still are, few subsidies available to farmers in Alaska from the federal government other than homestead lands in the past, and a small amount of loan monies through the FmHA (Farmer's Home Administration). Until oil was discovered at Prudhoe Bay, the new state government had little capital to invest in development of its lands. Throughout the planning process for agricultural project development, four very important elements were in place: 1) there was a positive policy toward agriculture (Alaska State Legislature, 1977), 2) state government had capital to invest and a state agricultural loan program in place, 3) persons in the private sector were willing to invest capital and time in agricultural enterprises, and 4) world grain prices were high (Thomas and Lewis, 1981; Engelbrecht and Thomas, 1987).

In the mid-1980s, a change in administration caused a change in Alaska's agricultural policy to one adopting a lassaiz faire attitude. This combined with falling income from oil revenues and oil-related jobs in the public and private sectors, and rapidly falling grain prices, resulted in not completing the planned infrastructure. The only element in place is the Alaska Farmer's Cooperative in Delta with grain and fertilizer facilities, now operating under its capacity. The 20 grain hopper rail cars purchased by the state have been sold. The two keys to economic viability of the agricultural projects were the grain and fertilizer facility near Fairbanks and the port terminal in Seward. The former was never begun. Materials for the latter were purchased, only to have been recently sold for removal to China. Because these two components of the infrastructure are missing, the opportunity to export gram does not exist, and grain and fertilizers cannot be moved as efficiently as they could have been to areas in Alaska from Delta Junction. This has produced a negative chain reaction throughout the gram and meat sector of the industry (Figure 7). The present structure of the industry is very much as it was in 1976 (Figure 8).

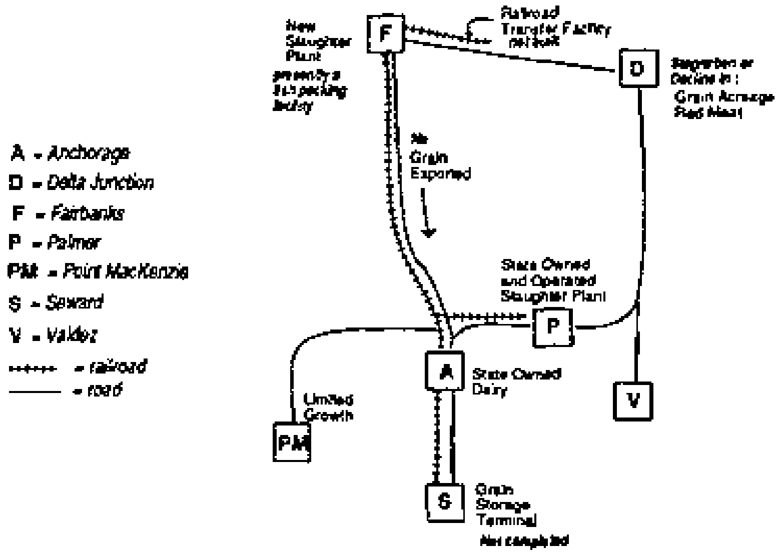

Figure 7. Collapse of Alaska's agricultural development model.

Despite the problems within Alaska's agricultural industry, the farm-gate value of products is increasing although the product mix has changed somewhat (Pearson and Lewis, 1989; Brown, 1990). Alaska's farmers supply close to 80 percent of the non-restaurant market for potatoes. A feed and fertilizer plant in Fairbanks produces many types of animal feed. The largest amount of product is dog food for dog mushers as well as pet owners. There is continuing growth in the vegetable sector, particularly lettuce. There is a small processor of frozen products in Anchorage, but over 90 percent of the vegetables and potatoes are marketed fresh (Swanson and Lewis, 1990a). There is an increasing demand for Alaska products because of their quality. Reindeer antler and meat products (Stern, et.al., 1980) and indigenous berries and berry products (Lewis, et.al., 1990) have a high potential for sales in Alaska, U.S., and international markets. To aid producers, the Alaska Division of Agriculture promotes product sales through their "Alaska Grown" marketing program (Swanson and Lewis, 1990b).

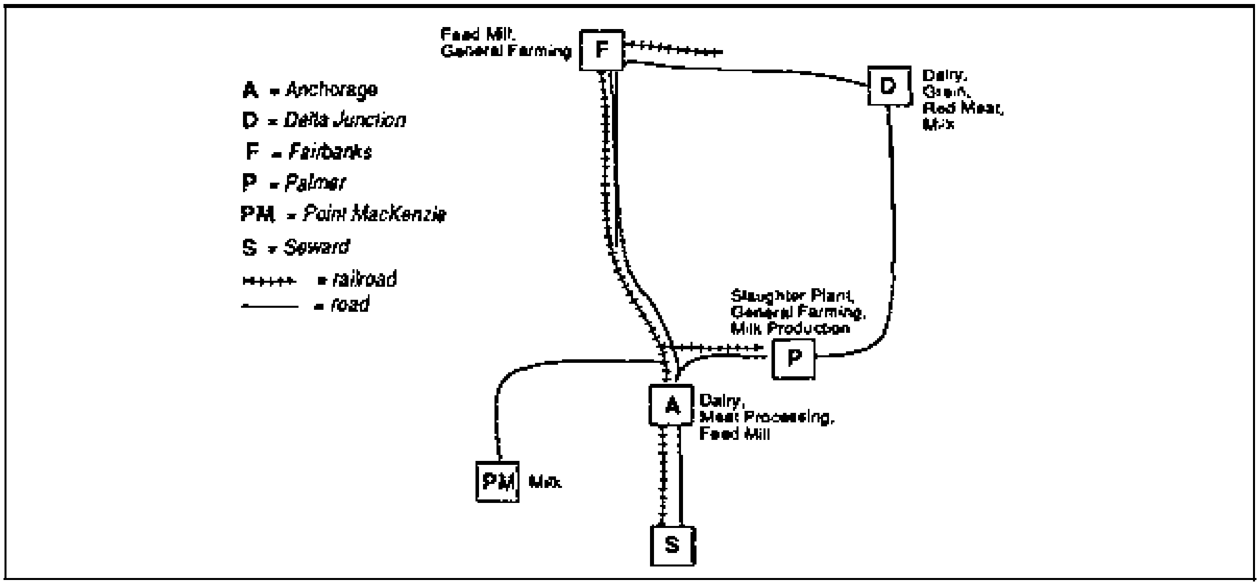

Figure 8. Present status of the transportation network and infrastructure In Alaska's agricultural industry.

CONCLUSIONS

The agricultural plans of the 1970s called for very rapid development of farms within the new projects. The reason was to have a critical mass of product moving through the marketing system to gain the planned transportation, handling, and processing efficiencies. Farmers were asked to build farmsteads, clear land of the native tree cover, produce crops, and build dairy herds to be in full production in under five years. This was a mistake. Few of the farm owners were able to meet the schedule, and those who did faced an incomplete infrastructure. An even bigger mistake, however, was made by state government. Planners called for stringent qualifications for persons to become eligible to purchase land in the Delta and MacKenzie Projects. Primary among them were appropriate experience in farming and farm management, and sufficient capital resources to qualify for loans near $1 million. Legal constraints within the state attorney general's office removed almost all qualification suggested by planners. Those remaining were: applicants had to be over 18 years of age, had to have resided in the state for one year, and had to have no less than $35,000 in liquid assets. As a result, many who purchased land had no experience in farming and had insufficient capital to qualify for large loans although all received such loans. This, coupled with the rapid development schedule, was a blueprint for failure for most would-be farmers. Success rates among the few capable of farming large tracts or managing dairy herds composed of high-production genetic stock would undoubtedly have been higher if the infrastructure had been completed as planned.

An increasing value of agricultural products is encouraging. However, the increase will remain small if products cannot be exported because of the state's small population. To export products and to process products will require large injections of capital. In this regard, Alaska does not differ from other areas in the circumpolar north such as the Siberian region of the Soviet Union (Novosolov, 1979). The difference lies in the ease of importing food to remote communities. Alaska has an extremely well developed transportation system when compared to that found in Siberia (Garmiov, 1981). Food products can be easily imported and moved to remote areas. Without a compelling need to produce food and without the necessity to depend on income from an agricultural industry, it is doubtful that there will be support from the public sector to construct or complete the appropriate infrastructure. If there is a real interest in future expansion of Alaska's agricultural industry, planners would do well to learn from historical experiences.

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United States Department of Agriculture
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BRIEFING PACKET
6/90

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Quality Services to the SCS, NCSS, Notion ond World

Building quality, efficiency and flexibility into collection, delivery and use of soil survey information

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Standard procedures tor assigning T values.

SOME CURRENT ACTIVITIES

Shifting focus ot soil survey to planning, maintenance and update by physiographic region or MLRA.

Improving technical guidance tor field operations in the maintenance and update phase otsoil surveys.

National Soil Information Syslem development.

Improving methods tor estimating soil properties.

Developing methods lo document mop quality and mnp unit composition.

Revising guides and procedural documents 10 reflect current standards ond procedures - Nat. Soils Handbook, Soil Survey Field Manual, hydric soils criteria, laboratory methods manual, wetlands manual, STATSGO user manuals.

STATSGO demonstration products.

GIS - soil attribute database interface.

Working with researchers to generate input parameters tor models from soil survey information.

Streamlining the soil survey publication process.

Creating uniformity in T values.

Developing National Soil Characterization Database to store field and laboratory characterization data from cooperating Agr. Exp. Sta. laboratories and NSSL

Improvement of Soil Taxonomy through notional ond international collaboration.

Global change initiative to characterize und define soil properties und processes as related to climate and. human influences.

June 1990

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Fact Sheet

National Soil Survey Center

National Soil Survey Center (NSSC)—All staffs have national leadership responsibilities for policy and procedures for their particular area of specialty.

Soil survey **Quality** Assurance Staff	Assures the quality of, **soil survey mapping and manuscript** preparation in the states. Assists states **in producing technically** sound, consistent, readily available soils Information. **Provides for technical** oversight, quality assurance, and coordination for soil correlation, soil series descriptions, soil classification, soil survey manuscripts, and map compilation.
Soil Classification Staff	Controls the **evolution** of soil **taxonomic** system. Improves system to clear up definitions and computations, domestically and internationally. Assists states in preparing proposals to amend Soil Taxonomy and maintain taxonomy in an up-to-date usable form. **Trains** in soil classification.
Soil survey **Interpretations &** Geography Staff	Develops policy for the direction, structure,**procedures,** and standards for interpreting and delivering soils information. Works with SCS staff **specialists—agronomists,** engineers, range conservationists, and water quality, GIS and cartographic specialists-to develop soil information delivery system. Soil **scientists** coordinate with NTC soil interpretations staff in developing transfer of technology and training users of the information.
Soil Data Systems Staff	Responsible for the structure and modification of databases in line with SCS and Soil Survey priorities. Designs automated databases and works with IRM in choosing new hardware-software combinations for automated work in states. Contracts for systems development and provides instructions and training to states and to NCSS and others in how to use systems. Developmental work is mainly within the framework set by the various staffs, NSSC work groups, and the SCS at large.
Soil Survey Laboratory Staff	Provides reliable, new information and understanding about soils, soil relationships, and soil survey methods. Develops and provides soil characterization data; improves characterization methods; develops new concepts, methods, understanding, predictions of soil behavior and information in sup port of soil survey interpretations and modeling; and develops information, theories, and **understanding** about formation of soils. **genetic** factors. and landscaping relationships **in** support of **soil** mapping, **soil** classification; and soil correlation.

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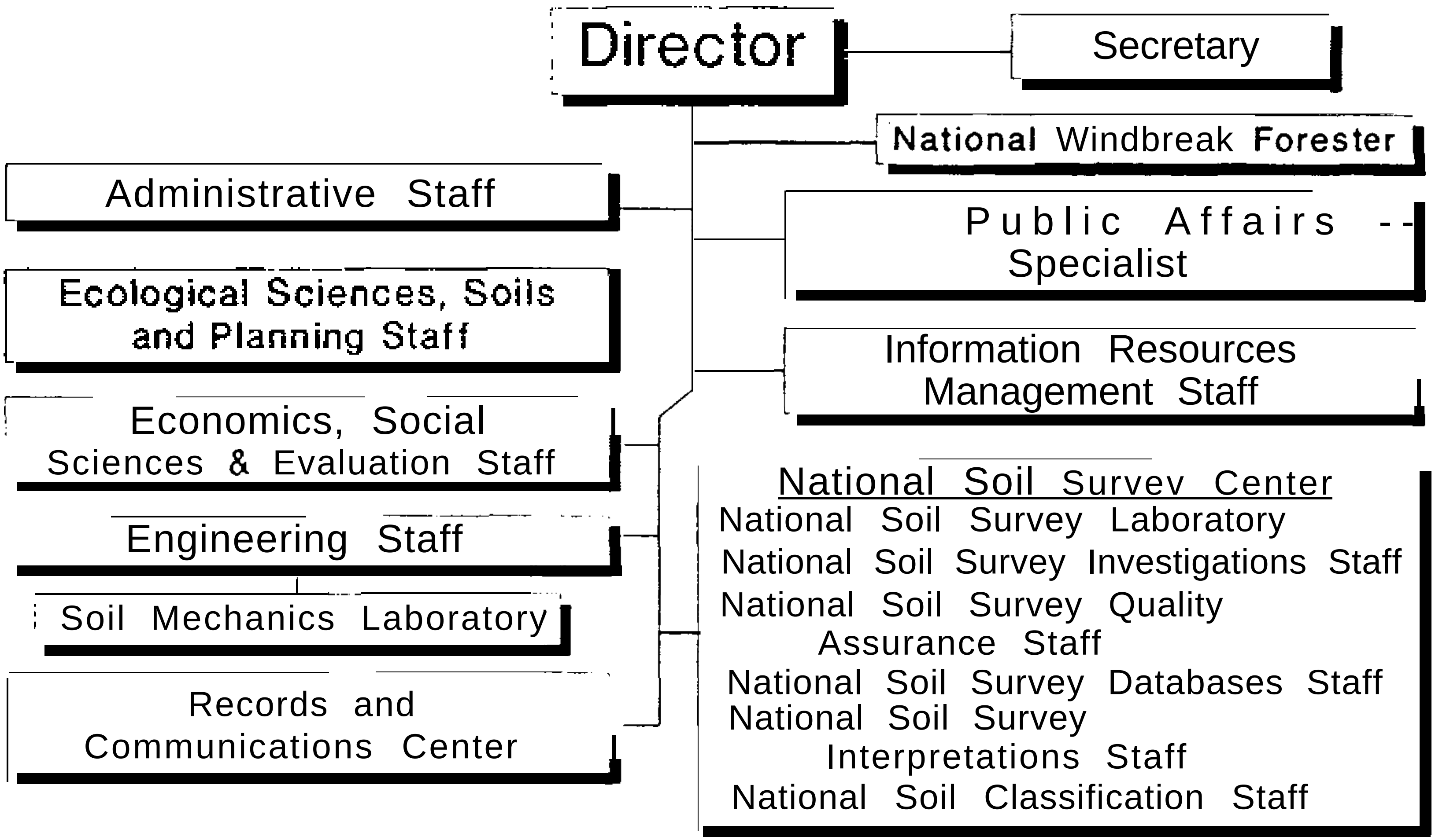

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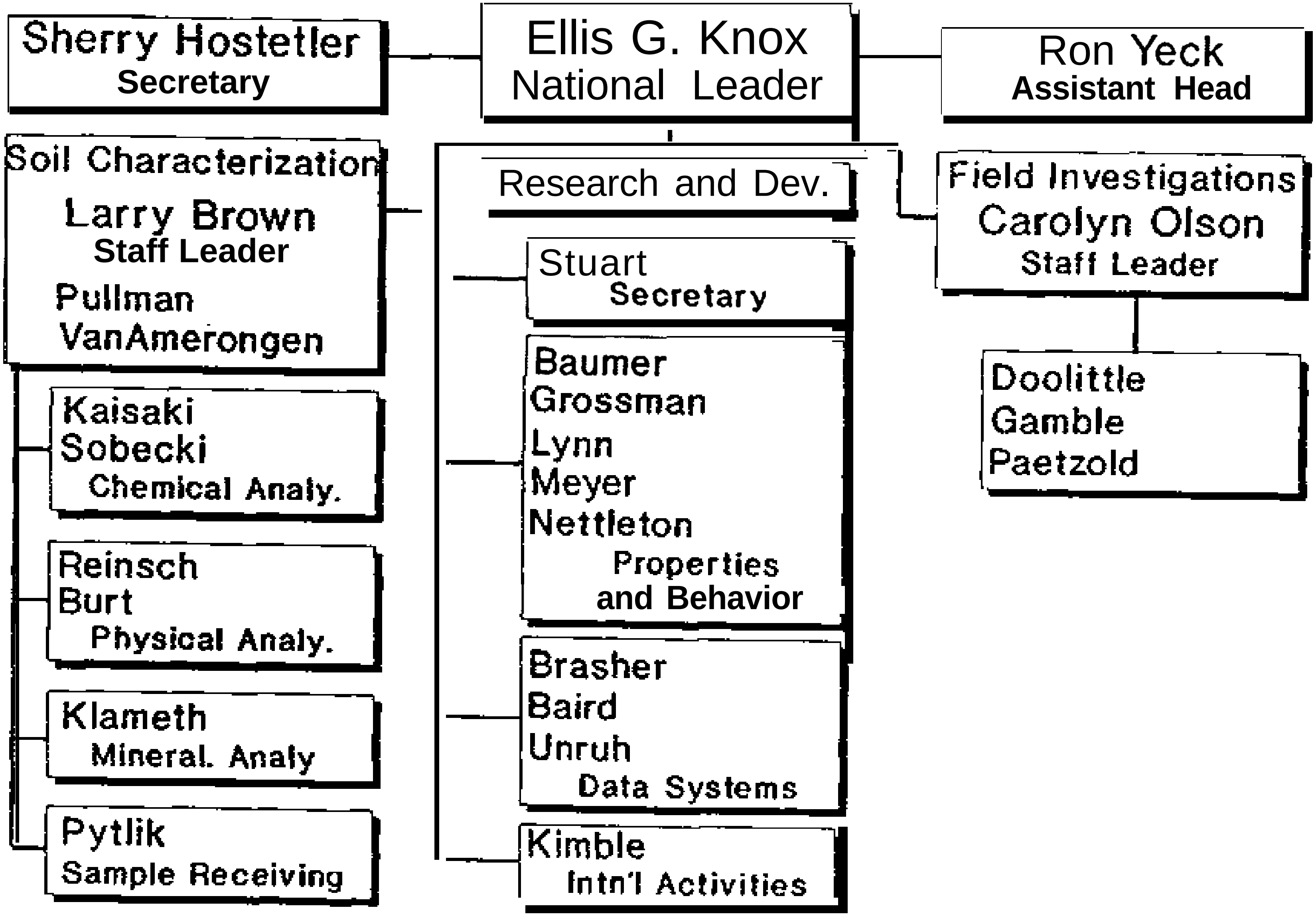

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WESTERN REGIONAL SOIL SURVEY WORK PLANNING CONFERENCE
Fairbanks, alaska
June 17-22, 1990

THE IMPACT OF FIRE ON PERMAFROST SITES IN INTERIOR ALASKA
speech by Joan Foote, INF

Greetings, It's a pleasure to be here today. I hope you are finding this week worthwhile and that Alaska is a" interesting and worthy place.

I was asked to talk about fire ecology in interior Alaska. I will take a few minutes to describe how we view fire in Alaska and how it impacts the vegetation you see when you look at the landscape. However, most of the time I will talk about the impact fire has on permafrost and the active soil layer that lies above it.

Introduction

Fire Fire is a" integral part of the ecology of interior Alaska. It burns a total of 3.5 to 5 million acres (1.4 to 2 million hectares) annually. I" a low fire year that is equal to a" area the size of the state of Connecticut. I" a high fire year, a" area equal to state of Massachusetts would burn. The natural fire frequency is 35 to 125 years. depending on the type of vegetation. Sites with black spruce burn most frequently, sites with hardwoods or white spruce burn at longer intervals. The oldest trees that I know of are less than 350 years in age. Most mature trees are 120 to 250 years in age.

Most of the fires in interior Alaska are caused by lightning, though increasing numbers are caused by man. Land managers are beginning to use fire as a management tool. Fire suppression activities started in the 1960ies. In the beginning all fires were extinguished. Today fire management plans exist for each region of the state. These plans, which were developed by all the land owners in the region, determine the type of suppression activity, I.E. full, modified, or partially modified, that will be used when fire occurs.

Individual fires vary in size; some are less than one acre (0.4 hectare) in extent Other single fires can be more than 500,000 acres (200,000 hectares) in area. No two fires are alike. Some are hot, others cool. Some burn superficially, others deeply. Some move rapidly, others slowly. Some travel from tree top to tree top as crow" fires, others "ever leave the forest floor. Most are a mix of the two.

The resultant burns vary in size and shape and have irregular boundaries. Sometimes areas will be missed by the fire. However most of the above ground vegetation is consumed or killed. The ground surface is left looking black and bleak. Even though some of the surface organic layers may be consumed some of it is usually left intact. This means many of the roots, rhizomes and buried seed are available for sprouting.

Vegetation Most of the plant species growing in interior Alaska are well adapted to fire. Because of this, most plant species present on the site at the time of the fire will return following the fire. However some, like white spruce, may have difficulty. White spruce seed seldom survives fire. In addition white spruce do not produce sucker shoots and do not produce a viable seed crop every year.

With few exceptions, the stages of stand development that occur following fire reflect the rate at which different plants grow and mature. Initially those species that can efficiently utilize the flush of nutrients made available by the fire, dominate; the liverwort, **Marchantia**, and the moss, **Ceratodon**, come in on exposed mineral soil surfaces, while fireweed, corydalis, blue joint, raspberry and young shoots from many of the low shrubs do likewise on organic surface*. Initially the faster-growing herbs dominate. Then for a period the low shrubs are most visible. With time the tall shrubs and tree seedlings are the tallest. These are soon over-topped by the hardwood saplings. Unless fire or other disturbance intervenes the spruce will out live the hardwoods and dominate. Given even more time black spruce may replace white spruce. The moss layer is slow to develop. It does not form a continuous layer on the forest floor until after the spruce. especially black spruce, dominate the upper canopy.

The vegetation patterns you see on the landscape reflect different fire histories, different vegetation histories and different developmental stages

Permafrost Interior Alaska lies in a zone of discontinuous permafrost. This mean it is present on some, but not all sites. It is found primarily on north-facing slopes, toe-slopes, valley bottoms away from active streams, and beneath black spruce-feathermoss-sphagnum vegetation types. Since black spruce forests are the end point of succession on many sites, permafrost can form over extensive areas of interior Alaska.

Permafrost forms when the ground frozen in winter does not thaw or melt during the succeeding two summers. However, in this part of Alaska this does not mean it is permanent! Permafrost is maintained primarily by the insulating effects of topography and/or the vegetation cover shading it. All plants shade. However it is the development of the moss layer, the thick continuous cover of feathermoss and/or sphagnum, that insures the presence of permafrost close to the surface. Destroy this moss layer and you cause the permafrost to melt. Encourage the moss layer to develop and you ensure permafrost will form. As the moss layer thickens, the soil temperature* decline, decomposition slows and the undecomposed organic layer thickens. This provides more insulation and the cooling cycles builds. The presence of sphagnum indicates the presence of water. This usually means the permafrost layer is rich in ice.

Immediate and short fire effects

A typical site (slide) with permafrost will have scraggly looking black spruce trees, an extensive low shrub layer of labrador tea and blueberry, and a deep continuous layer of feathermoss and sphagnum. Reindeer lichens (slide) may or may not occur nestled within the upper layers of feathermoss. Permafrost occurs within 30 cm of the surface.

Soon after fire ignites the fuels on one of these areas a" active flame front develops (slide) and moves irregularly over the landscape. The flame front may moves along the ground, up into the tree crowns, along from tree crow" to tree crow", back to the ground, back to the crown, etc. After the flame front passes the area will continue to smoke and smoulder (slide) for some time, especially in hot spots. In the end (slide) the trees are mostly killed, some have fallen and the surface is mostly black. Heat is still penetrating into the organic layer, especially in the hot spots. During the days following the fire temperatures on the dry, blackened surfaces may reach over $59^{o}c$; these temperatures are lethal to seedlings.

Suppression activities that accompany fire usually include the construction of some type of fireline. They may be wide or "arrow, made before, during or after the fire. The ones show" in this slide have been made by caterpillar tractors. They can also be made by pick, shovel or eve" primer cord (slide). However, in all cases the surface is scrapped to either mineral soil or ice.

One week after the fire most surfaces are black (slide). Even though the sphagnum mounds are not black they have been sufficiently heated so that most of their mass is dead. A few grass blades and low shrub sucker shoots are beginning to appear.

Three months later (in September) the surface is still black and mostly bare. However patches of mud, wet mud, have appeared (slide). Erosion channels have formed in the firelines (slide). Water bars, where constructed, help to slow the development of water channels (slide).

While studying the revegetation process following the 1971 Wickersham Wildfire we also followed the changes that occurred to the active layer above the permafrost layer in the soil profile. Six sites were selected; three sites were on the lower slopes either side of the valley. Each set contained an unburned control site, a heavily burned site, and an adjacent fireline site.

Temperature sensors were installed a 0, 5, 10, 20, 50, 100 , and 150 cm depths in the soil profile. Leads from the sensors were buried, run through a pipe and connected to a junction box (slide) which was housed in a red wooden box. This set-up withstood the activities of both hare and squirrel. Adjacent to the temperature sensors a probe line was established. This consisted of ten flagged stakes. Each time the site was visited we recorded the temperatures at each depth and measured the depth to permafrost at flagged stakes by inserting a steel probe as far as possible into the ground.

Ten years after the fire the control site looked similar to its pre fire condition. The site around the temperature control box and probe line can be see" in this slide. However the disturbed sites have changed visibly. Along part of the probe line in the burned site the grasses are waist high (slide). Elsewhere along the same probeline the willows and low shrubs shoots are knee high. The fireline now appears green rather than brow"; many saplings are visible on the more stable sites (slide). Grass and willows (slide) are growing on the drier sites and cotton grass (slide) grows in the wetter sites of the probe line.

Freeze/thaw trends

Summer thaw pattern During winter the soil profile freezes completely, As spring and summer-progress the upper layers thaw. By graphing the frost probe information gathered weekly the seasonal pattern of thaw is visible. In the unburned control site (slide & figure 1) the thaw starts in early May and continues to gradually deepen until late September or even early October. The maximum depth never exceeds 50 cm. The pattern varies little from year to year. In the burn the pattern of thaw (slide & figure 2) is similar until mid June. At that time the rate of thaw sharply increases. The depth of thaw continues to deepen at this rapid rate until August. Thereafter the rate slows and finally comes to a halt sometime in September. The thaw is a little deeper each succeeding year and much deeper than in the unburned stand. In the fireline the pattern of thaw (slide & figure 3) is similar to that in the burn. However the period of rapid thaw begins about two weeks earlier in June and the deepest thaw depths are not reached until sometime in September.

Annual freeze/thaw profile When the freeze/thaw profile for all sites is drawn on the same graph the differences and similarities become clear. The pattern is different for each site. Thawing starts on all sites in early May (slide and figure 4). During the summer thawing is least in the unburned site, and greatest in the fireline site. The fall freeze-up is somewhat different on each site. In the unburned control, it begins about the same time (late September) from both the top and the bottom of the active layer, but the rate of downward freeze from the ground surface is greater than the rate of upward freeze from the permafrost/active layer interface. The soil profile is entirely frozen by mid December.

By contrast, in the burned site the soil continues to thaw at depth until after the surface layers have begun to freeze!! Freezing of the surface layers starts in early October, freezing at depth starts one month later. Freezing continues from both directions until the profile is completely frozen in late January. Freeze-up occurs one week to one month later in the burn than in the unburned control. The pattern on the fireline differs from both of these: it melts deeper and at a faster rate, starts freezing upward from the surface of the permafrost before it begins to freeze downward from the ground surface, and the soil profile remains partially unfrozen longer. The profile is completely frozen late in February or one month later than in the burned site and two months later than in the unburned control site.

Changes in the depth of thaw through time The maximum thaw depths on these sites have been followed for the first eighteen years following fire (slide & figure 5). During this time little variation has occurred in the unburned control, while a big change has occurred on the disturbed sites. The depth of thaw remained around 50 cm in the unburned control sites while it increased an average of 13 cm per year in the burn and 15 cm per year on the fireline until 1985. Since then the trend is somewhat unstable but appears not to be getting any deeper.

Influence of aspect So far I have been talking about the pattern of thaw on lower slope sites that have a northwest-facing aspect. What happens across the valley where the slopes have a southeast-facing aspect (slide figure 6)? The pattern of thaw on in the two control sites is similar: they vary little from year to year and both thawed to a depth of about 50 cm.

All disturbed sites thawed to deeper levels; the deepest thaw depths were reached on the two fireline sites. The southeast-facing fireline thawed to a maximum depth of 305 cm in 1979 or five years after the fire. The maximum depth of '270 cm was reached in 1985 on the northwest-facing slopes or six years later! The maximum depth of thaw was greater on the southeast-facing slope than on the northwest-facing slope. Thawing depth on the two burned sites continued to deepen until 1985 and was a little deeper on the northwest-facing slope. Thaw trends since 1985 when the maximum depths were reached are unstable and difficult to interpret on all sites but, at least the pattern on the southeast-facing slope, suggest that is may be in the recovery phase.

Other phenomena

Subsidence Subsidence occurs, at least in the areas of ice-rich permafrost. Subsidence along the probe line in the fireline varied from a few inches to over one half meter in ten years (slide & figure 7).

Ground temperature envelope When comparing the soil temperatures of one site with those of another its useful to compare what is called the ground temperature envelope. The ground temperature envelope for a site defines the temperature extremes that would occur in the soil profile on that site. The line on the left of the graph (slide & figure 8) is the minimum temperature that occurred at each depth, the line on the right is the maximum temperature that occurred at each depth. The middle line is the mean of the two extremes. The values for 1979 are connected by solid lines, those for 1980 are connected by dashed lines.

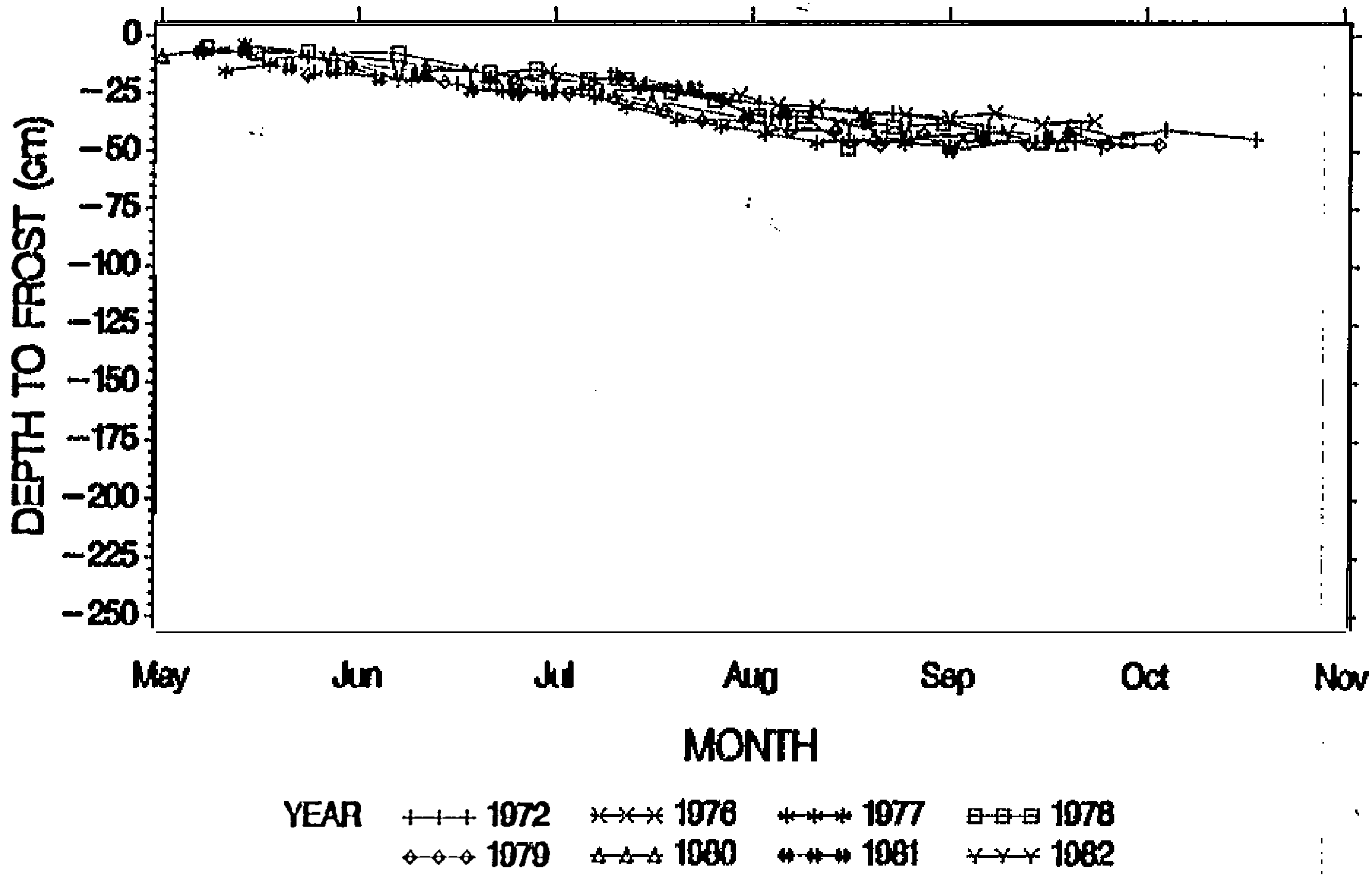
In the control the extremes at the surface varies from -20°c to + 20°c making an average of 0°c. At 80 cm down in the soil profile the temperatures varied from -5°c to +1°c for an average of -2°c. In the burn the temperatures varied from -15°c to +25°c at the surface and from 0°c to +1°c at a depth of 150 cm; average temperatures were about +2°c at the surface and +0.5°c at depth. This contrasts with the warmer temperatures found on the fireline. There the temperatures varied from -5°c to +21°c at the surface and -0°c to +10°c at a depth of 150 cm. Averages were 13°c at the surface and +5°c at at depth.

Soil temperatures at 10 cm The 10 cm depth in the soil profile is where most of the roots occur. The seasonal pattern found at this level in the soil is shown (slide) in figure 9. The coldest temperatures are reached in Feb. At that time the unburned control is the coldest and the fireline the warmest; both are below freezing. The warmest temperatures are reached in early August. This is almost one month earlier than the deep soils attain their warmest temperatures!! In August the fireline is the warmest site and the burn the coolest site; and all sites are warmer than +10°c.

Other effects Before I end this discussion I will briefly mention some other ways in which fire, acting on the soil, impacts the site. When silica is part of the surface materials, hot flame can melt the sand and at least temporarily seal the surface so that neither water or germinating seed can penetrate. In the process of consuming organic material, a hot flame may volatilize some of the nutrients. When this occurs these nutrients are lost from the site. However at other times when the flame temperatures are cooler, the fire released nutrients, thus making the nutrients more available to the plants on the site. Heat from the flame may penetrate the soil. In addition the blackened surfaces will continue for days and years to absorb solar radiation. Both increase soil temperatures which in turn speed up chemical reactions and thus growth. It also increases the number of decomposers and their rate of activity which again increases the amount of available nutrients. Earlier I mentioned erosion and subsidence. The long term effect of this can not be underestimated. When the ice content of the permafrost soil melts and the soil loses strength, soil particles move. When the substrate moves all living plants situated on top of it are impacted. Some, like the trees in this slide, will split upward from the base; each side of the tree moving with its own mass of soil. More frequently the plants, especially the young germinating seedlings, will be uprooted. Vegetation will be lost from the area until a new type of stability is attained.

Figure 1

THAW DEPTH
UNBURNED



Figure

THAW DEPTH
BURNED

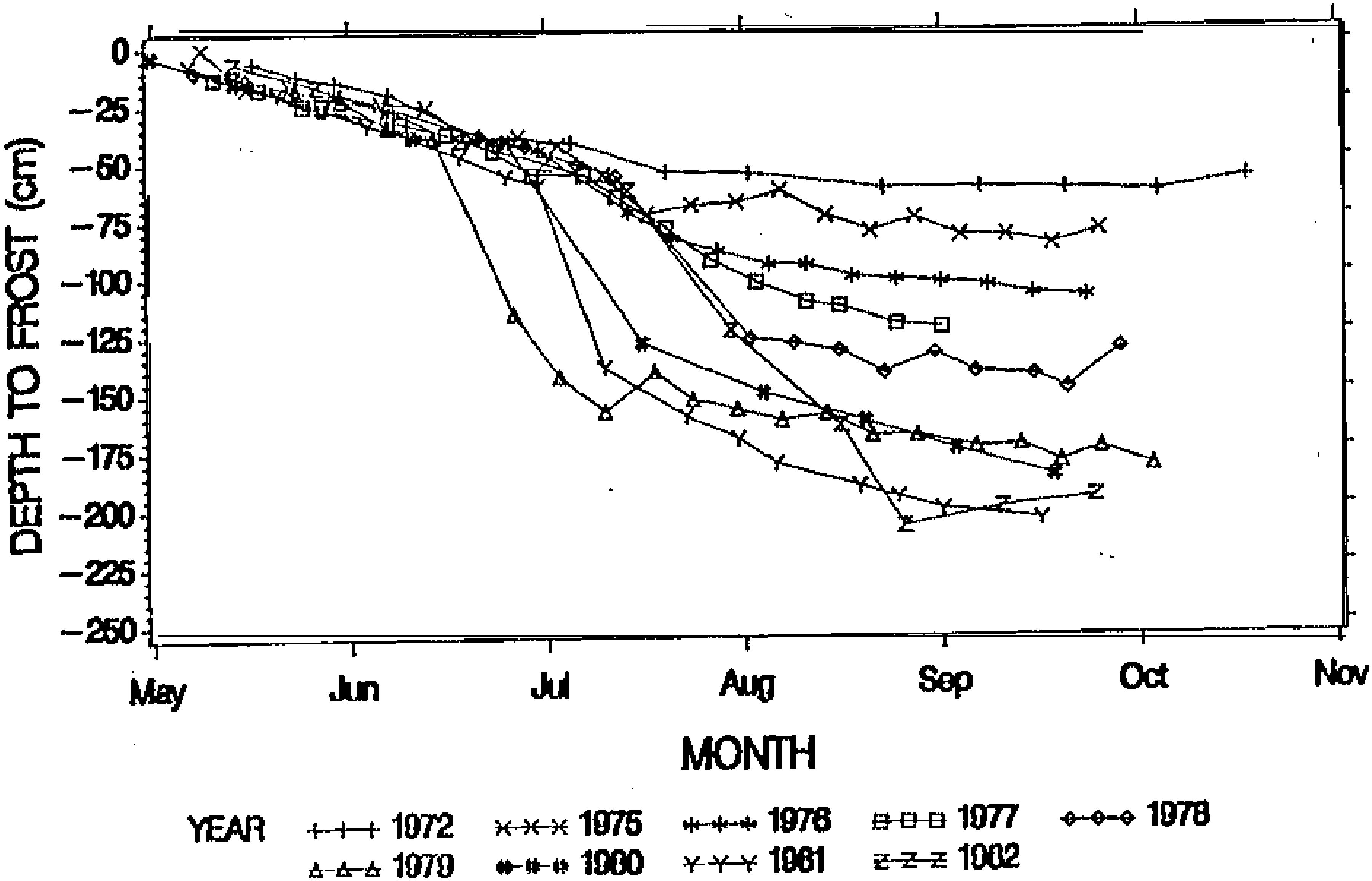


Figure 3

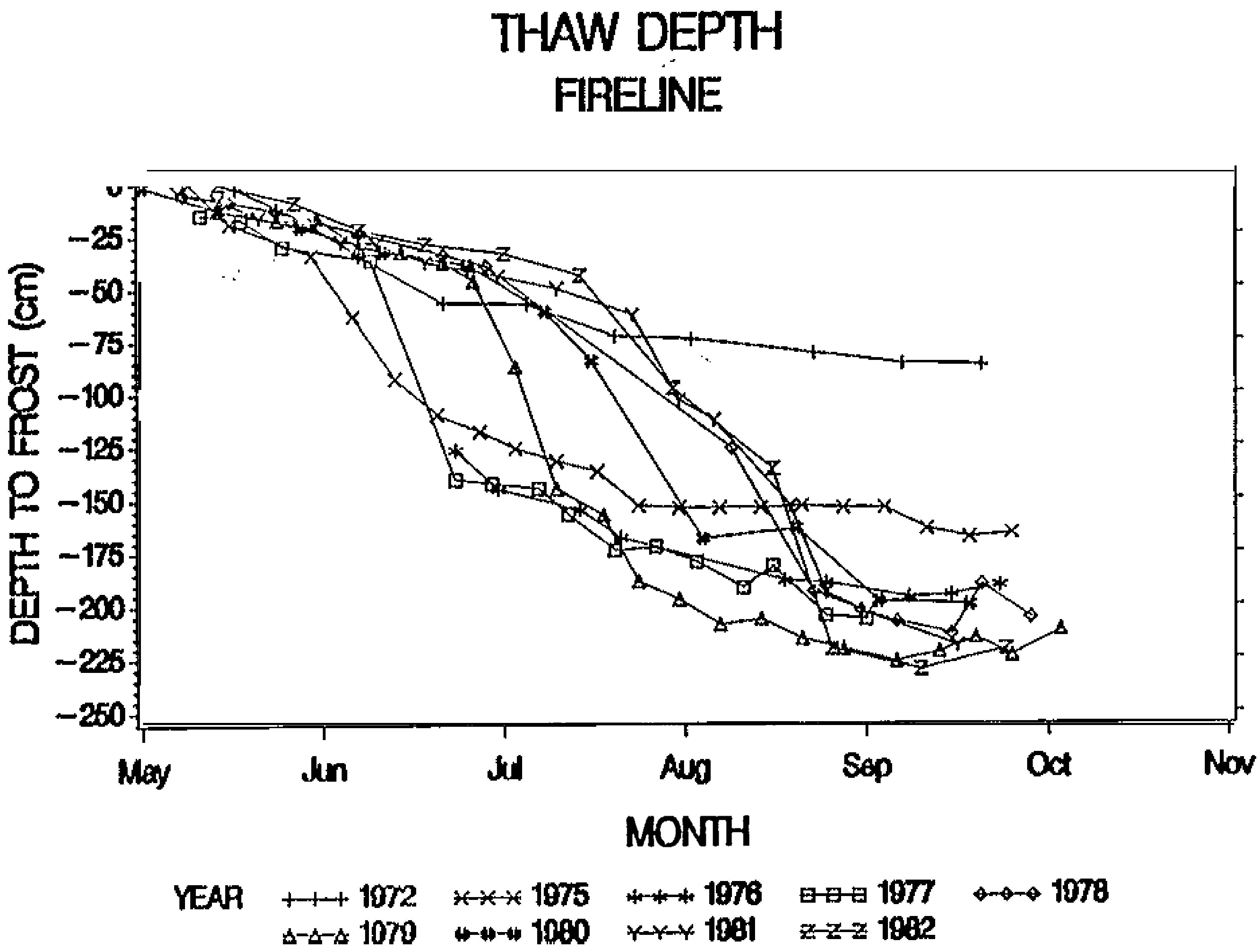
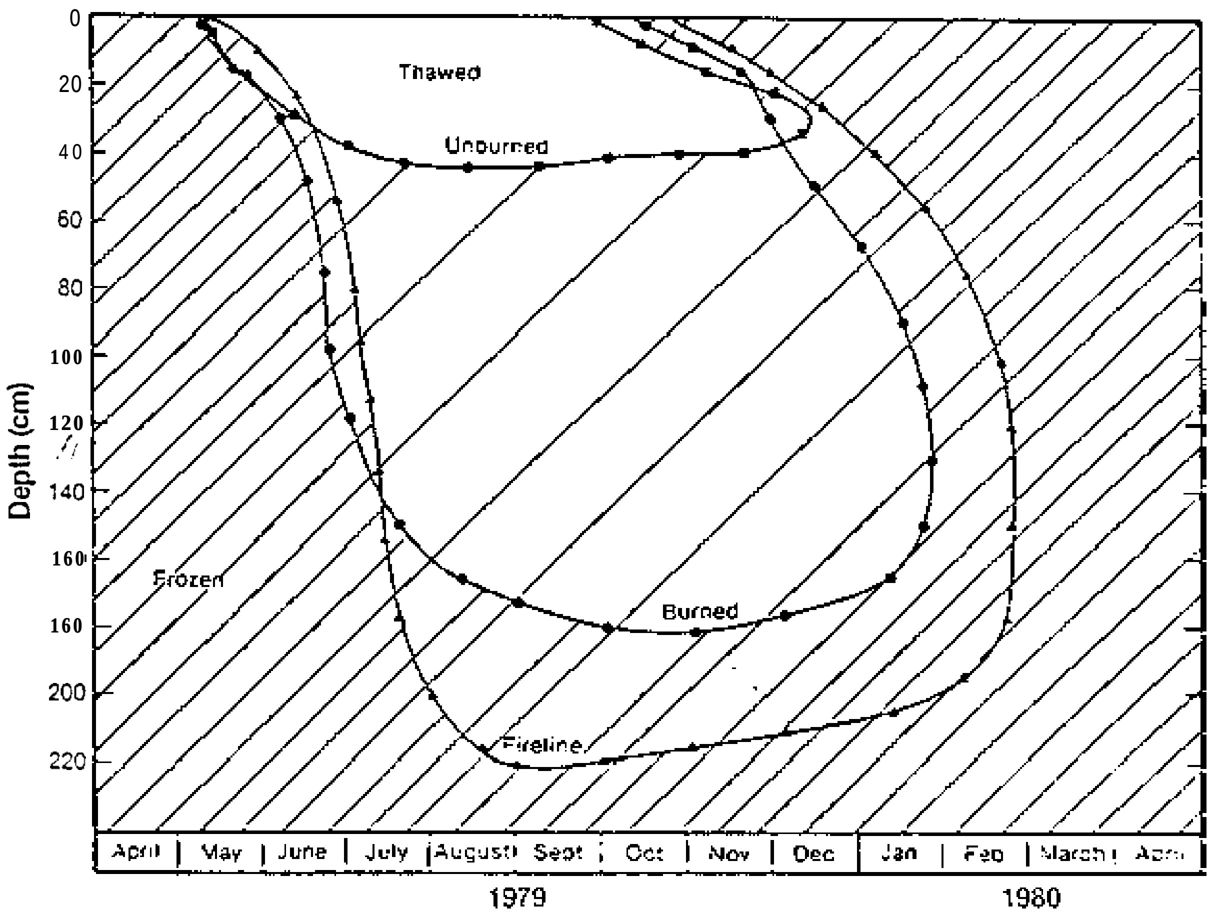
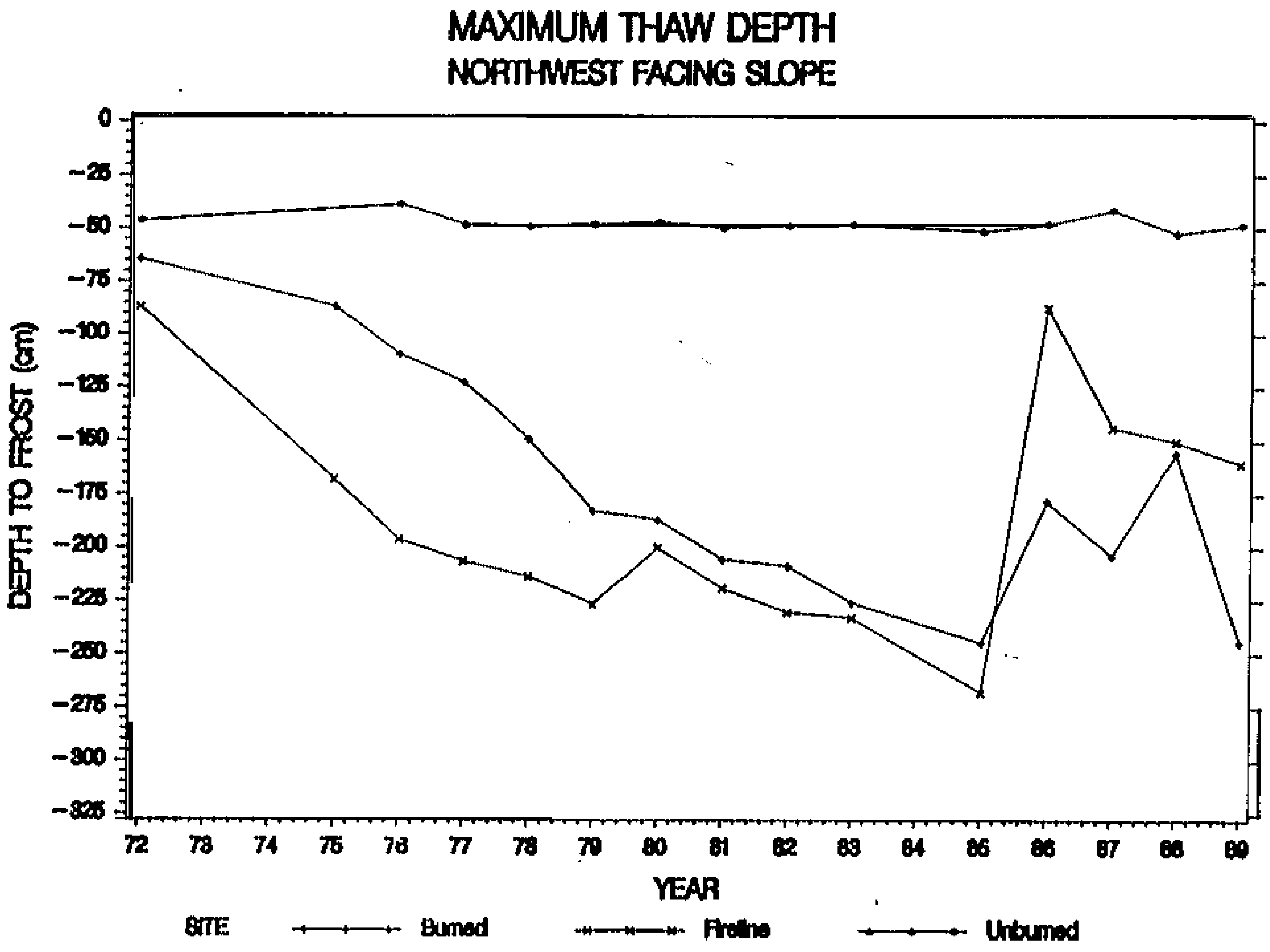

THAW DEPTH
FIRELINE
DEPTH TO FROST (cm)
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
-250
May
Jun
Jul
Aug
Sep
Oct
Nov
MONTH
YEAR
1972
1975
1976
1977
1978
1979
1980
1981
1982

Figure 4



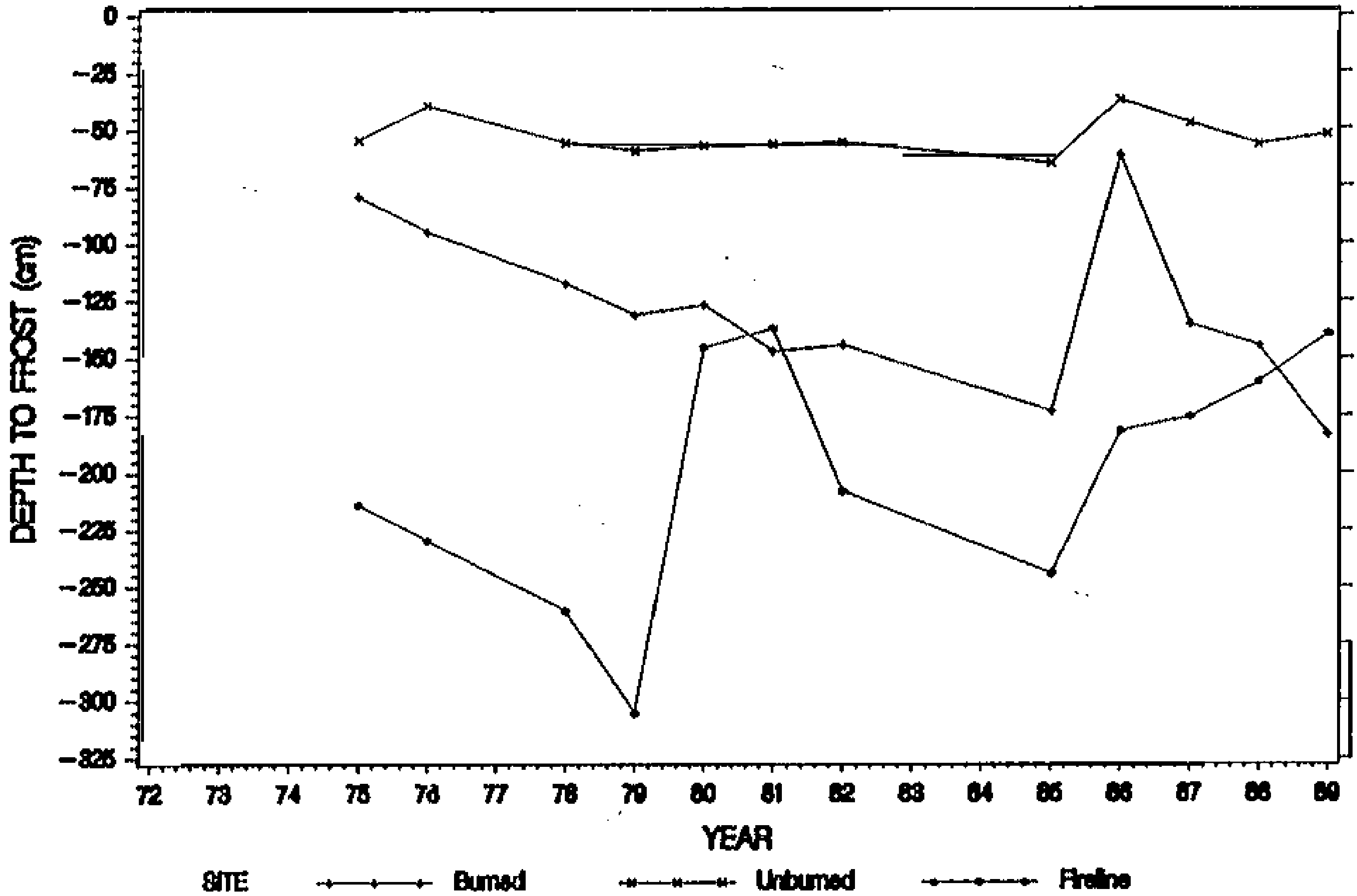
Thawed
Unburned
Frozen
Burned
Fireline
Depth (cm)
0
20
40
60
80
100
120
140
160
160
200
220
April
May
June
July
August
Sept
Oct
Nov
Dec
Jan
Feb
March
April
1979
1980



MAXIMUM THAW DEPTH
NORTHWEST FACING SLOPE
DEPTH TO FROST (cm)
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
-250
-275
-300
-325
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
YEAR
SITE
Burned
Fireline
Unburned

Figure 6

MAXIMUM THAW DEPTH
SOUTHWEST FACING SLOPE



132

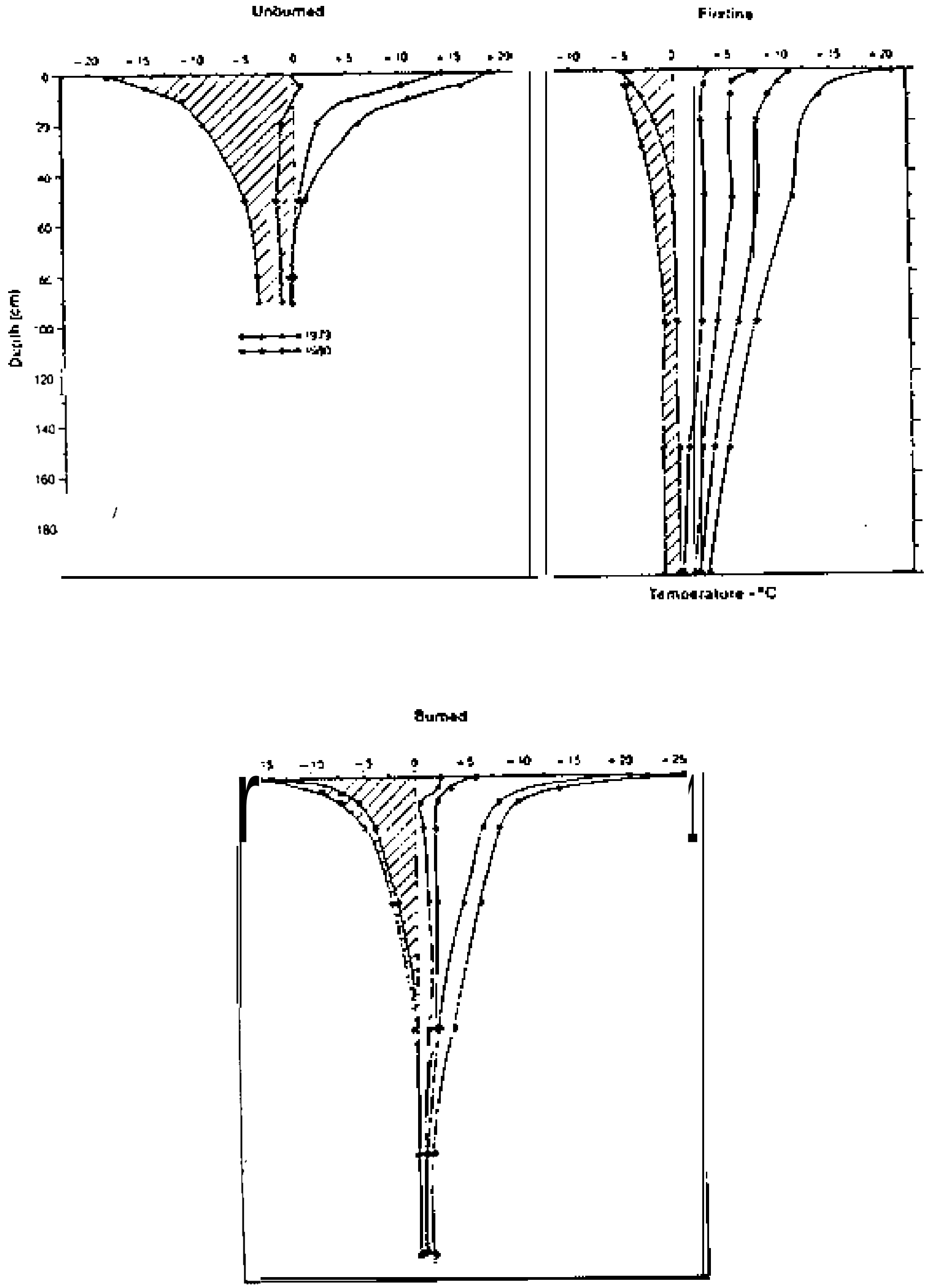

Unburned
Fireline
Burned
Depth (cm)
Temperature - °C
1979
1980

Figure 1

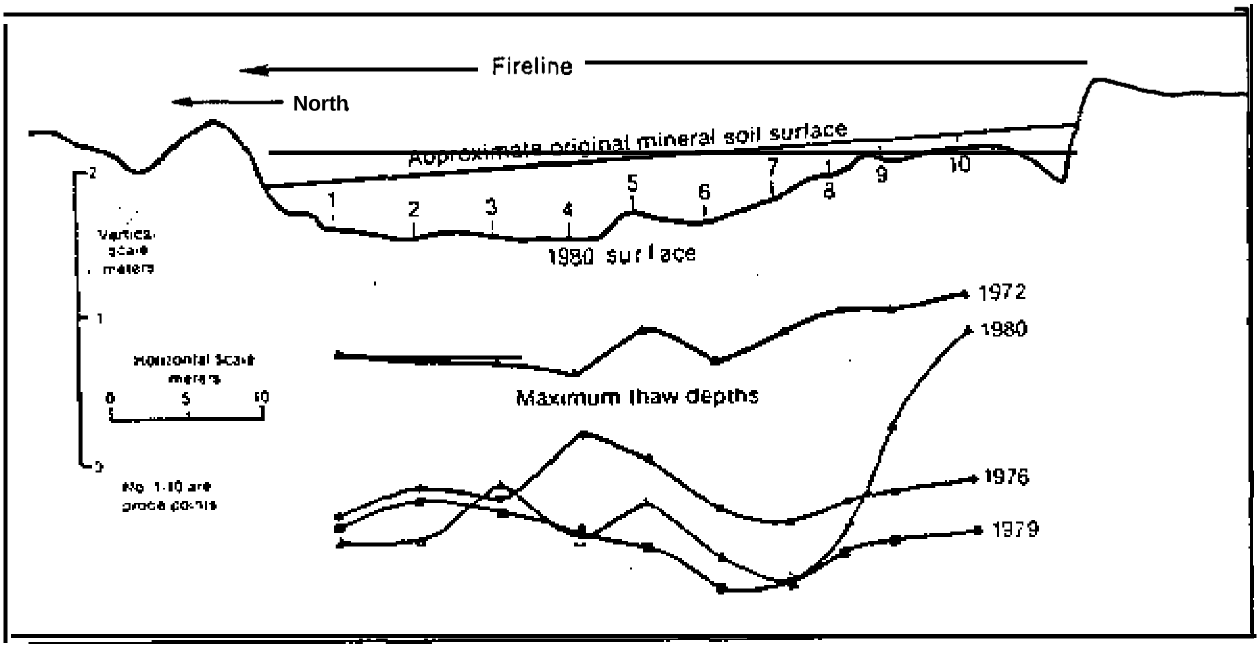
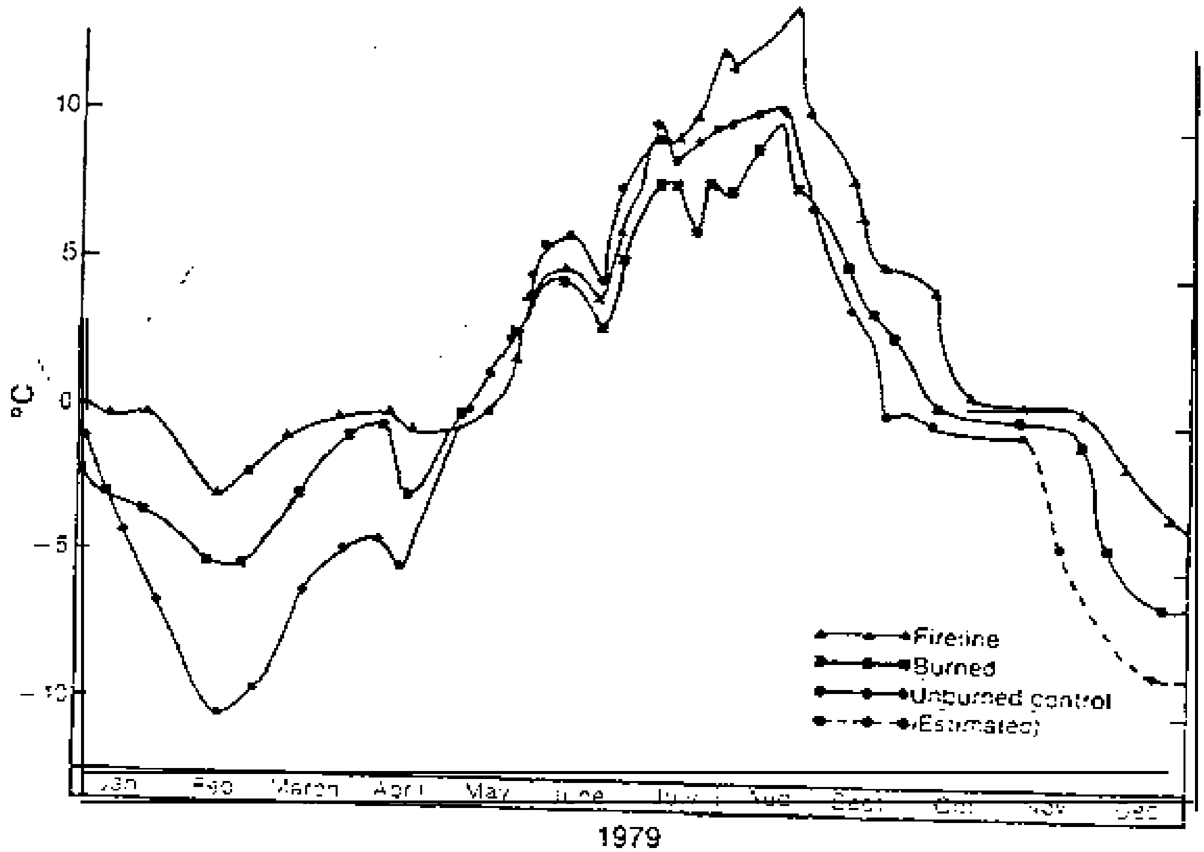

Fireline
North
Approximate original mineral soil surface
1
2
3
4
5
6
7
8
9
10
1980 surface
Vertical scale meters
Horizontal scale meters
0 5 10
No. 1-10 are probe points
Maximum thaw depths
1972
1980
1976
1979

Figure 9



10
5
0
-5
-10
°C
Fireline
Burned
Unburned control
(Estimated)
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
1979

SOIL SURVEYS AND PERMAFROST

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Permafrost is a topic which will be discussed many times this week. It is a topic which which we could barely begin to cover, even if we spent the entire week discussing it. I would like to use the next few minutes, however, and discuss some general concepts concerning soils with permafrost and the implications on soil mapping, classification and management.

First, what is permafrost? Permafrost is a thermal condition defined as a thickness of material with a temperature at or below 0 degrees C. for two years or more. Since the definition is based solely on temperature, even bedrock can have permafrost.

Above the surface of the permafrost or permafrost table is the active layer, the zone of seasonal freeze and thaw. The thickness of the active layer and the depth to the wermafrost table is determined the thickness and tvoe of vegetative cover, soil texture, aspect and relief.-'Churning of soil layers due to cryoturbation is most evident in the active layer.

Soils with permafrost range across all texture classes. The soils may have a high moisture content resulting in a high ice content and extremely firm consistency, or they may be essentially dry and loose. Those permafrost soils with a high ice content may have the ice disseminated throughout the soil as pore ice and thin lenses, or the ice may be segregated into massive wedges and blocks. Each of these variations has an impact on interpretations and potential land use.

Soils with permafrost are found consistently in northern Alaska (Zone of Continuous Permafrost *(Pewe 1975))* but become inconsistent in central and Interior Alaska (Zone of Discontinuous Permafrost *(Pewe 1975)).* As one moves south through the discontinuous zone, larger and larger blocks of permafrost free soils are found.

In northern Alaska or the continuous permafrost zone, permafrost temperatures are relatively cold, approximately -5 degrees C. or lower. Improper management, such as disturbance of the vegetative cover, will lead to thickening of the active layer and some lowering of the permafrost table. Seldom, however, will the permafrost table drop below the soil profile. If the soil is medium to fine textured with a high moisture content, poor drainage and unstable soil conditions will occur over the impermeable permafrost table. Management in this region is geared toward protecting the existing properties of both the active layer and the permafrost.

In the zone of discontinuous permafrost, permafrost temperatures are relatively warmer, approaching 0 degrees C. As such, permafrost soils are much more sensitive to any factor which will alter their thermal regime. Even minimal disturbance can have a considerable affect on the active layer, the permafrost table, and accessory soil properties; subsequently affecting potential use of the soil.

The easiest way to alter the thermal regime of a permafrost soil in the discontinuous zone is to alter the properties of the insulating organic mat. Wildfire, a common occurrence in Interior Alaska, as well as man induced disturbances such as land clearing, will lessen or destroy the insulating organic cover. The result is thickening of the active layer and lowering of the permafrost table. If the soil is ice rich, poor drainage conditions will occur until the permafrost table drops low enough to open up natural drainage outlets. At that point, many soils become well drained. In many cases, if no further surface disturbance occurs, natural succession of vegetation will result in re-establishment and thickening of the organic mat. The mean annual soil temperature will begin to decrease. The permafrost table will rise in the soil again as the soil temperature drops continuously below 0 degrees C.

Management of permafrost soils in the discontinuous zone may be directed either at maintaining the existing permafrost conditions or at lowering the permafrost table to a depth where it will not have an affect on management. An example of permafrost protection is the Trans-Alaska pipeline with its raised sections and cooling supports over permafrost soils. An example of permafrost removal are the large land clearing operations to turn permafrost soils into productive agricultural land.

What are the implications of permafrost on the soil scientist who is trying to map, classify and interpret these soils? In the continuous zone, there is little problem. The overwhelming majority of soils have permafrost in the profile and management is geared toward maintaining that permafrost. Interpretations are focused on the surface organic and mineral layers and the thin underlying active layer. The series and particle size control sections extend to 14 inches if permafrost is within 14 inches of the surface. If permafrost is deeper than 14 inches, the control section extends from 10 inches to 10 inches below the permafrost table. Classification is fairly straight forward and the soil scientist can concentrate on mapping out soils based on textures, ice content, and key genetic properties.

Things are a little more complicated in the discontinuous zone. Consider a single landform having uniform lithology and soil material. That landform has been subject to a wildfire, with a scar separating burned and unburned sections. The soil on the unburned side of the fire line has a thick organic mat, shallow permafrost table, pergelic temperature regime, and a poorly drained active layer. The control section of the soil is 0 to 14 inches. The soil classifies as a loamy, *mixed, nonacid Histic Pergelic Cryaquept.* On the other side of the fire line, the soil has no permafrost in the profile, and is well drained with a cryic temperature regime. The control section for this profile is from 10 to 40 inches. The profile classifies as a coarse-silty over clayey, mixed, nonacid Typic *Cryochrept. Now* complicate the issue a little. The soil which has thawed due to organic mat destruction, will cycle back to its permafrost state and change classification as the vegetative mat is reestablished and soil temperature lowers. A further complication is that all stages of the cycle may occur on a landform, depending on the severity of a burn, and the continuous overlapping of fire scars.

How can a soil scientist adequately map, classify and interpret these soils. The mapping is fairly straight forward. Separate map units are set up for the extremes of the cycle and possibly an intermediate stage if it covers significant acreage. One map unit for the poorly drained soil with shallow permafrost, one for the well drained soil with no permafrost, and possibly one for the somewhat poorly drained soil with the permafrost table lower in the profile. All other intermediate stages of the cycle are handled as inclusions. If the thawed and frozen components are intermingled in small acreages, a complex is set up, describing and interpreting each component.

To provide adequate interpretations, the permafrost soil must be interpreted both for its current condition in the frozen state and for its potential in the thawed state. Most large scale land management uses will require that the permafrost table be lowered. Interpretations for both states can be handled in the map unit descriptions, although the descriptions become lengthy. It is more difficult to handle the dual interpretations and properties in automated databases. Only the properties and interpretations for the soil in its current frozen state are stored in the national databases. The potential thawed properties and interpretations could be handled using state tables in the state soil survey database.

A soil that is currently in the "thawed" state will be interpreted for management of its thawed properties as well as how to keep it "thawed".

As discussed above, classification of permafrost soils in the discontinuous zone becomes very difficult. First, the definition of pergelic temperature regime does not exactly coincide with the presence of permafrost. Pergelic soils. have a mean annual soil temperature lower than 0 degrees C., while permafrost has a continuous temperature of 0 degrees C. or less. Secondly, the temperature regime, control section, drainage class, and presence of a histic epipedon can all change across a fire scar or fence line, resulting in different classifications. The current classification scheme does not show the relationship between the frozen and thawed states of a soil. Especially confusing are the family differences. The limited control section of the frozen soil does not allow family or series separations that are necessary to manage the soil following thawing. A classification scheme is needed that will recognize the characteristics of the extreme ends of the cycle yet still show the relationship between those extremes.

A proposal has been developed to modify SOIL TAXONOMY with regards to permafrost soils. Copies of the proposal are available to those who wish to study it in detail. In general terms, however, the proposal would: *a)* redefine the pergelic temperature regime to coincide with the definition of permafrost; *b)* redefine the pergelic and cryic temperature regimes to allow for the temporary cycling of mean annual soil temperature from pergelic to cryic and back; *c)* recognize permafrost at the great group level by adding a "*geli*" great group for soils in the pergelic temperature regime. Typic subgroups would recognize the "cold" noncycling permafrost soils. Cryic or "cyclic" subgroups would recognize the "warm" permafrost soils which may cycle if disturbed; *d)* open up the control section of soils in cryic subgroups of "geli" great groups to 10 to 40 inches. This would allow the frozen and thawed counterparts to remain in the same family. The soil from our earlier example would classify as a *coarse-silty, mixed, nonacid Cryic Geliaquept* when frozen and as a *coarse-silty, mixed, nonacid Cryic Geliochrept* when thawed.

In conclusion, permafrost'soils provide a soil scientist with a considerable challenge to understand the dynamic processes involved and to provide useful data and interpretations to land users. There is a great deal to learn and understand. Permafrost soils are one of the many challenges that keep a soil scientists work challenging and rewarding in Alaska. As we work to better understand these soils, we need to work with and listen to others who share the same concerns. This means improving technical soil communications with the Soviet Union, Canada, and other circumpolar nations which have permafrost soils.

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SOIL CLIMATE ISSUES

R. F. Paetzold

Three soil scientists were out in the field one day, trying to classify a soil. This one particular soil was giving them problems. The soil was sandy with a high or very high saturated hydraulic conductivity. Its position in the landscape was such that it also received extra water in the form of run-on from other soils. No measured soil water data was available. The first soil scientist claimed that the soil should be in the aridic soil moisture regime because it was incapable of being used for crop production without irrigation. The second soil scientist claimed that it should be ustic based on the fact that it received more water than the surrounding soils, which were aridic-ustic because they had to be fallowed every other year in order to grow crops. In addition the soil produced more native grass than the surrounding soils that were in grass, and could produce more cattle because of the extra grass. The third soil scientist said that both were wrong. He claimed that it should be udic because it had a high hydraulic conductivity and much of the water that entered the soil was lost through deep drainage or percolation. In other words the soil was highly leached, especially compared to the surrounding soils. Also, the fact that water readily moves through the soil has implications for engineering interpretations such as septic tank filter fields, pesticide movement and ground water quality. Which soil scientist is right? Each has a good argument for hi classilication, and each can find support for his argument in the Soil Taxonomy (1975) and in the Guy Smith Interviews (1986).

This story illustrates some of the problems with the current system of soil climate classilication in the Soil Taxonomy. I think that the greatest problem associated with the use of soil moisture and temperature regimes is the lack of documented concepts of the soil climate regimes. We don't know why we make the separations between regimes, i.e. the basis for separating soils because of climate. Do we want to separate soils based on genesis, management, arbitrary and artificial criteria, or what? If we base our separations on management concepts, we need some uniform management scheme. The vegetation native to drier areas is well adapted to using water when it is available, becoming dormant when it is not. Crops, on the other hand cannot go dormant and hence die when water becomes unavailable. There are areas where there is enough water for native vegetation to thrive and provide plenty of grazing for livestock and wildlife, but not enough for cropping. Do we base our classification on management for native spccics, i.e. grass on the prairies, trees in the forests, etc., or on management for crop species? This is not a trivial question. Separations of soil moisture and temperature regimes based on forest management might give useless separations for grassland and crop management. Management for particular crops would pose similar problems. Separations based on crop management would have little applicability to forest and range management. In addition. deciding which crops to use for basing separations on might prove to hc more of an exercise in international diplomacy than a scientific endeavor. It would seem impossible to set up a classification scheme based on management that would be useful for a large area. And a scheme based on soil genesis, may be of little use in management. Native vegetation or domestic cropping practices should he used as clues to the local soil climate, but the concepts and definitions of the soil moisture and temperature regimes should not be based on the vegetation of a small part of the world.

The present system appears to be based on some combination of genesis, management, intuition based on experience, and arbitrariness. Smith (1986) indicates that the philosophy of John Stuart Mills was closely adhered to, especially that the best classilication is the one that permits the largest number and most important statements about the objects that are grouped. I would suggest that consistency in the kinds of statements made among the groups is also important. If there is no consistency than one ends up with problems separating groups. However, regardless of the classification philosophy, the overriding consideration in the development of the Soil Taxonomy apparently was to be careful not to split any existing soil series. On page 27 of his interviews, Guy Smith stated "The temperature limits were fixed by the necessity of avoiding the splitting of established series." And again on page 32, "Many of the complications of the definitions in Soil Taxonomy are due to the strong bias by the soil survey staff against changes in the definitions of soil series. And in an effort to avoid splitting the series, we have introduced what looked like inconsistencies in many places but really arc consistently in favor of one reason, namely that we want to keep the soils together in the taxonomy if they really belong together because of their genesis and their behavior." This constraint results in complicated and somewhat arbitrary soil climate regime definitions.

Another factor resulting in more or less arbitrary definitions is the lack of soil climate parameter measurements. According to Guy Smith (1986, p. 115-6) "We had predetermined the classification of the soils on the Great Plains. We then lit the definition to this predetermined boundary, using climatological data to do it. If we subsequently found that our definitions were in error, then we were much more apt to change the definition than the classification, which was predetermined. We said we want these. soils to be in aridic subgroups of ustic great groups, or in udic subgroups of ustic great groups, or typic subgroups of ustic great groups. This was based on a lot more experience with land use than it was on the climatological data." And on p. 112 (Guy Smith, 1986) "Not all soil climatic regimes have been defined. The gap left between the definition of aridic, ustic and xeric soil moisture regimes was deliberate. We have no information about these soils that enable us to develop that part of the taxonomy and had we attempted to close that gap so that there would be a place for every soil. we feared that the pedologist might attempt to classify the soil by simply applying the definitions in Soil Taxonomy. It must be remembered that classification involves not only the application of the rules to see where the soil fits in Soil Taxonomy but equally importantly, it requires that the classifier study that classilication to see whether that is appropriate." Thus it appears that the soil climate definitions in the Soil Taxonomy are based largely on soil scientists intuition about the soils in the Great Plains region of the United States of America, a relatively small part of the world.

Many of these intuitions arc a result of the training of soil scientists in the field of soil genesis. On page 32, Guy Smith (1986) states "... we want to keep the soils together in the taxonomy if they really belong together because of their genesis and their behavior." Also on page 10 of the Soil Taxonomy "If genesis is ignored in forming a taxonomy, the system will have reduced value to the soil survey." Also on page 10 of the Soil Taxonomy "Because we want to be able to make the most important statements possible about the taxa, those properties that arc important to plant growth and that result from or influence soil genesis should be considered in the higher categories. Those that are important to plant growth, but arc unrelated to genesis should be considered only for the lowest categories."

In spite of the statements quoted above, a case is made for interpretations being the governing factor behind the definitions in the Soil Taxonomy. On page 10 of the Soil Taxonomy it is stated that "Interpretations arc predictions of the consequences of specific uses of soils, commonly in terms of plant growth under specified systems of management but also in terms of engineering soil behavior after a given manipulation. The grouping that helps us make the most precise and most important interpretations is the best. A taxonomy for the use of the soil survey must be tested by the nature of the interpretations that can bc made. This taxonomy is designed to facilitate interpretations, but the interpretations themselves require at least one additional step or reasoning. The intcrprctations may also require information that is not available from the taxonomy." On page 50 of his interviews, Guy Smith rays "Interpretations were the major control in design of Soil Taxonomy, the major control at the family level and the series."

The lack of consistent concepts for soil climate regimes hinders both the application of these regimes in soil classilication and the modification of the definitions of the regimes to simplify measurements and to group soils in new areas. Guy Smith (1986) indicates that we should bc more concerned with putting things that belong together into a taxon, than following the rules that are set by the limits of Soil Taxonomy. However, without concepts for the various regimes, it is difficult to make consistent groupings. This results in problems of joining soils across state lines and with other agencies.

Guy Smith was very deliberate in not providing specific concepts for the various soil climate regimes. On page 25 of his interviews, he states 'I very carefully tried to hide all of this stuff in Soil Taxonomy to force the people to examine the definitions to see how they grouped the soils. If I had given all the background on all these questions then people, I feared, would pay more attention to the reasons why we did something than to what we said. Then they would be less inclined to examine the groupings of soils that result from the definitions in Soil Taxonomy." I suspect also that it would be difficult to put the various reasonings behind the regimes into words, especially considering that the overriding consideration apparently was to minimize splitting of soil series.

Problems involving classitication arc not unique to soil science. Classification is a process basic to all sciences. According to Trewartha (1954) it consists of recognizing individuals having certain important characteristics in common and of grouping these individuals into certain classes or types. By noting the similarities between numerous individuals, and then by recognizing these individuals as forming a class, the many are reduced to one. Thereby simplicity and order are introduced into what at first may have been a bewildering multiplicity of individuals. Classification thereby aids in establishing general truths from numerous individual instances. Since the climate of any locality or region is composed of a great variety of elements, it is nearly impossible for two places to have identical climates. It is this almost limitless number of individual climates on the earth which requires a grouping into classes and types. It should be noted that all classifications of climates are manmade and are not naively given. There is no divine plan which is being sought. There can be a variety of ways of classifying earth climates, each of which has merit. It follows that there are a number of good classifications of climate. There is no one which is best, for some arc better for one purpose and some for another. They all have the same goal, however, viz.. the reduction of innumerable locality climates to a relatively few groups or classes having important characteristics in common.

The Koppcn classification of climate has been criticized by geographers from various points of view (Trewartha, 1954). Many of these criticisms can be applied to the Soil Taxonomy. Some feel that the dearth of meteorological observations for large parts of the world makes a climatic classitication with rigid boundary criteria unsatisfactory. They point out that this too often leads to pronounced discrepancies between climatic subdivisions and features of the natural and cultural landscapes. To include as Koppcn does, the humid Puget Sound region with its splendid Douglas fir forests in the same climatic type (Mediterranean, Cs) with central California obviously indicarcs a weakness in the classification. Others have pointed out that, while some of the Koppen climatic boundaries have been chosen with certain natural landscape features in mind, others have been purely arbitrary choices. It has been suggested also that Koppen has erred in applying to higher altitudes his formulas derived for lowland climates.

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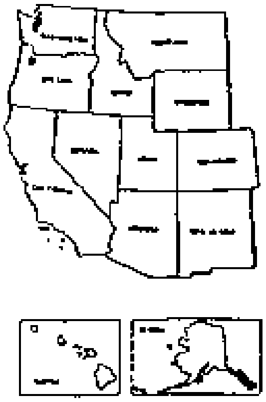

WESTERNRECIONALCOOPERATIYESOILSURVEYCONFERENCE

University of Alaska Fairbanks

June 18-22, 1990

FIELD TRIP GUIDE

Compiled by

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FIELD TRIP ITINERARY

Western Regional Cooperative Soil Survey Planning Conference

June 20, 1990 Fairbanks, Alaska

0800 Leave M-B-S Complex parking lot

0820 Stop **#1 - T-Field**

Visit soil pits in spruce forest with permafrost and cleared field with thermokarst-Joe Moore and Joe White

1000 Stop **#2 - West Ridge**

Temperature regimes of forested vs. cleared field--Dr. CL. Ping

1030 Stop **#3** - Farmers Loop Road

Features associated with ground subsidence caused by thawing of ice-rich permafrost--Drs. Robert Speck and Nils Johansen

1200 Lunch at Stop **#4**

1230 Stop **#4** - Permafrost Tunnel

and

Stop **#5 - Trans-Alaska** Pipeline

--Drs. Robert Speck and Nils Johansen

1500 Eielson Agricultural Project

Agricultural practices and conservation in the subarctic--Ann Rippy and Steve Hemshrot

1730 Return to M-B-S Complex

John E. Witty
Western Regional Soil Survey
Work Planning Conference
Fairbanks, AK
June 17-22, 1990

REVISIONS IN SOIL TAXONOMY

John E. Witty
National Leader, Soil Classification

INTRODUCTION

I really appreciate the invitation to attend the Western Regional Soil Survey Work Planning Conference here in Fairbanks. Attending these meetings is one of the best ways to learn what is going on in the Western Region concerning soil surveys, especially with regard to new ideas or ways of doing things. Also my trips to Alaska have been among my most enjoyable ones.

In this presentation I am going to give you a brief update on soil classification and the Soil Survey Manual, with emphasis on revisions in Soil Taxonomy. Last March I gave a similar talk at the State Soil Scientists' Workshop in Kansas City, so some of you will hear a partial repeat of that talk. If you have any questions I will try to answer them, and if you have any suggestions how we can better work together to improve Soil Taxonomy, I would appreciate receiving them.

SOIL CLASSIFICATION STAFF

I am stationed in Washington, DC, but will probably move to Lincoln in the spring of 1991. The other soil classification staff members, Richard Fenwick, Robert (Bob) Engel, and Margaret Hitz, are stationed in Lincoln. Richard's main responsibility has been to complete the Soil Survey Manual. Bob has been working mainly on amendments; he has also been assisting at workshops and has helped the Quality Assurance Staff by participating in some field reviews. Margaret is our new secretary, but she also provides secretarial help to the Field Investigations Staff. We have one "active" vacancy. I call it active because it is scheduled to be filled this summer. We have some other vacancies which may never be filled.

KEYS TO SOIL TAXONOMY

The 4th edition of Keys to Soil Taxonomy was published in March, and you should all have your copies by now, except maybe the Forest Service soil scientists. We mailed 5 1/2 boxes of Keys (225 copies) to Pete Avers, and they seemed to have gotten lost in the mail even though my office and

Pete's are only separated by 14th Street and about half a mile of hallways!

We had originally planned to publish the Keys in 1989, but because of delays the date had to be changed to 1990. YOU are all probably aware by now that we have changed publishers from Cornell University to Virginia Polytechnic Institute & State University, Blacksburg, VA. I believe many of our cooperators have received a complimentary copy. Additional copies can be ordered from VPI. This year I ordered 3,000 copies for SCS distribution, mainly nationally, but also internationally. This is 500 more than was ordered in 1987 and 1000 more than in 1985. It seems that the states' mailing lists are getting bigger and bigger. Anyhow, my current supply is nearly exhausted, but we will try to fill requests for additional Keys to new employees.

There are two major changes in the Keys this year: 1) a new order, Andisols, is added; and 2) the keys to subgroups have been converted to the same format as the keys to orders, suborders, and great groups. These are the same changes that are spelled out in Issue No. 13 of the National Soil Taxonomy Handbook. Adding the new order and changing the format of the keys to subgroups has made the new edition approximately one third thicker.

National Soil Taxonomy Handbook Issue No. 13 was published about the same time that the page proofs to the Keys were being checked. During the process of page proofing the Keys, a certain number of errors were found and corrected and some editing was done. Consequently some of the errors that you have found in Issue No. 13 have already been corrected in the Keys. If you find any additional errors in the Keys, I would appreciate it if you would let me know about them. The Keys still require some editing, but in many places the intent should be clearer now than in previous editions. Before the next edition is published in two years, I plan to have the Keys thoroughly edited - which was never done with Soil Taxonomy before it was published in 1975.

DISPOSITION OF PROPOSED AMENDMENTS

Most of the proposals originating in the United States have come from the NCSS membership. However, we have a big problem in coming up with an efficient way to submit proposals and to get them in a review process leading either to their acceptance or rejection. It seems that our current procedure results in a few proposals being lost or unduly delayed, but with current staffing levels I do not know of a better way.

»The following is a summary of the current procedure:

1. The originating State Soil Scientist forwards the proposal to the Chair of his Regional Soil Taxonomy Committee. The Chairs of these regional committees are the heads of Soils Staffs at the National Technical Centers.

2. The receiving Chair submits the proposal to his committee members for review, with a request that they approve or disapprove the proposal and document their recommendations. Complimentary copies should also be sent to the Chairs of the other Regional Soil Taxonomy committees and to the National Leader for Soil Classification.

3. The Chair summarizes the recommendations, notifies the originating state concerning the recommendations, and forwards the summary and recommendations to the National Leader for Soil Classification.

4. The National Leader for Soil Classification forwards the proposal to the other Chairs of the Regional Soil Taxonomy Committees and the Chair of the Soil Science Society of America's Soil Taxonomy Committee for their review and recommendations, unless the first regional committee had recommended that the proposal should not be accepted and this recommendation is clearly justified.

5. After receiving the recommendations from the Soil Taxonomy Committees, the National Leader for Soil Classification follows up on these recommendations. The originator will be notified if the proposal is not approved. If it is approved, it will be published in the National Soil Taxonomy Handbook.

These basic procedures are described in National Soil Taxonomy Handbook Issue No. 3.

SOME CURRENT PROPOSALS UNDER CONSIDERATION

The following are some proposals that we are currently working on:

1. The proposal to recognize a new diagnostic horizon, the *glossic* horizon. This proposal resulted from problems in applying the definition of tonguing. *Tonguing* will probably be removed as a diagnostic feature. This also requires modifications in the definitions of the albic horizon and interfingering.

»2 . Modifying the series control section. A major change being considered is to extend the series control section by starting at the surface rather than at 25 cm, and by extending down to a depth of 1.5 m rather than 1 m if the bottom of any diagnostic horizon is shallower than 1.5 m. If a paralithic contact is within 1.5 m of the surface, the series control section would extend 25 cm below the contact or to 1.5 m, whichever is shallower. Other parts of the definition will remain unchanged.

3. Redefining Ultisols to include frigid or colder soil temperatures. This is a proposal coming from the State of New York.

4. Adding new classes to keep the soils with continuous permafrost separate from those with cyclic permafrost. Soils with cyclic permafrost lose the permafrost in. the upper part as a result of fires or clearing, but if these soils are allowed to revert back to their natural vegetation the permafrost returns within a period of 40 or more years. Whether or not soils have continuous permafrost or are subject to cyclic permafrost has considerable impact on their interpretations.

5. Making the use of SI units in Soil Taxonomy official. We are currently using SI units in Soil Taxonomy, but an amendment approving their use has *never* been prepared.

6. Modifying the definition of the cambic horizon to allow a horizon that has all the properties of an oxic horizon except thickness to be included as part of the cambic horizon.

7. Subtracting out the contribution of organic matter when estimating clay content on the basis of 2.5 or 3.0 times 15-bar water content.

8. Requiring Albolls to have evidence of wetness in addition to chroma of 2 or less.

9. Recognizing subgroups of Troporthods for use in Oregon.

10. Deleting the *oxidic* mineralogy class.

11. Clarifying the definition of *kandic horizon.* There seems to be confusion concerning whether the top of the kandic horizon is dependent on a clay'increase only or whether there has to be a clay increase coinciding with low CEC. The clay increase defines the top of a kandic horizon. The horizon has to have low CEC, but not necessarily at the top,

12. Allowing the sharp increase in clay in Paleargids to be within the argillic horizon rather than only between the eluvial and the illuvial horizon.

Concerning the International committees, we hope to finalize the Vertisol proposal this year. I received the International committee on Vertisols' recommendations early last winter, but there were still a few loose ends. I prepared a new draft and returned it to Juan Comerma, Chair of ICOMERT, for his comments, but I have not heard back from him yet. We are also planning to send the draft out one more time for a quick review by a dozen or so people before I prepare the final amendment to Soil *Taxonomy.* I hope it will be finalized this fall or winter.

Other very active International Soil Classification Committees are those on Aquic Soil Moisture Regimes, on Aridisols, on Spodosols, and on Soil Moisture and Temperature Regimes. We hope to wrap up their proposals within the next 1 1/2 to 2 1/2 years. Their status is as follows:

1. Aquic Soil Moisture Regimes.--We are holding a workshop on wet soils in Louisiana and Texas during the two weeks before the annual ASA meetings in October. Johan Bouma, Chair of ICOMAQ, hopes to be able to prepare his final recommendations to SCS after this workshop, so we believe it will be a very important meeting concerning our decisions for classifying wet soils. I am currently preparing draft keys based on Dr. Bouma's preliminary recommendations for testing at the workshop. Some of the proposed changes would:

a. Drop the term *aquic moisture regime* and substitute *aquic conditions.* Aquic conditions would require saturation, reduction, and morphological or chemical evidence of wetness.

b. Substitute the term *redoxomorphic features* for the term *mottles* in essentially all places where mottles are now mentioned in Soil Taxonomy.

c. Recognize either an *endoaquic* (groundwater table) or an *epiaquic* (perched watertable) great group for each of the *aquic* suborders, and develop appropriate subgroups for each of the new great groups.

d. Recognize oxyaquic subgroups. These subgroups would include soils that have a watertable but *no* evidence of reduction. They have generally been excluded from aquic subgroups because they do not have "mottles with chroma of 2 or less" within the specified depths even though there is a watertable.

2. Aridisols.--Aridisols have received a lot of attention at soil classification workshops, but it has been very difficult to develop a final proposal for revising their classification. Based on the recommendations that resulted from our Cold Aridisol tour in August, 1989, Joe Nichols is working on a new draft. After the Vertisol proposal is approved, I plan on concentrating on the Aridisol proposal to see if we can finalize it

3. Spodosols. --Refer to Bob Rourke's presentation, this conference.

4. Soil Moisture and Temperature Regimes.--Refer to Ron Paetzold's presentation, this conference. The International Committee on Soil Moisture and Temperature Regimes was recently reactivated and Ron accepted the leadership for this committee. He has published one circular letter with a lot of questions and suggestions. I believe we will see considerable progress with this committee in the near future.

One other committee is the International Committee of Soil Families (ICOMFAM) with Ben Hajek as Chair. So far we have not had very much activity by this committee, but I believe there is room for considerable improvement in Soil Taxonomy at the family level. For example, we need to review all the criteria and decide what new criteria should be added and what old criteria deleted or changed. Another question is: Should we leave the family criteria all in one chapter or tailor them to each individiual order and list separate sets of family criteria at the end of each order chapter, following the keys to subgroups?

SOIL SURVEY MANUAL

Richard Fenwick has kept very busy getting the Soil Survey Manual ready for printing. He submitted the manuscript to our publication staff in Washington at the end of May. I believe they will give it one more quick editorial check; then it will be submitted for departmental approval. I do not know how vigorous a review it will receive there, but after we have departmental approval it will be ready for design layout and then printing. It is my understanding that the design work requires 4 or 5 months, so printing will not begin until late fall or early winter.

In 1970 Dr. Marlin Cline prepared a draft outline for the revised Soil Survey Manual. I believe the intent was to have it ready for republication within 3 or 4 years, but those 3 to 4 years have stretched 'into twenty. During most of those 20 years somebody has been assigned to vork on the manual as a major part of his job. When I think back on the history of this revision, I believe the fifth draft was about 95% ready for publication in 1975. A decision was made, however, not to publish the fifth draft, but to revise it extensively. It then rapidly dropped back to being about 50% ready, and it has taken a tremendous effort to pull it back up, among other reasons because it has been very difficult to satisfy the reviewers. I have often thought that we would have been better off if the fifth draft had been published; but on the other hand we will now end up with a much better manual than the fifth draft was. We have learned a lot since 1975, and this new knowledge is incorporated in the manual. Obviously we will never stop learning, so the Soil Survey Manual will always be somewhat out of date, but I do believe it will be a valuable reference work and even a valuable textbook.

FUTURE PLANS FOR SOIL TAXONOMY

Sometime in the future I believe there will be considerable demand for republishing *Soil Taxonomy* and eventually computerizing it, so that the computer will classify the soil when the necessary data are fed into it.

So far when I have been asked when Soil *Taxonomy* will be republished, I have given a date of 1995. The reason for picking this date is that I believe most of the international committees will have finished their work by then so that their recommendations can be incorporated in the new edition. Publishing before their work is completed would be impractical.

For the past several years the staffing level on the Soil Classification Staff has only allowed us to maintain or slowly improve Soil Taxonomy. With the completion of the Soil Survey Manual and with our vacancy filled, I believe we will be able to start revising the definitions of the diagnostic horizons and properties in preparation for the republication of Soil *Taxonomy.* This will improve the chances for publishing the new edition in 1995.

Before Soil Taxonomy is computerized we will have to have a considerable amount of assistance from the Soils Database Staff. Currently their work load is too heavy to begin this job. Another possibility is for someone to determine the procedures for computerizing Soil *Taxonomy* as a thesis project for an advanced degree.

Thank you.

Use Dependent Temporal Soil Properties

R.B. Grossman[a/]

The subject is very broad. The writer has chosen to consider only aspects on which he has worked. This leaves out subjects of much more importance than those considered. An example is the Water Erosion Prediction Project (WEPP).

We are deficient in information about agronomic-related properties such as infiltration rate and measured root abundance. Most of these properties are "se dependent and temporal. If we are to establish a data base, there is need for norms of measurement and generalization.

New Soil Survey Manual

We present several descriptive features from the New Soil Survey Manual. These features are strongly influenced by soil use and commonly would be expected to change through the year.

Morphological Features and Description:

Structural Unit. "This is used for any repetitive soil body commonly bounded by planes or zones of weakness that is not an apparent consequence of compositional differences. A structural "nit that is the consequence of soil development is called a ped... Earthy clods and fragments stand in contrast to peds. For both, soil forming processes exert weak or no control on the boundaries. Clods exhibit some rearrangement, through mechanical means, of primary particles to a denser configuration, at least adjacent to the surface of the body. The shape, grade and size of clods should be described using the same terms interchangeably. There is the further implication of a size sufficient to reduce the favorableness of the tilth. The distinction between clods and fragments rests on the degree of consolidation by mechanical means. Soil fragments include (1) "nits of undisturbed soil with bounding planes of weakness that are formed on drying without application of external force and which do not appear to have predetermined bounding planes, (2) units of soil disturbed by mechanical means but without significance rearrangement to a denser configuration, and (3) pieces of soil bounded by planes of weakness caused by pressure exerted during examination, with size and shape highly dependent on the manner of manipulation."

Mechanically Bulked Subzone. "The subzone has undergone a reduction in bulk density through mechanical manipulation and an increase in discreteness of structural units, if present. Usually the mechanical manipulation is the consequence of tillage operations. Rupture resistance of the mass overall, inclusive of a number of structural units, is loose, or very friable, and occasionally friable. Individual structural units may be friable or

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even firm. Mechanical continuity among structural units is low. structure grade, if the soil material exhibits structural ""its < 20 mm across, is moderate or strong. Strain that results from contraction on drying of individual structural units may not extend among structural units. Hence, internally initiated desiccation cracks may be weak or absent eve" though the consolidated soil material has considerable potential extensibility. Cracks may be present, however, if they are initiated deeper in the soil."

Mechanically Compacted Subzone. "The subzone has been subject to compaction, usually in tillege operations but possibly by animals. Commonly, mechanical continuity of the fabric and bulk density is increased. Rupture resistance depends on texture and degree of compaction, with friable usually the minimum class. Mechanical continuity of the fabric permits propagation of strain that results on drying over several centimeters. Internally initiated cracks appear if the soil material has appreciable extensibility and drying has been sufficient. I" some soils this subzone restricts root elongation. The suffix d may be used if compaction results in a strong plow pan."

Water Compacted Subzone. "The subzone has been compacted by repetitive large changes in water state without mechanical load except for the weight of the soil. Repetitive occurrence of free water is particularly conducive to compaction. Depending on texture, moist rupture resistance ranges from very friable through firm. Structural units, if present, are less discrete than for the same soil material if mechanically bulked. Usually structure would be weak or the condition would be massive. Mechanical continuity of the fabric is sufficient that strain which originates on drying propagates appreciable distances. As a consequence, if extensibility is sufficient, cracks develop on drying. In many soils over time, the water compacted subzone replaces the mechanically bulked subzone. The replacement can occur in a single year if the subzone is subject to periodic occurrence of free water with intervening periods when slightly moist or dry. The presence of water compacted subzone and the absence of the mechanically bulked subzone is an important consequence of no-till farming systems."

Surficial Bulked Subzone. "The subzone occurs in the very "ear surface. Continuity of the fabric is low. Cracks are not initiated in this subzone, although they may be present if initiated in underlying more compacted soil. The subzone is formed be various processes. Frost action under conditions where the soil is drier than wet is a mechanism. Wetting and drying of soil material with high extensibility is another origin; certain Vertisols are illustrative."

Crust. "A surficial subzone, usually less than 5 cm thick, that exhibits markedly more mechanical continuity of the soil fabric than the zone immediately beneath. Commonly, the original soil fabric has been reconstituted by water action and the original structure has been replaced by a massive condition. Raindrop impact, freeze-thaw cycles and water sorting or movement while the material is wet are mechanisms leading to reconstitution. Raindrop-impact, and thaw-related crust are recognized."

Extra-Structural Cracks. "The cracks to be discussed are the result of localized stress release to form planar voids that are wider than the repetitive planar voids between structural units or which occur in massive or weakly structured material at relatively wide intervals . . . .

Four kinds of extra-structural cracks may be recognized:"

"face-initiated reversible cracks form as a result of drying from the surface downward. They close after relatively slight surficial wetting and have little influence on ponded infiltration rates."

"Surface-initiated irreversible cracks form in the near-surface on water reduction from exceptionally high water content related to freeze-thaw action and other processes. The cracks do not close completely when rewet, and extend through the crust formed by frost action. They act to increase ponded infiltration rates."

"Subsurface-initiated reversible cracks form on appreciable reduction in water content from 'field capacity' in horizons or layers with considerable extensibility. They close in a matter of days if the horizon is brought to moderately moist or wetter. They extend upward to the soil surface unless an overlying horizon is very weakly compacted (loose or very friable) and does not permit the propagation of cracks ... Such cracks importantly influence ponded infiltration rates and evaporation directly from the soil."

"Subsurface-initiated irreversible cracks are the 'permanent' cracks of the USDA soil taxonomy system . ..."

Water:

Field Water State Class. Table 1 is a set of classes of field water state. Tactile and visual tests are employed for implementation of the water state classes. In one test a ball is formed in the hands and dropped progressively greater distances onto a nonresilient hard surface. Height at which rupture occurs and manner of failure are recorded. Additionally, the maximum length of a rod or of a ribbon of specified size may be determined. Color value change from air dryness also may be useful for some soils. A field office procedure for preparation of reference soil material at standard water states has been developed that uses nylon oven cooking bags. These bags pass 1 to 10 g of water vapor per hour depending on temperature and air movement. Soil at a known water content greater than that desired is dried in the bags to a predetermined weight, which is indicative of a water content that is a water state class limit. Determination of the suction for a particular field water content employs a water desorption curve for the soil material. Computation of such curves is described by Baumer and Brasher (1982) and Baumer and Rice (1988). The most accurate computation requires particle size, clod bulk density (moist and dry), water retentions at 15 bar and at the suction used to estimate field capacity (1/3 or 1/10 bar usually), organic carbon (as organic matter), and the ratio to clay of cation exchange capacity at pH 7 by ammonium acetate. Methods are in Soil Survey Staff (1984). An approximate curve can be obtained using only the information on standard interpretative records.

Water State Annual Pattern. This is a description of the field soil water over the year as applied to horizons. layers, or to standard depth zones using the classes of internal water states and of inundation. The description must be for a specific use of the soil. Table 2 is illustrative.

Infiltration. "Three stages of infiltration may be recognized-- preponded, transient ponded, and steady ponded. Preponded infiltration pertains to downward water entry into the soil under conditions that free water is absent on the land surface. The rate of water addition determines the rate of water entry ...."

"Infiltration under conditions where free water is present on the ground surface is referred to as ponded infiltration. In the initial stages of ponded infiltration, the rate of water entry usually decreases appreciably with time due both to the deeper wetting of the soil and a consequent reduced suction gradient and to closing of cracks and other surface-connected macropores. Transient ponded infiltration is the stage in which the ponded infiltration decreases markedly with time. After long continued wetting under ponded conditions, the rate of infiltration decreases to a fairly steady rate. This stage is referred to as steady ponded infiltration ...."

Index Surface Runoff Classes. "The concept indicates relative runoff for very specific conditions. The soil surface is assumed to be bare and surface water retention due to irregularities in the ground surface is low. Steady ponded infiltration rate is the applicable infiltration stage. Ice is assumed to be absent unless otherwise indicated. Finally, both the maximum bulk density in the upper 25 cm and the bulk density of the uppermost few centimeters are assumed within the limits specified for the mapping concept."

"The concept assumes a standard storm or amount of water addition from snowmelt of 50 mm in a 24-hour period with no more than 25 mm in any single l-hour period. Additionally, a standardized antecedent water state condition prior to the water addition is assumed: the soil is conceived to be very moist or wet to the base of the soil, to 1/2 m, or through the horizon or layer with minimum saturated hydraulic conductivity within 1 m, whichever is the greatest depth. If the minimum saturated hydraulic conductivity of the soil occurs below 1 m, it is disregarded and the minimum to and including 1 m is employed. For soils with seasonal shallow or very shallow free water, very low saturated hydraulic conductivity is assumed in the application of the guidelines ...."

"Class placement (table 3) depends only on slope and on saturated hydraulic conductivity."

Consistence:

Rupture Resistance of Equidimensional Specimens. Specimens are 25-30 mm on edge and crudely equidimensional. Field evaluation involves using the fingers and the feet to make placements in tactile classes that would be part of the soil scientists set of skills. A bathroom scale may be used and the pressure applied with a foot. If the specimen cannot be ruptured with the full body weight, impact energy is applied. Usually progressively greater amounts of impact energy are delivered to the same specimen until rupture occurs. A hammer with a flat end may be employed. The rupture resistance classes may be applied to soil material that has been air-denied and then inundated. This is one cementation test. Table 4 contains the classes.

Dry Crust Evaluation. Both thickness (in millimeters) and rupture resistance are evaluated. The thickness of the crust is taken as the thickness of the reconstituted zone only. Adhering weakly reconstituted soil is not included. Table 5 gives the classes of rupture resistance. The specimen is rectangular, 1 to 1 1/2 cm on edge (along in-place horizontal axes) and 1/2 cm thick. The thickness of the specimen may be inclusive of adhering noncrusted zone material if the reconstituted zone is less than 1/2 cm thick. Specimens are crushed between thumb and forefinger along an in place horizontal axis. Evaluation commonly would be done in the field "sing a tactile sense of the classes. A top loading balance may be used to evaluate the force applied. A bar 5 mm wide is placed on the balance to simulate the crust specimen. The specimen is crushed between the forefinger and thumb of one hand while simultaneously applying the same apparent pressure to the balance with the forefinger of the other hand through the 5 mm bar. The balance is read when the crushed specimen ruptures. Direct measurement by pressing down on the specimen as it rests on the balance is an alternative. If used, it should be indicated. Values tend to be lower because the contact area between the specimen and the balance may be low. If the specimens cannot be broken in the hand. the force necessary to rupture may be measured with a penetrometer.

Penetration Resistance. The standard field test for penetration resistance involves insertion of a flat end rod a distance of 6.35 mm (1/4 inch) in about 1 second (Bradford, 1986). Commonly the pocket penetrometer is used. The "Geotester" is an alternative. Usually, the diameter of the rod is 6.35 mm. but other diameters may be used. 30° cones with 1.3 cm^2 and 3.2 cm^2 bases may be used and a 20" cone inserted 10 mm is under examination for pieces of soil. For class placement, measurements for all tips should be adjusted to the expected measured strength for the standard determination using the flat-end rod as described previously. The water state should be specified; this usually requires water contents. Orientation should be indicated and the weight of the penetrometer treated as a surcharge if insertion is vertical. The set of classes in table 6 has been proposed. Five or more determinations should be made 5 cm or more apart. Median or average values with a standard deviation should be reported. A value of 1 MPa is about where initial root restriction may be expected. Restriction should be quite pronounced at 2 MPa unless the macroscopic organization facilitates root ramification.

Use Dependent Temporal Soil Property Records

The writer has assisted a group in west Texas in the development of a property record for use-dependent quantities. Fred B. Pringle, Soil Scientist, Amarillo, Texas, has been the principal architect. The record is an outgrowth of the water management teams which were established in the Texas High Plains about 10 years ago. To organize the information obtained by these water management teams it was necessary to consider the operations that control the expression of the tillage pan. Table 7 is an example of a current record. It is computerized through the efforts of James Featherston, Economist, SCS, Temple, Texas.

The record is for a map "nit or a component of a map unit with constraints specifying permanent alterations such as terraces, the calendar year "se and cropping sequence or rotation, and the water regime. For the example, the water regime involves irrigation and the "se of furrow diking. The field operations by month are given (see back side), and from these operations bulk densities are assigned to the tillage zone. The upper tillage zone is the part subject to bulking; the lower tillage zone is subject to compaction except for occasional deep loosening operations. The final infiltration rate is dependent on the bulk density and crust expression. In turn, the hydrologic group changes with the final infiltration rate, in this case ranging from A to C. The runoff curve number is related to the bulk density through its dependence on the hydrologic group. Anticipated yields are based on local predictive relationships that are largely determined by the pattern of soil water state. Deep drainage loss is based on water balance computations. The economic analyses (back side) includes only the direct costs; interest and other costs for use of the land are not included.

Several years ago the writer developed a soil property record for winter wheat, conventional tillage, for Sharpsburg silty clay loam, 2-5 percent slopes, a map unit in the Lancaster County, Nebraska, soil survey. A portion of the record forms table 8. The identification number has 5 parts: the first is the position in the list, the second gives the position or subzone to which the information applies; the third describes the feature or observation: the fourth gives the orientation and/or location; and the fifth the water state history as it pertains to the growing season.

The first two entries differ in the water state of the near surface. Discing while dry produces larger clods and resultingly higher roughness in the period immediately after harvest, usually in July.

The record also contains a means to record characteristics that occur for short periods at an indefinite time. The characteristic is a fluid condition in the near surface during thaw. The entry "fluid 2307," says that for 7 days during February and March, the mechanically bulked subzone is fluid.

Use Invariant Bulk Densities for Ap Horizons

The Ap horizon by definition is subject to change in physical organization in response to human activities. For many soils these changes occur yearly in response to tillage. Bulk density in particular may exhibit large changes. The interpretive soil property record cannot satisfactorily encompass bulk density and other characteristics of the Ap horizon which are strongly influenced by physical organization. The reason is that the interpretive soil property record is use invariant. The values in the record pertain to phases of map units with no consideration of change due to soil use. This is not a criticism. It follows necessarily from the fact that soil use is not a mapping criterion. To meet the situation, a proposal is under study to supply bulk densities that are strongly use and time invariant.

Table 9 contains the values obtained to date for the cultivated sites of the Water Erosion Prediction Project (WEPP). The table contains two kinds of bulk densities. One is for <2 mm that has been wetted by capillarity against low suction and desorbed against 1/3 (or 1/10) bar. The other is for <2 mm that after wetting by cepillarity is inundated, air dried and then re-wet by capillarity before desorption to 1/3 (or 1/10) bar. The bulk density after oven drying is determined on the sample that has been inundated. From the change in bulk density on oven drying a linear extensibility is computed.

In addition, the Proctor density would be measured or estimated. The Proctor density is widely used in soil mechanics. The soil material is subjected to a standard impact energy over a range in soil water contents. Usually the bulk density measured has a maximum bulk density, which is the Proctor density. Presently the Soil Mechanics Laboratories of the SCS have agreed to run 200 Proctor densities on an exploratory basis.

The two reconstituted bulk densities, and the Proctor density are run on <2 mm soil material that has been prepared in standard fashion. The measurements should be strongly use invariant. They are therefore suitable measurements conceptually for the interpretive soil property record. The expectation is that these bulk densities would be employed in models to predict the actual bulk density. The models would introduce the volume percent and bulk density of clods obtained from the mechanically compacted subzone. Further, the increase in bulk density on inundation may be useful for model prediction of compaction by precipitation. Additionally the extensibility may help predict whether the near surface zone would be granular or crusted during the wind erosion season. Finally, the Proctor density may be useful in prediction of bulk density of the mechanically compacted subzone from knowledge of the mechanical pressure and the water state while subjected to mechanical action.

Rock Fragments and Erosional K

Rock fragments may be incorporated in K and hence be use invariant or be in the C factor of USLE and be use dependent.

The rock fragment area1 percent on the ground surface is potentially very sensitive to soil use. Concentration of rock fragments on the ground surface is susceptible to reduction by tillage or the trampling of animals. Relatedly, lag accumulation on the ground surface is dependent on the amount of consolidation plus erosion since the last tillage. The adjustment downward of erosion estimates due to the presence of rock fragments at the soil surface in USLE (or RUSLE) should be treated as a use-dependent phenomenon, Therefore, the rock fragments should be in C and the K employed in USLE or RUSLE should be for the fine earth.

The volume percent rock fragments from the interpretive soil property record may be employed to compute a K adjusted down for the volume of rock fragments if the purpose is to compare soils on an index basis independent of soil use. This has been done for the Food Security Act. Figure 1 shows the computation. Set the quotient of erosional K inclusive of rock fragments over K for the fine earth equal to the soil-loss ratio. Next, solve for erosional K inclusive of rock fragments. Finally, calculate K inclusive of rock fragments from the value of K for the fine earth (0.40 in the example) and the soil-loss ratio as computed from the volume of >2 mm (60 percent).

It may be helpful to describe an hypothetical experiment for the reduction in K due to the presence of rock fragments. One starts with an horizon from which all the macroscopic vegetal material has been removed. The horizon is tilled. One may assume that the volume of rock fragments equals that computed from the weight percentages in the property record using for the assumed computation the bulk density immediately after tillage. Immediately prior to the artificial rainfall and for a short time after initiation, the areal percentage of rock fragments on the ground surface (the mulch) and the volume percentage in the horizon should be the same. As the experiment proceeds, the rock fragment cover on the ground surface increases to where it considerably exceeds that computed from the rock fragment volume. At this later stage the computation of erosion should involve the rock fragment mulch in C and the use of K for the fine earth.

The increase in rock fragments depends on the decrease in thickness of the surface horizon. This decrease is the result of water compaction plus truncation. Hopefully, the difference between the capillary rise and inundation bulk densities, as discussed in the previous section, may be used to estimate water compaction. The increase in rock fragment mulch per unit decrease in surface horizon thickness is greater if the-rock fragments are small. A procedure has been written for the increase in mineral mulch as truncation proceeds using the information on the soil property record. The approach raises the increase in the amount of cover by rock fragments for a given truncation as the diameter of the rock fragments decrease in size.

Clod Bulk Density at Intermediate Water Content

Clod bulk densities at a water content near field capacity and at oven dryness are available for thousands of pedons. From these bulk densities the linear extensibility from field capacity to complete dryness may be computed. The bulk density of clods at water contents intermediate between 1/3(or 1/10) bar retention and over dryness may be computed. and from this intermediate bulk density an intermediate linear extensibility and related crack space may be calculated. The computation assumes a linear increase in bulk density with decreasing water content between 1/3(or 1/10) bar water retention and a lower water content. Below this lower water content it is assumed that the bulk density does not increase. This lower water content is a decreasing fraction of the 15 bar retention as the linear extensibility rises. Figure 1 shows the assumed relationship.

The equation describing the assumed relationship follows.

$$Dbi = Dbf + \frac{(Dbd - Dbf)(Wi - FxW15)}{Wf - FxW15}$$

Where,
Dbi = clod bulk density at intermediate water content

Dbf = clod bulk density at 1/3 or 1/10 bar

Dbd = dry clod bulk density

Wi = the water content intermediate between field capacity and complete dryness

Wf = gravimetric water content at 33 or 10 kPa bar retention

W15 = gravimetric 15 bar, water retention

F = is a factor that changes with the coefficient of linear extensibility:

CQLE	F
<0.06	0.6
0.06 - 0.09	0.5
0.09 - 0.12	0.4
≥0.12	0.3

From the bulk density at intermediate water content, Dbi, an intermediate extensibility may be calculated:

$$COLEi = \left(\frac{Dbi}{Dbf}^{1/3} - 1\right)(Cmi)$$

Where Cmi is the volume fraction of fine earth fabric at the intermediate water content and Dbi and Dbf are as defined previously.

A related quantity is the percent cracks at the intermediate water content:

$$CSPi = 100\left(\frac{Dbf}{Dbi}^{1/3} - \frac{Dbf}{Dbi}\right)(Cmi)$$

It is assumed that the field water content could be modelled from precipitation and evapotranspiration on a continuing basis. From the standard bulk densities at 1/3 or 1/10 bar and at over dryness the intermediate bulk density may be computed for the model-determined water contents. If root restriction can be predicted for the intermediate bulk density. then the hydrologic model would be predictive of root ramification. For some soils with high extensibility clod bulk density exceeds that expected to be root limiting at water contents above the I5 bar retention. This would suggest that the roots would be restricted to planar macropores before the 15 bar retention is reached.

Intermediate bulk density could be used to predict surface connected cracks from the water content as determined by a hydrologic model. From intermediate clod bulk density either linear extensibility or crack percentage may be computed as discussed previously. Both quantities depend strongly on the physical organization for horizons that are subject to tillage. If the near surface subzone is mechanically bulked, the extensibility and crack expression would be far less than if compacted. The adjustment for physical organization is not considered here. For surface connected cracks, greater weight must be given horizons at shallow depth. A possible approach is to divide the soil into 10 cm subzones. The relative potential for surface connected cracks would be estimated by computation of a weighted average COLEi or crack space percent for a 50 cm zone. The uppermost 10 cm would be weighted five, the 10 to 20 cm zone, four; the 20 to 30 cm zone, three; the 30 to 40 cm zone. two; and the 40 to 50 cm zone, unity.

The closing of the cracks on wetting would occur over several days.

Other Measurements

Several measurements follow which pertain to use dependent properties. More detailed information may be attained from the writer.

Aggregate Size Distribution. The determination is made on relatively loose near-surface soil which is air dried and passed through a nest of sieves using a vigorous hand rocking motion. To the extent feasible, the specimen is subject to 100 oscillations in 1 minute in a 20 cm diameter sieve. The weight of soil material in a sieve is kept to less than 500 g. Commonly sieves with the following screens are used (in mm): 75, 20, 5, 2, 1, 0.8. 0.5, and 0.25.

Aggregate Stability. A wet sieve retention test may be employed: The sieve is 12.7 cm (5 inch) diameter and has 0.5 mm mesh. Place 3 g of the airdry 2-l mm material uniformly in a sieve that is submerged in about 500 ml of distilled water. The l-O.5 mm may be used in place of the 2-l mm. The mesh should be 2 cm below the top of the water. Let stand overnight. Raise and lower the sieve 20 times in 40 seconds. On the upward stroke the sieve should drain but not be raised far enough that air enters beneath. After the wet sieving, the sieve and contents is dried and the weight retained determined. Provision should be made to retain soil that drops through the screen on air drying. If discrete 2-0.5 mm grains are present, a dispersing treatment is employed. The measurement is not considered valid if half or more of the sample after dispersion consists of mineral material that does not pass 0.5 mm.

Reconstitution on submergence is a qualitative morphological test. The soil is placed in classes determined by the reconstitution of the air dry soil on rapid submergence in distilled water. Cells 25 mm diameter are constructed that have 0.5 mm screen in the base. About 6 ml of air dry 2-l mm material is placed in the cell. The soil is inundated by lowering the cell rapidly into 40 ml of distilled water held in a beaker. The cell is allowed to stand in the beaker overnight after which it is removed, drained, and the specimen air dried in place at room temperature. The air dry soil is then placed in monphological classes:

Bulk Density Measurement bv Excavation. The compliant cavity method is used for soil zones which are too thin or are insufficiently consolidated to obtain clods. A compliant cavity is made by placing a ring of resilient foam plastic on the ground surface. This compliant ring is covered by a rigid ring 13 cm inside diameter which is mounted on the ground surface by driving threaded rods into the ground through holes in the ring and then tightening down the ring with wing nuts. The cavity is lined with 1/2 mil plastic film and a bar with a hook gauge attached is placed across the cavity. Water is placed in the cavity up to the tip of the hook gauge. The volume of water is a measure of the cavity volume prior to excavation. The soil is then excavated to the desired depth and the volume of water necessary to fill the resulting cavity to the tip of the hook gauge is again determined. The increase in volume of the water measures the excavation volume. The oven dry weight of the soil excavated is determined, a correction is made for weight and volume of >2 mm in the sample if necessary, and the bulk density is computed. The weight of macroscopic vegetal material per 100 cc may be reported.

An alternative in the rigid frame method. Rings 25-30 cm diameter and 10-15 cm high are placed on the ground surface or inserted in the soil. Two small cylinders are mounted on the rings. A bar with a hook gauge with two holes is mounted on the ring. Excavation is carried out, as described for the compliant cavity method. The area of the excavation is obtained by tracing the periphery on a clear plastic overlay.

The percent clods in the sample that withstands a standardized sieving operation may be measured. From this percentage, the bulk density of the subfabric for the soil material smaller than the lower limit of the clod size may be calculated. Additionally, the weight percent clods in a sample large enough to obtain a reasonable estimate of the larger clods may be obtained. From this percentage the bulk density inclusive of the larger clods may be computed.

Equations follow for the computation of the subfabric and whole fabric bulk densities:

Subfabric	Whole fabric
$\dfrac{100 - W>}{\dfrac{100}{Dbu} - \dfrac{W>}{Db>}}$	$\dfrac{100}{\dfrac{W>}{Db>} + \dfrac{W<}{Db<}}$

W> and W< are the weight percentages greater than and less than 5 or 2 mm. Db> and Db< are the parallel bulk densities. Dbu is the measured bulk density.

Cover. Point count or line intercept measurements are made (Hartwig and Laflen, 1978). The total transect length should be 50-100 times the 90 percent diameter, defined as the upper size limit that accounts for 90 percent of the total area of the surface cover features. Three measurement tapes are used: a 90-m tape with 30-cm intervals; a 30-m tape with 15-cm intervals, and a 2-m retractable ruler with l-cm intervals and marks at 1 mm. Larger features that require longer transect lengths by the above guidelines are excluded from shorter transect measurements and the" added back by computation to obtain the total cover.

The ground surface may be divided into components that differ in cover. Examples of components would be within the drip line of trees, within the drip line of shrubs and outside that of trees, and outside of the drip line of either trees or shrubs. Canopy effectiveness should be estimated. Rock fragment size distribution may be evaluated. The cover characteristics for the components may be used to compute soil-loss ratios of the Universal Soil Loss Equation for each component as well as a weighted average soil-loss ratio for the area overall. An integrated color value may be computed for the ground surface components and for the area as a whole.

One-Dimensional Roughness. The measurement pertains to a line and vegetation is usually either excluded or restricted to dense crowns that would deflect flowing water. Slotted rods are fabricated by welding two sections of shelf standard together laterally to form an open rectangular tube. The slotted rods are leveled. Distance to the ground surface is measured at regular intervals by dropping a piece of retractable ruler through the slots. A guide is used to keep the piece of retractable ruler normal to the slotted rod. The distances to the ground are corrected for slope of the ground surface along the line. The standard deviation after connection at the slope is calculated. The number of stations is kept constant at 31. Distance between the stations is 5, 10 or 15 cm depending upon the scale of the features that determine the surface irregularity. The direction of measurement relative to overland water flow and local features controlling this flow should be specified.

Surficial Soil Vegetal Material. The main purpose is to measure the weight of macroscopic vegetal material in the O-3 and possibly 3-10 cm zones after removal of attached above ground vegetation and litter. A second purpose is to measure the areal percent of attached crowns and stems. A measurement area at least about 10 cm wide and 1 m long is selected. Litter is closely clipped and removed from the measurement area which is cut around the periphery to 2.5 cm (1 inch) depth. The areal percent of attached crowns and stems within the outline of the sample area is measured by point or line-intercept methods. The soil material is then removed to the desired depth. The sample is placed in a solution of Calgon and allowed to stand overnight. Macroscopic vegetal material is removed by successive suspension and decantation through 1 mm or 0.8 mm screen. The material on the sieve may be washed with tap water under pressure. The vegetal material is air dried, weighed, and reported as kilograms/hectare or pounds/acre. Estimates by size classes may be made.

Single Drop Entry Time. The purpose is to measure the time it takes for a single drop of water placed on the surface of air dry soil to be absorbed. Savage, et al. (1969) describe the method. Distilled water is used and the drop size should be about 0.05 g. The time from application until the drop disappears is recorded. At least 5 drops should be observed for each component of the soil surface and the median and range or the mean and standard deviation reported. The soil surface should be subdivided on the basis of color and/or other features if cryptogams are suspected.

Resistance of Ground Surface to Moving Air. Sand, 2-1 mm with a density of approximately 2.65 g/cc, is sprinkled sparsely on dry ground surface. Air is blown across the ground surface with sufficient intensity to just move some of the sand grains. The air may be delivered from a blower used to clean camera parts. The effect of this moving air on the ground surface is recorded. Three classes may be employed:

Class	Description
High	No discernible effect
Moderate	Very little movement
Low	Readily discernible movement

Resistance of the Ground Surface to Rubbing. The first finger is moved over the ground surface while exerting a pressure through the ventral surface of the outer joint of roughly 3 kPa. The rate of movement should be about 10 cm in 1 second. For most people the surface area of the finger in contact with the ground surface while exerting 3 kPa is about 3 cm^2. A force of about 100 g is therefore applied to-exert a pressure of 3 kPa. This force may be learned by passing the first finger across a top loading balance. These classes are used:

Class	Description
High	No discernible effect
Moderate	Observable effect but little or no material moved
LOW	Observable soil material moved.

Strength at Low Suction. For the field-occurring fabric stainless steel rings 30 cm diameter and 10 to 20 cm high are inserted into the soil by alternate pressing downward and cutting away. The ring must be inserted into a consolidated zone that will provide a floor for the contents. The ring is then undercut and protruding parts of the bottom cut away. The core is placed in a container using loose soil to cushion and wetted against 0.5 kPa using 0.0111 $CaCl_2$ and then inundated overnight. The CaC12 solution level is then lowered to where a suction of 0.5 kPa is applied at about the midplane of the object inserted to measure strength. The Pilcon vane shear device is employed. The depth ranges O-2 and O-5 cm are measured. Also the Pocket Penetrometer is employed. Two tips are used: the 6.4 mm diameter flat-end rod inserted 6.4 mm and the 30" cone with a 1.3 cm^2 base.

To simulate the strength immediately after tillage, air dry soil material is passed through a No. 4 sieve (4.6 mm). A section of 20 cm diameter plastic sewer pipe 18 cm long is attached to a pedestal made from two insulation fire bricks placed flat-wise and fastened together with calking compound. Screen with 8 to 10 mm wide openings is placed in the bottom of the cell. The soil material is added to the cell to a height of about 15 cm. The screen is then slowly raised upward through the soil material. The soil material is then taken through the water cycle described for the field-occuring fabric. Strength is measured with the Pilcon vane for the zone at depth 10 to 15 cm.

Root Quantification. To measure the roots on a broken horizontal surface, rings 25 or 30 cm diameter may be inserted in a horizontal plane and removed by undercutting and prying upward. The rings are inverted and a 5 cm square grid placed over the broken surface of the soil. The protruding roots in each square are counted.

To obtain the amount of roots in a volume of soil as part of characterization sampling requires a variable strategy depending on the size of the roots and the distribution within the horizon. In some instances it may be necessary to remove 10 to 100 kg of soil, mix, and obtain a representative 1 kg subsample. For mechanical root washing, the sample weight should be about 1 kg. The bulk density and rock fragment percent for the horizons would be used to compute the measured root quantity to a volume basis. In many instances, a subsample of the standard field sample may be used for the root determination. If row crops are sampled, the excavation should be at right angles to the direction of the rows. Further, the vertical edges of the sample volume should coincide with the midplane between rows. If fine, alive roots are to be measured. the field sample should not be air-dried and kept refrigerated. The roots may be separated using a mechanical root washer or by hand. If a root washer is used. subsequent hand separation is necessary.

Crowns and associated large roots present a sampling problem. A large whole sample should be taken that encompasses several crowns and associated large roots. The crowns and associated large roots should be sampled separately.

The large sample, exclusive of the crown and associated directly attached roots, should be subdivided in the field and about a 1 kg sample taken for analyses. The weight of crowns and associated roots should be reduced proportional to the subdivision of the associated sample. In some instances, to avoid the problem posed by crowns and associated large roots, a surficial thin zone, perhaps O-5 cm, would not be sampled.

Table 1. Field water state classes for the new soil survey manual.

Class	Criteria[a/]
Dry (D)	>1500 kPa suction
Very Dry (DV)	<(0.35 x 1500 kPa retention)
Moderately Dry (DM)	≥(0.35 x 1500 kPa retention) to (0.8 x 1500 kPa retention)
Slightly Dry (DS)	≥(0.8 x 1500 kPa retention) to 1500 kPa suction
Moist (M)	1500 kPa > Moist >1 or 0.5 kPa[b/]
Slightly Moist (MS)	1500 kPa to midpoint water retention difference (MWR)[c/]
Moderately Moist (MM)	MWR to upper water retention (UWR)
Very Moist (MV)	UWR to 1 or 0.5 kPa suction
Wet (W)	<1 kPa or <0.5 kPa suction
Not Satiated (WN)	No free water
Satiated (WA)	Free water present

a/ Matrix suction, not total.

b/ 0.5 kPa for coarse soil materials.

c/ The Midpoint Water Retention is midway between the 1500 kPa retention and the upper water retention, which is the water retention at 5 or 10 kPa. The choice of 5 or 10 kPa is dependent on the composition of the soil material.

Table 2. Water state annual pattern.

INSERT TABLE 2

Table 3. Manual index runoff classes.

Table 4.

Class Names[a/]	Numerical Expression	Test Notes
Loose	--	Specimen not obtainable
Very friable, soft	<8 N	Force; forefinger and thumb
Friable, slightly hard	8-20 N	Force; forefinger and thumb
Firm, hard	20-40 N	Force; forefinger and thumb
Very firm, hard	40-80 N	Force; forefinger and thumb
Extremely firm, very hard	80-160 N	Force; f oot
Extremely firm, extremely hard	160-800 N	Force; foot
Rigid, rigid	800 N to 3 J	Impact energy
Very rigid, very rigid	≥ 3 J	Impact energy

[a/]First term applies to slightly dry and wetter water states (method G015) and the second to dryer states; the cementation terms: <80N- weakly cemented; 80-800N- moderately cemented: 800N-3J-strongly cemented; and ≥3J - indurated.

Table 5. Dry crust rupture resistance classes for the new soil survey manual,

Class Name	Force at Rupture N	
Fragile	<3	
Extremely Weak (WE)		Present, but not removable
Very Weak (WV)		Removable: <1
Weak (W)		1-3
Medial	3-20	
Moderate (M)		3-8
Moderately Strong (SM)		8-20
Resistive	≥20	
strong (S)		20-40
very strong (SV)		40-80
Extremely Strong (SE)		≥80

Table 6. Penetration resistance classes for the new soil survey manual.

Classes	Penetration Resistance MPa	
Small	to.1	
Extremely low		to.01
Very Low		0.01-0.1
Intermediate	0.1-Z	
LOW		0.1-1
Moderate		1-2
Large	≥2	
High		2-4
Very high		4-8
Extremely high		≥8

Table 8. A portion of a soil property record for winter wheat, conventional **tillage,** Sharpsburg silty clay loam, 2-5 percent slopes, Lancaster County, Nebraska.

I

Component 2
01 Ground surface
02 **Immediate** near surface
03 Mechanically bulked
04 Mechanically compacted
05 o-5 cm
06 crust

Component 3
001 Thickness
004 Roughness SO. cm
005 Smoothness, **Pct.**
006 Drop Shatter, cm
008 Structure
009 Consistence
010 Bulk Density, Mg/m^3

Component 4
01 **Interrow**
04 Normal to **tillage** configuration
05 Not specified
06 Exclusive of row

I

Component 5
01 Usual
02 Dry
03 **>25 mm** rain in 1 hour

Identification No.	S	O	N	D	J	F	M	A	M	J	J	A
01 01 004 01	1.2											1.2
02 01 03 004 04 04 02 01	1.5	1.5 1.5	1.3 1.5	1.2 1.5	1.2 1.5	0.8 1.2	0.8 1.2	0.8 1.2	mvfr 0.8 1.2	0.8 1.2	4.0 2.5	mfr 2.0
10 009 01	mvfr	mvfr	mvfr			fluid	mvfr	mvfr		mvfr	mfr	
						2307						

Table 9.

Insert Table 9.

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$\frac{K}{Kf}$ = S-L-R

K = S-L R x Xf

Kf = 0.24
>2 mm = 60% by volume
S-L R = 0.22

K = 0.09

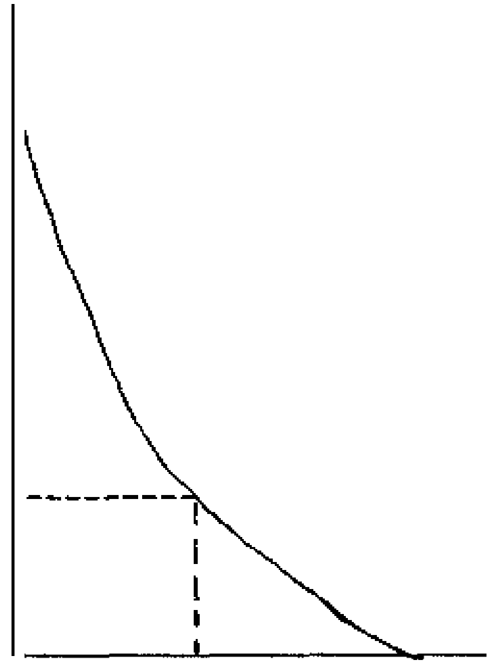

Figure 1. Computation of erosional K inclusive of the >2 mm from the volume percent >2 mm. Employ the relationship between soil-loss rati and rock fragment mulch on page 19 of Wischmeier and Smith (1978). Assume that the rock fragment volume (60 percent) and the mulch are equal. For the example, the K exclusive of >2 mm (Kf) is 0.40.

The volume of >2 mm (V,) is obtained from the weight percent >2 mm ($W_>$) in the interpretive record, the bulk density as freshly tilled (Db) a the particle density of the >2 mm ($Dp_>$). The equation is as follows:

$$V_> = \frac{W_>}{Dp_>}\left(\frac{100}{\frac{W_>}{Dp_>} + \frac{100 - W_>}{Db}}\right)$$

Landscape Descriptors: How They Might Be Used with "Soil-Landscape Units"

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Landscape descriptor is a fancy term for the landform names used to identify the physiographic position of a soil, a map delineation, or a soil-sampling site, *i.e.*, where they occur in a landscape. The term might even be extended to include the features of a small landform-element that give it distinctive character, such as slope shape, gradient, and aspect, and its size, microrelief, vegetation, etc. Landform names can come from the common language, from the geological literature, from a hierarchical landform classification I am suggesting elsewhere (Peterson, 1990), or can be manufactured on the spot for unrecognized situations-I call the latter "free form" names. We arc familiar with using landform names to tell where soils or soil map units occur when writing a soil survey report or technical papers. Here, I would like to suggest another place landforms could be used perhaps even more effectively-for *soil-landscape* units-and discuss why landform identifications would be critical for defining such map units.

The idea of a soil-landscape unit presumably is that of a map unit analogous to a soil consociation, a soil complex, or a soil association, but one that would "incorporate more landscape information into future soil surveys,' as a national committee had it. Tbii idea for a new kind of map unit has teased, titillated, and frustrated more than one soil scientist. and at least the aforementioned national committee that was looking for a better vehicle for communicating soils information to modern users (Franzmeier, 1989). The vagueness of this alluring concept has led at least this writer to make unfortunate comments at a national meeting, and to not be able to quit worrying at the problem. Now I would like to suggest that we have been approaching this potentially-useful map-unit concept *backwards*, by fussing over the technicalities of "making a soil-landscape survey,' such as the appropriate map scale, type of base map, format for soil-landscape-unit definitions, how ooe soil-landscape unit would be related to and correlated with others, etc. Here is my idea of what a soil-landscape unit is, or could be-I'll get back to landform descriptors shortly:

> A *soil-landscape unit* is a soil association designed explicitly *for helping to tell a narrative story* about how landuse, or hydrological behavior, or erosion-deposition, or ecological-relations, ..., operate in a landscape much larger than an ordinary soil consociation's delineations. The *plot* of the narrative is how events on one soil relate to events on another soil that is adjacent or somewhere down the line.

The soil-landscape *story* comes first, then the design of tbe map. Since the readers will have to picture where the soils are, during the unfolding of the plot, they will have to be told where in familiar terms that suggest the landscape for their mind's eye. Those terms will be landform names. These landforms have to be parts of tbe landscape that a person either can see on the ground, or in an oblique view from an aircraft, or in an oblique aerial photo, or block diagram that mimics an aerial view. The landforms should bc so familiar to the reader that they don't stand in the way of the story's plot. Such familiarity can be created quickly by tying landforms to *stories* about landscapes and soils that are important and interesting to the reader. That's how we learn most new words.

Soil-landscape units, *i.e.*, the soil-association map units of the map that will back-up the landuse story, mostly will be idiosyncratic, that is, the features and patterns that lend sharpness and familiarity to the reader's mental picture of an area will be peculiar to that local area or some limited region. Tbe soil-landscape units probably will not be amenable to correlation, by an orderly procedure similar to soil correlation, because they won't repeat in anything like the consistent fashion soil properties do. But the story plots should be pretty standard, the vocabulary can become familiar, and as readers become familiar with the genre, they should be able to guess ahead what will happen next in the soil-landscape story.

To paraphrase Shakespeare, *the story's the thing!* *The* construction of soil-landscape maps (*i.e.*, soil-associations) and reports should follow simply from the

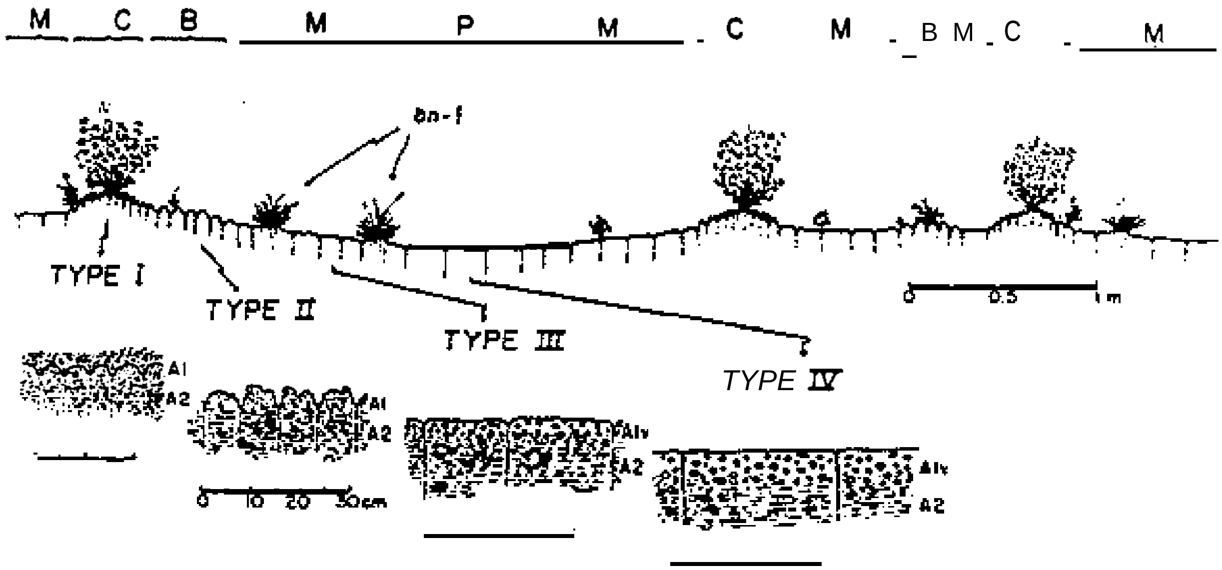

Figure 1. A schematic, cross-sectional diagram of the microtopographic positions of four soil-surface morphological types associated with gently-sloping, shallowly loess-mantled xerollic Argids and Orthids of the Humboldt Loess Belt of northern Nevada. Microtopographic positions are: C = coppice dune, bn-1 = bunchgrass coppice, B = coppice bench, M = intercoppice microplain, P = playette. Vertical scale exaggerated. Type 1 soil-surface is litter covered. Circles indicate vesicles in crusts. *A1v* is the horizon notation for a crust. (After Eckert *et* al, 1989.)

demands of the story's plot, but we'll have to have a coherent landform vocabulary to describe events hap pening across a landscape. To write the story, the author will have to be intimately familiar with the particular landscape, its soils, and the problem or potential that is the story to be told. But that is nothing new for soil scientists!

A Soil-Landscape Story

In the Humboldt Loess Belt of northern Nevada, and in adjacent states, rangeland seedings are not uncommonly afflicted with a pox of small, barren spots. These barren spots are equally barren under the native big sagebrush-grass vegetation because they have *vesicular* crusts that prevent establishment of most grasses and shrubs. Adjacent to these barren spots are much less evident areas where the seedings are more-or-less sparce, depending on moisture during seedling emergence, and also small spots with vigorous stands of grass. These also reflect moderately vesicular-crusting or non-crusting soil behavior. This detailed pattern of seeding establishment is a soil-landscape story in microcosm because the "landforms" involved are microtopographic forms. Yet it nicely illustrates a soil-landscape story because events on one "landform" and its "soil" are related to events on adjacent ones.

The microtopography (read "landforms") comprises small, conical mounds of eolian material, called coppice *dunes,* that collect under widely-spaced shrubs (Fig. 1). The litter-covered, loamy A horizon here has a compound, very-weak medium prismatic and strong very-fme subangular-blocky structure. it does not crust, is permeable, and allows vigorous seedling emergence when the shrub is removed and the spot seeded.

Where the sagebrush on a coppice done has died, or around the margins of some shrubbed coppice-dunes, the litter is absent and the medium prisms of the A horizon have been frost-heaved into inch-high "pinnacles" (pointed tops of the prisms). These still slightly-elevated, pinnacled, microtopographic forms are called *coppice benches. Though* they appear very thinly crusted, the frost-heave pinnacles are very-fme subangular-blocky internally and are permeable. The "trench cracks" between the pinnacles are a centimeter or so wide and deep, and provide "safe sites" for vigorous seedling germination and emergence.

The relatively wide spaces between the coppice dunes are mostly-barren, very-gentle slopes that lead down to a flattish spot or a barely-visible micro-rill. This very gentle slope is called an *intercoppice microplain* and the flattish spot is called a *playette*. A few bunchgrass coppice dunes may occur on the microplain. The microplain has a vesicular crust that is cracked into prominent shrinkage polygons (the tops of prisms of the A horizon) with narrow cracks, and the playette has an even more prominently vesicular-crusted surface and yet larger shrinkage polygons with very narrow cracks. On the microplain, the few seedlings that establish are mostly in the cracks, and on the playette only rare seedlings ever establish (Eckert et al, 1989).

The dynamics of the crusting that causes this pattern of seedling establishment or failure is directly related to the pattern of runoff and flooding on the adjacent microtopographic forms. Crusting soil material – commonly silty or very-fme-sandy, low-clay and low-organic-matter, unstructured material-is caused to crust by wettiog. The greater the wetting the harder the crust, with the hardest crusts formed by saturation (Hillel, 1960). The actual crust, of course, forms only when the soil dries out. The vesicular pores are created in *saturated* crusting-soil-material by the merging of small bubbles of entrapped air, that is under relatively high capillary pressure, with larger bubbles under less capillary pressure. The vesicular pores grow larger with recurrent saturations (Miller, 1971).

During snow melt, or during heavy downpores, water largely infiltrates into the coppice dunes and coppice benches and their soil surface does not saturate or crust. Some water runs on to, then slowly across the intercoppice microplain shallowly saturating its surface. A few-centimeter thick crust forms. Water runs onto and briefly *ponds* on the playettes, deeply saturating and crusting their surfaces.

Why Use *Soil-Landscape Stories?*

The preceding, abbreviated story of how crusting and seedling establishment are related to the microtopography (read "landforms") of certain Argids illustrates how landform identifications can be used to help communicate soils information. If one wanted to show where the soils with this crusting behavior occur in a landscape with crusting Argids and non-crusting, sandy Torriorthents, for example, a simplified soil map that showed only these two conditions would be the "soil-landscape map" that would go along with this story. The reap unit that showed the crusting soils would be a "soil-landscape map unit" inasmuch as the microtopographic forms (read "landforms") each would coincide with a "soil" with different surface morphology and behavior. This map unit also would be a "soil association" with the spots of differing surface morphology and microtopographic position being the "component soils." For this illustrative soil-landscape story one tells *only* those soil facts important to the story, and shows *only* those areas on the accompanying map that are concerned with the story.

In contrast, with our standard soil surveys we try to tell *everything* about *every* soil, and try to show the position of *each* of soil on the map. We drop the whole load and bury the reader! In both a soil-landscape story and a standard soil survey, we use landforms to tell where things are, but in a soil-landscape story the pattern of landforms is used to support the story. Instead of being encyclopedic, hence boring and coofusing to many readers, a soil-landscape story should hook into a reader's interest by talking about a single thing the reader thinks is important and then sneak in only those soil facts needed to support the story. Having an interesting story with a strong plot is the crux!

From this point of view, the "soil-landscape unit" is merely another sort of soil association designed to illustrate a story about soils and landscapes. Indeed, "soil-landscape unit" is a redundant term. Let's not try to pre-design soil-landscape units, rather let's concentrate on the stories to be told, and how to tell them!

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ENGINEERING PROBLEMS ASSOCIATED WITH PERMAFROST

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Introduction

Permafrost simply means permanently frozen soil and covers more than 20% of the world's land surface and more than 80% of Alaska. The permafrost province is typically divided in three areas, the area of continuous permafrost, discontinuous permafrost and sporadic permafrost. Each of these areas have different engineering problems related to permafrost. The southern limit of permafrost roughly coincides with the 30°F (-1" C) average annual temperature isotherm.

Continuous Permafrost.

In the continuous zone the soil is frozen to great depth. This is the true Arctic. Permafrost thicknesses of one tu two thousand feet are encountered. The active layer, the soil zone that freezes and thaws every year, is on the order of a foot or so in thickness depending on local climate.

To my way of thinking, in this area we do not have permafrost problems, but rather active layer engineering problems. The active layer is very sensitive to damage and heals slowly. Bulldozer tracks can turn into shallow watercourses. Geophysical survey lines may remain visible from the air for years.

Engineering in the High Arctic is often a case of not disturbing the tundra, which is another way of saying the active layer, and "protect the permafrost." The protection is relative. What engineers often really mean is that the active layer needs to be protected. Some numbers will illustrate this. Suppose the active layer is1 ft. thick and the permafrost is 1000 ft. thick. An increase in thawing depth of an additional foot will have a major impact on the active layer, an increase in thickness of 100%, whereas the permafrost is now a "mere" 999 ft. thick, a reduction of 0.1%.

It is no wonder then that road construction in the Arctic centers on protection of the active layer while using the frozen soil as a base. The same is true in building construction. The structure is solidly founded in the frozen soil; efforts are made to protect the active layer or freeze it. Of some concern is frost heave from the active layer, but with the thicknesses encountered this is rarely a problem when the structure is anchored in permafrost.

Discontinuous Permafrost

In the discontinuous zone engineers encounter true permafrost problems, some of which you have seen on the fieldtrips in the local Fairbanks area. The permafrost will be absent in areas with a favorable location, such, as some south facing slopes, and present in cooler areas. Since the average Fairbanks temperature is 25.8° F, permafrost thickness in Fairbanks is limited and the temperature of the permafrost warm, relatively speaking. The soil temperature may be within a degree Farenheit of thawing. In a location like the CRREL permafrost tunnel site near Fox, Alaska the total thickness of frozen soil is about 100 ft. In other open south-facing areas such as the south-facing fields around the University farm, permafrost may be absent.

There are two another complicating factors regarding permafrost in the discontinuous zone such as in Fairbanks and those are related to :

1. Soil Type (especially as related to moisture content).
2. Soil cover (including vegetation, but also man-made coverings such as a highway pavement).

Because permafrost is defined as a thermal condition, soil moisture play an important part in Permafrost Engineering. Unless there are special circumstances such as saline pore water, soil moisture will be in the form of ice when the soil is below freeing. Engineers divide permafrost soil in two categories, Thaw Stable Soils and soils which are not. Soil moisture content in the form of ice and the distribution and relative amount of ice with respect to available pore space is critical. If the volume of the ice in the soil exceeds the available pore volume the soil is said to have "excess ice". Such a soil would undergo a volume change as the ice melted, but there is more to the problem.

Soils with a high capillary rise and good permeability such as silts have the potential for forming a great amount of excess ice. This is true regardless of permafrost presence or not. Frost susceptible soils may form taber ice, create frost heave problems, and will cause problems when thawed. The difference between permafrost silt and a silt subjected to annual freezing and thawing is that the permafrost silt has been frozen longer. The problems upon thawing are the same. Since the soil thaws from the surface downward, the water released has nowhere to go. The result is a significant reduction in the bearing capacity of the soil from the reduction in shear strength of the soil. (Like a teacher of mine said, "You cannot slice water".) Mud has essentially no bearing capacity and we see the results each spring when the load limits are re-imposed on our highway in the spring where the road foundation is a frost susceptible soil. Permafrost engineering for these kinds of soils will typically be directed towards efforts in keeping the soil frozen. To accomplish this, there are two methods. One is using insulation, the problem here is that insulation alone may not be sufficient to keep the soil frozen. There will be a thermal gradient through the insulation, and the soil that needs to be protected may only be a fraction of a degree below freezing. Insulation "ill work if the total temperature change is confined to the insulation layer. This is the approach used in the Northern Contiguous States. The placement of insulation on the subgrade keeps the subgrade from freezing and hence there is no ice lens development in the soil. The same process but in reverse is used in the High Arctic. Insulation on top of the active layer will protect the permafrost from thawing and even raise the permafrost table into the insulation and confine the annual temperature variations to within the insulation layer and any soil above it. In the discontinuous permafrost zone this may not be possible, the heat input is too great and the amount of insulation needed may be uneconomical. In many circumstances soil freezing is the answer to the question of soil stability. There are two ways of approaching this, artificial freezing or using the natural conditions and thermopiles. A good example of the latter is the above ground section of the trans Alaska pipeline in the Fairbanks area. The thermopiles take out enough heat in the winter so that although they do not work when the air temperature is higher than the soil temperature, enough soil is frozen in the winter to keep enough of the foundation frozen through the summer. A combination of insulation and thermopiles is often an optimal solution.

Since the silty soils in the Fairbanks originated at different times, the lower, older silts have often massive ground ice associated them; a relic from the tundra conditions near the end of the last ice-age. This is clearly seen in the CRREL permafrost tunnel where the soil layer with C 14 dates in the 11,000+ year range has massive ground ice present. These ice-wedges are actually fossil wedges, and hence inactive. This silt is then overlain by a younger silt member which contains today's permafrost table. If the warming of the soil allows this massive icemass to thaw we see to some spectacular thermokarst features. They are well developed in many locations in the Fairbanks area. As stated earlier, just a small increase in soil temperature may trigger thawing of these silts. As far as the soil is concerned it is immaterial whether the increase is due to changes in the soil surface by reduction of shade or a long term increase in average temperature conditions from global warming or greenhouse effect. Soils engineers working in the discontinuous permafrost zone know that regardless of the cause of the soil warming, the results can be disasterous. The Fairbanks area has many examples; roads with constant maintenance problems; homes abandoned because of thermokarst subsidence.

But frozen silts do have one redeeming feature, they can be excavated in the frozen state without too much of a problem with regard to machinery. Thaw stable soils like gravels cannot readily be excavated with continuously operating equipment while. frozen, but must be thawed or sometimes blasted first., The placer mining operations in Fairbanks and the construction of the pipeline reaffirmed these constraints.

Clean permafrost gravels can be used as a foundation without too many problems. Downtown Fairbanks testifies to this. The problem here is that the gravels may not be clean, for example there are many sloughs filled with ice- rich silt and organic materials that crisscross the floodplain deposits that underlie Fairbanks. When these deposits are encountered, the engineer must make a decision to either excavate the deposit and replace it with a clean, non frost susceptible gravel or keep the soil frozen using the methods already described. Engineers in Fairbanks use both methods depending on judgment and the local circumstances.

Engineers must also keeep in mind that the construction of buildings and roads affects the thermal regime. A simple operation like keeping the roads clear of snow in the winter increases the frost penetration from the winter cold, and a black asphalt road surface will accelerate thawing of the soil underneath in the summertime. If the underlying soil is frost suseptible or a frozen soil which is not thaw stable, significant amounts of differential settlement can take place. Fairbanks' roads show numerous examples of this.

Another set of engineering problems in Fairbanks are in connection with the groundwater supply and sewage disposal. The presence of permafrost complicates the groundwater system, however, I Will only briefly address one problem related to groundwater movement. In many areas of Fairbanks the geologic column consist of the bedrock which is overlain by gravels (sometimes these gravels are gold bearing and the source of the placer-mining industry in the area). The gravels are in turn overlain by reworked organic silts. The column is similar to the one seen in the CRREL permafrost tunnel. At the CRREL site the permafrost extends into bedrock, whereas in other areas the frozen section only extend into the gravels. This thawed portion of the gravel layer then acts as an artesian aquifer in many places. If the aquifer is reached by a well drilled through thr frozen silt, the flow of water through the well may thaw the soil surrounding the well casing and the water may continue to flow even though the well itself has been capped. Water can flow up along the outside of the casing. The well may continue to flow unchecked for extended periods of time. If this happens during the winter a substantial icing may develop, something that took place in one part of town in the winter of 1976/77.

Sporadic Permafrost

In the zone of sporadic permafrost, the frozen soil is present in sheltered, cool areas. The problem here is often one of finding it and if found, ask the question of whether the soil is thaw stable or not. The treatment will then be as discussed in the previous section.

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SOIL TAXONOMY- Insensitive to Native Vegetation in the WEST

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My purpose here is not to challenge the basic soundness of SOIL TAXONOMY, nor its many successes. I consider TAXONOMY and the old SOIL SURVEY MANUAL to be the two most important soils publications in my lifetime. Without a doubt, NCSS would not be what it is today had those two documents not been published. If I had to list the three attributes of SOIL TAXONOMY which I believe responsible for its success, I would name the following:

1. The requirement for quantification of morphology and chemistry.
2. The inclusion of soil climate as a classification criteria.
3. The planned provision for change in the system, and the reliance upon field experience to drive change.

When SOIL TAXONOMY was developed beginning over 40 years ago, the available data base was much smaller than at present and experience with detailed soil survey was largely confined to agricultural lands. It is no surprise that, from the very beginning, TAXONOMY worked better for cropland surveys than for wildlands. I believe this to still be true today, and I base that belief on conversations with numerous soil scientists in the BLM and Forest Service as well as my own professional experiences.

Just a week previous to this conference, I was participating in a soils training session for silviculturists and managers on the Bridger-Teton National Forest in western Wyoming. These users (hopefully) of the Soil Survey asked a specific and a general question, questions that I have heard before. Their specific question was: Why does one Soil Series support several habitat types and why does the same habitat type occur on more than one Series? A more general question, after listening to a soil scientist go over a soil profile description in detail, item by item, was: What does all of this have to do with growing trees? As I said, I have heard these questions before.

In my own research I have frequently come to the same frustration, that of not being able to relate soil properties and soil classification units to plant communities and plant response. In part this problem is definitional, and one has to remember that plant communities, habitat types, range sites or whatever are abstractions. They represent attempts to describe portions of the variability in vegetation observed in nature; the Soil Series is a similar abstraction.

I will argue however that the major source of this phenomena is real, and that its roots lie in the history of SOIL TAXONOMY. Specifically, the data base bias towards agriculture has desensitized SOIL TAXONOMY to native vegetation. The definitions of the epipedons were written with the idea that the soils would be plowed. The definitions of the textural control sections were apparently drawn up with the same concern. Finally, the def lnitions of moisture and temperature regimes were conceived in reference to the response of agronomic crops.

The “mixing’ of the upper 18 cm of the soil, required to identify eplpedons, destroys resolution at the interface of the Mollisols and Aridlsols. In the forest, this requirement results in the lumping of profiles with such diverse horlzonatlons as Oi-E-B,Oi-A-E-B, and A-B together wl thout recognition of the biological implications of such morphological distinctions. The response of vegetation in the arid regions to differences in surface soil texture is well known. It, with other factors, provides the basis for the “Range Site" concept. Yet in the majority of cases, the surface texture is not a consideration in the placement of a soil in the correct Textural Family. In detailed surveys of aqrlcultural regions, mapping units commonly are named after “Phases of Series” which represent the soils within the delineations. This simply has not been done on Order 3 Soil Surveys on the western wildlands. After we mix the surface tier to identify the eplpedon, we look under it for family placement.

In working wlth r lpar lan plant communities, one sees wide variation in water level and length of the period of occurrence of reducing conditions in soils of the same Series or, more commonly, Family. The development of Series concepts for high elevation, cold soils has been slow. These rlparlan areas are of immense lnterest to wlldland managers at the present tlme and it is a missed opportunlty that we are not able to provide specific information as to water relations and plant response in the mapplng units we delineate. A common *occurrence* would entail three or four plant communities on one Series and the same community being split over two or three Series or Families (e.g. Burns and Tonkin, 1982).

Now, let’s look at some of the features of SOIL TAXONOMY that cause these problems. The definition of the "aquic" moisture regime in TAXONOMY (Soil Survey Staff,1975,1987) discusses both an "aquic" a "peraquic" regime. The peraquic regime is not used as a taxonomic criteria. In practice, a soil will be identified as having an aquic regime if it has either: a.) a histic epipedon, b.) a sulfuric horizon, or c.) an umbric, mollic, or ochric epipedon AND dominant colors in a horizon at a depth of less than 50 cm of chroma 2 or lower without mottling or chroma 1 or lower with mottling (Soil Survey Staff, 1987). A high SAR that decreases with depth will also result in the identification of an aquic regime (e.g.Aquepts).

At the Subgroup level, a. Cryochrept is placed into the Aquic Cryochrepts if it has low chroma mottles within 75 cm of the surface. Aquic Cryofluvents and Aquic Cryorthents have low chroma mottles within 50 cm of the soil surface. An Aquic Cryoboralf either has low chroma mottles within 75 cm of the soil surface OR is saturated with water for at least three months within 1 meter of the surface. An Aeric Cryaquept has chromas higher than 2 in more than 40 % of the horizons at a depth of 15 to 50 cm. In these definitions, I believe there to be room for a wide range of plant response. An Aqualf has "dominant" chroma of 2 *or* less in coatings on surfaces of peds in the arqillic horizon and a chroma of 2 or less immediately below any dark A horizon. If there are no mottles in the arqillic or kandic horizon, the dominant chroma is 1 or less. So, is an Aeric Cryaquept always "wetter" than an Aquic Cryofluvent ? One would need to ask the plants I suppose.

Another concern that was discussed on the VI ISCOM meeting last summer was the difference between "High Latitude Cryic" and "High Elevation Cryic" temperature regimes. Crop response is different in these situations; I am sure native vegetation also responds differently. Plants used as indicators of temperature and moisture regimes have varying interpretations with location. Idaho fescue (Festuca idahoensis) is apparently an indicator of the cryic temperature regime when precipitation is less than 40 cm, but occurs on soils which have a frigid regime if precipitation is greater than 40 cm (Platou et al., 1986). This is a classic example of a plant making a different "integration" of soil properties than we do as taxonomists.

The literature dealing with attempts to relate soil properties with yields of native vegetation indicates very checkered results (e.g. Munn et al, 1979; Brown and Loewenstein, 1978; Grier et al., 1989). Aqain, I believe that the plants are simply integrating the soil and site factors in a much more sophisticated way than we have done so far.

To end this paper on a positive note, let me suggest some modifications of TAXONOMY that might improve the interpretive value of our taxonomic units for native vegetation.

1. Consider allowing a 10 cm thick epipedon for soils in the aridic moisture regime.

2. Develop textural family criteria that include the surface tier for soils in cryic temperature regimes and in aridic moisture regimes.

3. Evaluate soil textural families consistently for depth, from 18 to 100 cm.

4. Use "Temperature Degree Day" criteria to subdivide within the cryic and frigid temperature regimes.

5. Use peraquic as well as aquic moisture regimes (perhaps as a family criteria ?).

6. Use consistent depth strata to evaluate aquic and aeric subgroups and aquic suborders.

We have a large potential cliental in the resource management agencies. We will win over those people as supporters of the NCSS only if we can make SOIL TAXONOMY as useful to natural resource managers, dealing with native vegetation, as it has been for agriculturists.

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WEST REGIONAL SOIL SURVEY WORK PLANNING CONFERENCE

Fairbanks, Alaska
June 18-22, 1990
W. R. Folsche

The NCC organizational chart is attached. Special notes should be: (1) Lee Sikes has replaced Don Stelling who retired, (2) Hugh Allcon has taken a new position--Chief of the new Operations/Reproduction Branch, and (3) Fred Minzenmayer is going to be housed at the NCC (this is for coordination with the NSSC in our joint GIS effort).

Training is a big function of the Remote Sensing/GIS function of NCC. Courses offered are: (1) Fundamentals of GIS, (2) GRASS, (3) LTPlus, (4) GIS for Managers, and (5) Photointerpretation for Trainers. The staff is working on an advanced Remote Sensing/GIS course and a special course on Photointerpretation for NRI leaders.

The NCC is working on the following databases: (1) NATSGO, (2) STATSGO, (3) SSURGO, (4) TIGER, (5) DLG's, (6) DEM's, (7) PSU's, (8) Hydrologic Units. No copyrighted soils database will be put in the SSURGO database.

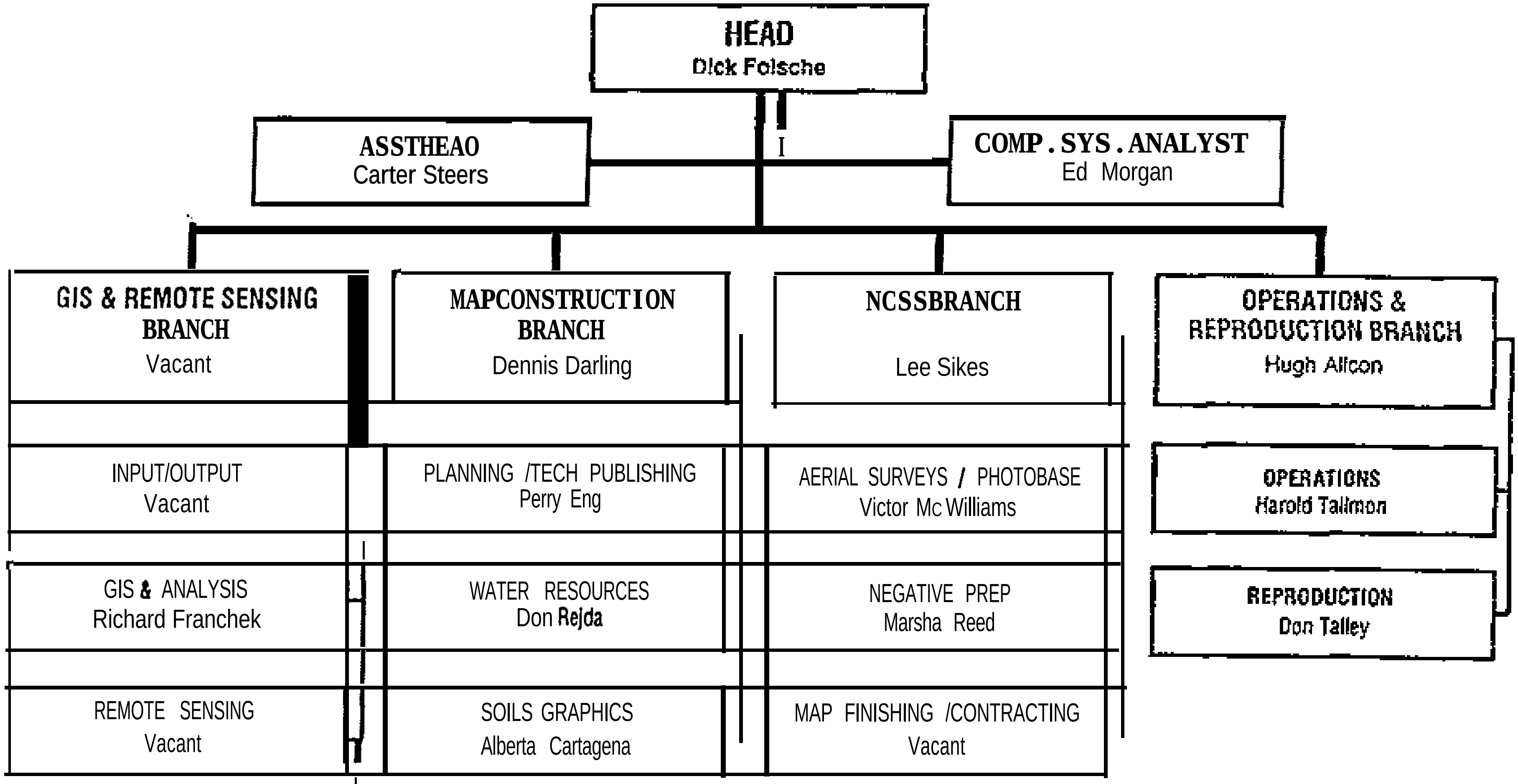
The NAPP maps for soils are to be coordinated with Jim Ware. In the future we can expect digital imagery to be used as a backdrop on GIS applications. Image classification for land use cannot satisfac-factorily be completed on FOCAS equipment.

When updating soils by MLRA, consideration should be given to NAPP flying dates, MOU from different counties, and scale. Soil scientists need to be involved with the use of soil databases in GIS activities. When others ask for soil databases, they also ask for assistance in applying soils in GIS. Soil scientists need to be prepared to give this assistance.

NCC is involved in TQM. We recognize you as our customer and will be asking more in the future what your needs are for the products that we do for you.

I appreciate your inviting me to participate in this conference.

National Cartographic Center



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June 1990

Western Regional Technical Work Planning Conference Task Forces

1. Soil moisture and temperature - Tommie Parham, chairman.

Background: Soil moisture and temperature regimes continue to be quite subjective determinations because the philosophy or their purpose seems to be unclear. Most of the temperature and moisture criteria was developed to make major separations for cropland, few were done to make the separations that may be needed.in the West. Yet even the cropland concepts have been somewhat lost because of poor documentation of changes to farming practices. With the current proposals of Soil Taxonomy including changes in determining moisture regimes, the question has been asked - What areas need to be separated?

Soil Moisture and temperature data or information or estimates are used for soil classification. However, there usually is no recording or data base of soil climate to reference or compare between areas when we try to correlate. A record of this information in an accessible manner is needed also for making interpretations that vary during the year with fluctuations of soil moisture states or temperature.

Items for consideration by the task force:

a. What land use or vegetative separations are needed in the western states that moisture or temperature regimes could better address?

b. What correlation procedures are needed to coordinate soil moisture and temperature regimes between states and agencies?

c. Even the data collected is biased by land use, so how do we develop techniques to morphologically support the needed separations and provide a predictive tool for future uses and responses?

d. Compare the accuracy of current models in assessing soil moisture and temperature regimes.

e. Develop a procedure that can be graphically displayed and computer accessed that records soil moisture and temperature for each soil series by month and depth.

f. Propose a process for implementing this procedure into NCSS soil documentation procedures.

2. Levels of interpretations - Larry Munn, chairman.

Background: Traditionally NCSS has interpreted soils at the phase of the soil series. NCSS has not established standards and procedures for different levels of interpretation commensurate with the levels and detail of soil survey data.

Items for consideration by the task force:

a. Is it reasonable to use SCS-SOI-5 data for STATSGO interpretations? Should criteria or interpretations be scale dependent?

b. What kind and amount of interpretation is needed for different kinds and degree of management?

c. How do we consistently interpret for different land use by different agencies?

d. Identify other techniques/procedures for interpreting soil survey data.

e. What guidance can we develop to interpret map unit delineations as opposed to components of map units?

3. Soil quality standards - Roger Poff, chairman.

Background: Soil quality standards are the stated conditions or threshold values for soil properties or soil conditions that indicate the health, quality, or productive potential of a soil.

Items for consideration by the task force:

a. Explore kinds of standards that may be needed by NCSS cooperators. Consider a replacement soil quality standard for T in erosion equation.

b. Develop proposed guidelines for the development of soil quality standards with close attention to terminology.

c. Develop a presentation for the ASA symposium on soil quality standards.

4. Sails changes by management - Mario Valverde, chairman.

Background: Soil interpretations have concentrated on interpreting the natural soil. However, a National Work Planning committee identified four major areas in which management induces changes to soils that affect its use: (1) soils changed by crop management, (2) soils changed by irrigation, (3) soils changed by drastic disturbances, and (4) soils changed by drainage. Physical and chemical properties change both temporally and permanently.

Items for consideration by the task force:

a. Construct a plan to handle use dependent temporal information at a level of detail significant to the major models for erosion, chemical amendment fate, etc. Examine the west Texas data collection program for possible use.

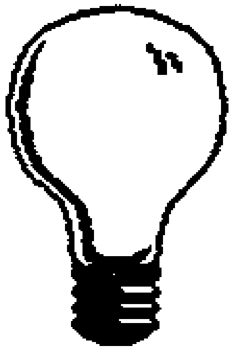
b. Develop procedures or framework to document the soil physical and chemical changes or modifications that influence long term soil behavior changes.

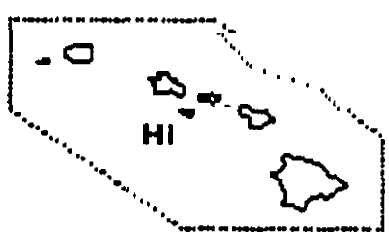
c. Draft a section for the National Soils Handbook to improve documentation of management altered soils for both when soils are being mapped and for when changes occur after publication.

'NCSS' Western Regional Technical Work Planning Conference

Taskforce I (Soil Moisture and Temperature)

June 1990





"NCSS" WESTERN REGIONAL TECHNICAL WORK PLANNING CONFERENCE

TASKFORCE 1 (SOIL MOISTURE AND TEMPERATURE) TOPICS

Soil Climate has been a concern at these Work Planning Meetings and others for the past 20-25 years. Yet in many places, conceptual applications are drastically different. Dave Anderson said it best - "A clear understanding of concepts is not uniformly applied. This results in applied inconsistency."

A project to develop a Soil Moisture and Soil Temperature Map of the Western U.S. was initiated in the early to middle 80's. The National Soil-Range Team and WRCC-50 worked together to produce the 1985 Map of the Western States.

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SOIL MOISTURE AND TEMPERATURE - TASKFORCE 1

Background: Soil moisture and temperature regimes continue to be quite subjective determinations because the philosophy or their purpose seems to be unclear. Most of the temperature and moisture criteria was developed to make major separations for cropland, few were done to make the separations that may be needed in the West. Yet even the cropland concepts have been somewhat lost because of poor documentation of changes to farming practices, With the current proposals of Soil Taxonomy including changes in determining moisture regimes. the question has been asked, What areas need to be separated?

Soil moisture and temperature data or information or estimates are used for soil classification. However, there usually is no recording or data base of soil climate to reference or compare between areas when we try to correlate, A record of this information in an accessible manner is needed also for making interpretations that vary during the year with fluctuations of soil moisture states or temperature.

"NCSS" WESTERN REGIONAL TECHNICAL WORK PLANNING CONFERENCE

TASKFORCE 1 (SOIL MOISTURE AND TEMPERATURE) TOPICS

1. What land use or vegetative separations are needed in the western states that moisture or temperature regimes could better address?

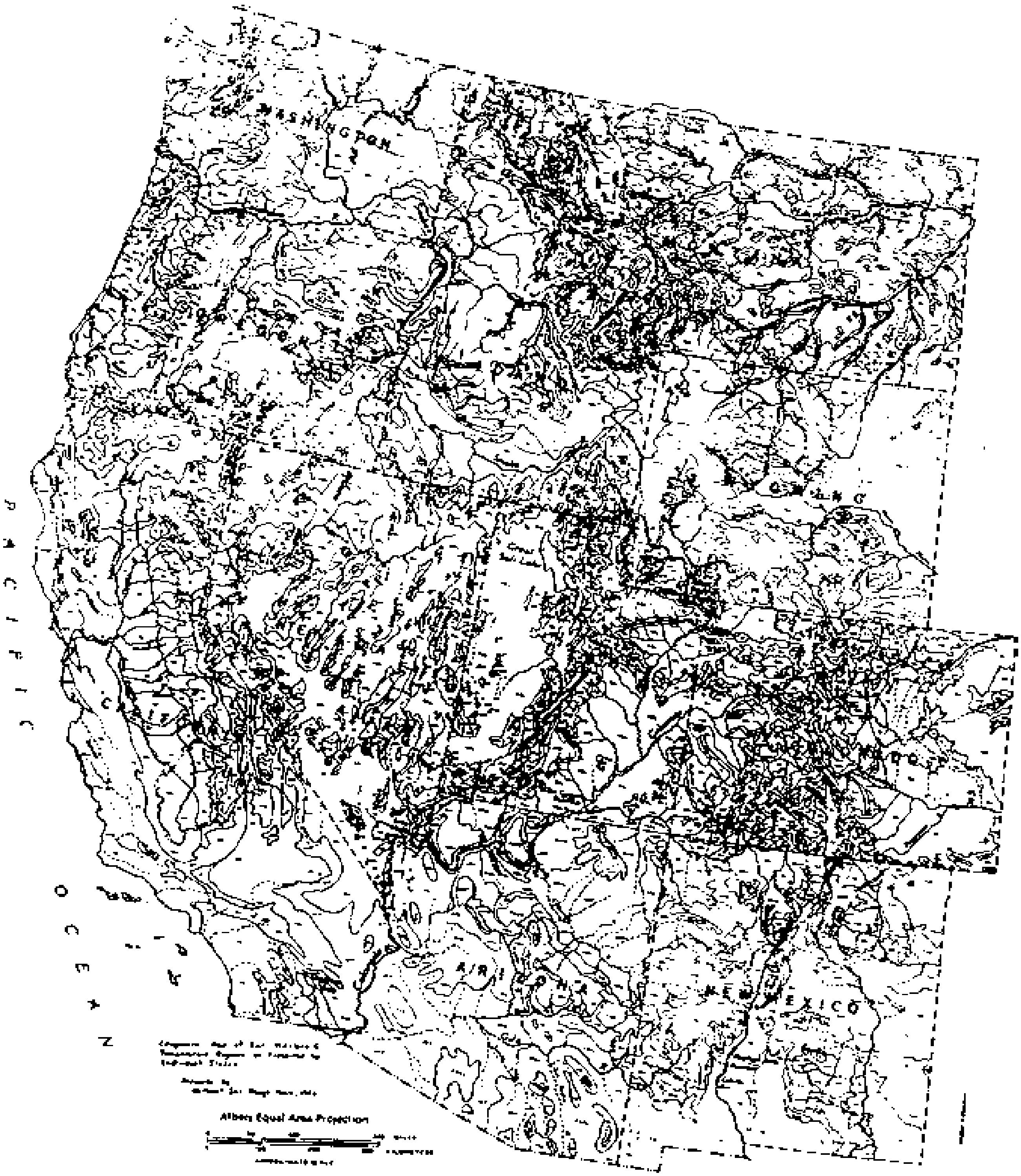
2. What correlation procedures are needed to coordinate soil moisture and temperature regimes between states and agencies?

3. Even the data collected is biased by land use, so how do we develop techniques to morphologically support the needed separations and provide a predictive tool for future uses and responses?

4. Compare the accuracy of current models in assessing soil moisture and temperature regimes.

5. Develop a procedure that can be graphically displayed and computer accessed that records soil moisture and temperature for each soil series by month and depth.

6. Propose a process for implementing this procedure into NCSS soil documentation procedures.


WASHINGTON
PACIFIC
OCEAN
NEW MEXICO
Albers Equal Area Projection

Map Unit Legend for the Composite Map of
Soil Moisture and Temperature Regimes as
Presented by Individual States

Prepared by: National Soil-Range Team, 1985

HtA - Hyperthermic/Aridic
TA - Thermic/Aridic
MA - Mesic/Aridic
FA - Frigid/Aridic
CA - Cryic/Aridic

This group of soils is interpreted as being within the concept of Typic Aridic or aridic(torric) defined on pg. 55, Soil Taxonomy.

TAx - Thermic/Aridic
MAx - Mesic/Aridic
FAx - Frigid/Aridic
TAu - Thermic/Aridic
MAu - Mesic/Aridic
FAu - Frigid/Aridic

This group of soils has two apparent interpretations: 1) that the subscript(s) includes both Typic Aridic and Xerollic or Ustollic Aridic soils or ustic; 2) that the subscript(s) equals Xerollic Aridic and Ustollic Aridic intergrade soils (intergrades only).

TX - Thermic/Xeric
MX - Mesic/Xeric
FX - Frigid/Xeric
CX - Cryic/Xeric

ITU - Isothermic/Ustic
IMU - Isomesic/Ustic
TU - Termic/Ustic
MU - Mesic/Ustic
FU - Frigid/Ustic
cu - Cryic/Ustic

IMUd - Isomesic/Udic
MUd - Mesic/Udic
FUd - Frigid/Udic
CUd - Cryic/Udic
PUd - Pergelic/Udic

Q Aquic
TQ - Thermic/Aquic
MQ - Mesic/Aquic
FQ - Frigid/Aquic
CQ - Cryic/Aquic
Thermic/Xeric
MX - Mesic/Xeric
FX - Frigid/Xeric

CX	-	Cryic/Xeric
ITU	-	Isothermic/Ustic
IMU	-	Isomesic/Ustic
TU	-	Termic/Ustic
MU	-	Mesic/Ustic
FU	-	Frigid/Ustic
CU	-	Cryic/Ustic
IMUd	-	Isomesic/Udic
MUd	-	Mesic/Udic
FUd	-	Frigid/Udic
CUd	-	Cryic/Udic
PUd	-	Pergelic/Udic
Q	-	Aquic
TQ	-	Thermic/Aquic
MQ	-	Mesic/Aquic
FQ	-	Frigid/Aquic
CQ	-	Cryic/Aquic

These groups represent the central concepts of the temperature and moisture regimes defined in Soil Taxonomy.

The following complex units were identified:

TAU	-	Thermic/Aridic and Ustic
TUA	-	Thermic/Ustic and Aridic
TAAu	-	Thermic/Aridic and Aridic bordering Ustic
MAU	-	Mesic/Aridic and Ustic
MUA	-	Mesic/Ustic and Aridic
MAAu	-	Mesic/Aridic and Aridic bordering Ustic
MauU	-	Mesic/Aridic bordering Ustic and Ustic
MXA	-	Mesic/Xeric and Aridic
MFX	-	Mesic and Frigid/Xeric
FAU	-	Frigid/Aridic and Ustic
FUA	-	Frigid/Ustic and Aridic
FUX	-	Frigid/Ustic and Xeric
FUdU	-	Frigid/Ustic and Ustic
FQA	-	Frigid/Aquic and Aridic
FCU	-	Frigid and Cryic/Ustic
FCUd	-	Frigid and Cryic/Udic
FCUdU	-	Frigid and Cryic/Udic and Ustic
FMCX	-	Frigid and Mesic and Cryic/Xeric
FMUd	-	Frigid and Mesic/Udic
FCX	-	Frigid and Cryic/Xeric
FMCX	-	Frigid and Mesic and Cryic/Xeric
CXUd	-	Cryic/Xeric and Udic
CFX	-	Cryic and Frigid/Xeric
CFQ	-	Cryic and Frigid/Aquic
CFUd	-	Cryic and Frigid/Udic
CUdU	-	Cryic/Udic and Ustic
CFMUdX	-	Cryic and Frigid and Mesic/Udic and Xeric
?	-	Either a symbol could not or was not assigned to the delineation or map unit lines were not closed or there were two symbols in the delineation.

1. What land use or vegetative separations are needed in the western states that moisture or temperature regimes could better address?

- Identify key plant (range to forestry types) indicators of soil moisture and temperature by MLRA's and similar LAT/LONG..

- Moisture separations needed in cryic regime.

- Production in native plant communities must be viewed in the light of Timing of and Type of precipitation.

- Utilize this information for making series separations ONLY.

- Develop consistency in interpretation of soil moisture and temperature regimes. Recommend conceptual clarification and definitions in Soil Moisture and Temperature Regimes be charged to John Witty, National Leader for Classification, and the International Committee on Soil & Temperature Regimes, Ron Paetzold Chairman.

- Research and Academic Communities can make significant contributions in the area of moisture/temperature studies.

- NSSL & Research Communities should standardize data collection needs of soil profile - Are we going to use SMCS? Should an arbitrary depth between 75 and 100 cm. be the standard? Should a second measurement be taken in aridic and ustic areas at 10 cm. depth?

2. What correlation procedures are needed to coordinate soil moisture and temperature regimes between states and agencies?

- Develop Regional soil climate map separating major moisture temperature combinations.

- National edict requiring states to gather standard information on specific data collection sites (benchmark soils) in MLRA's areas common to more then once state.

- Empower corralators at NSSC with LRR & MLRA responsibilities to facilitate join between states and settle disputes in cooperation with state and regional subcommittees. SOME JOIN PROBLEMS ARE REAL Studies for verification are needed!

- Formation of NCSS Cooperators taskforce or sub-committees at state/regional levels to decide which benchmark sites need monitoring at the state & regional levels.

- Consistent story from Correlation and Interpretation Staffs.

- Use the Momentum & Cooperation created by STATSGO to further address join problems.

- MOU's and requests for SS Updates must have provisions for correcting join problems with adjacent SS's.

- Establish what constitute minimum data set using standardized procedures that can be compared among states.

- Correlators must have the same guidelines & understanding for determining soil-moisture-temperature regimes.

- How do correlators in the 13 western states determine soil- moisture-temperature regimes? What are current guidelines?

- NSSL & Research Communities should standardize data collection needs of soil profile - Are we going to use SMCS? Should an arbitrary depth between 75 and 100 cm. be the standard? Should a second measurement be taken in aridic and ustic areas at 10 cm. depth?

3. Even the data collected is biased by land use, so how do we develop techniques to morphologically support the needed separations and provide a predictive tool for future uses and responses?

- Standardize collection procedures.

- Soil/native veg relationships are important in most of western range & forestlands - morphology alone as a predictive tool can be tricky & unreliable.

- Start reliable data bases to record observed changes in uses and the resulting responses.

- Morphological separations need to be based on long term data with diverse use w/ reasonable flexibility for overlap; data collection needs to be started.

- Art & Science must blend together to map soils do not become to rigid.

- Collect data from paired sites under contrasting landuses where morphological indicators of soil water & soil temp conditions are constant (depth to secondary calcium carbonate, thickness of A horizons in grasslands).

- We need to develop techniques to handle mans influence on soil moisture and temperature. Influences include cropping, logging, irrigation, drainage, and fallowing. this has gone on for thousands of years in some places and will probably not be discontinued. Perhaps with this in mind we should classify the soil as it occurs not as what it would revert to if a particular practice or practiced ceased.

- Ideally, management manipulation should not be able to change the classification of a soil (short term).

4. Compare the accuracy of current models in assessing soil moisture and temperature regimes.

- Charge Paetzold & Smallwood (current climate model experts) with evaluating current models.

- Newhall Model treats soil moisture Control Sections as buckets.

- No models that predict soil temp regimes with good degree of reliability for natural systems. Sites and spatial factors have not been considered; emphasize data collection for site verification.

- Computer models can be useful tools but they require data for input calibration and verification (often it is easier (more accurate) to measure the soil moisture and /or temperature directly than to measure the model input parameters.

- Joe Nichols of the SNTC is looking at Ekalaka Rangeland Hydrology and Yield Model. ERYHM-II climate water-balance model providing daily simulation of soil water evaporation, transpiration, runoff and soil water routing for individual range sites.

- WEPP

5. Develop a procedure that can be graphically displayed and computer accessed that records soil moisture and temperature for each soil series by month and depth.

- Recommend tying in with SNOTEL and expand SNOTEL to meet some of our moisture & temperature needs, provided high quality sensors can be added to present selective sites.

- BLM - Wyoming has program called STAMP (Soil Temp & Moisture Program). It stores and graphically displays soil moisture, soil temperature & precip data. Entered through a data logger and reader or entered manually (gravimetric moisture) graph any time period.

- Excellent charge for data base staff at NSSC. Logical structure need to be developed suitable for the kind and amount of data collected during a SS and after for interpretations for application program.

6. Propose a process for implementing this procedure into NCSS soil documentation procedures.

- STATES should prepare specific proposals for Soil Moisture and Temperature Monitoring on critical/Benchmark Soil Areas/MLRA's and look at funding through some of the GLOBAL CLIMATE CHANGE Proposals!

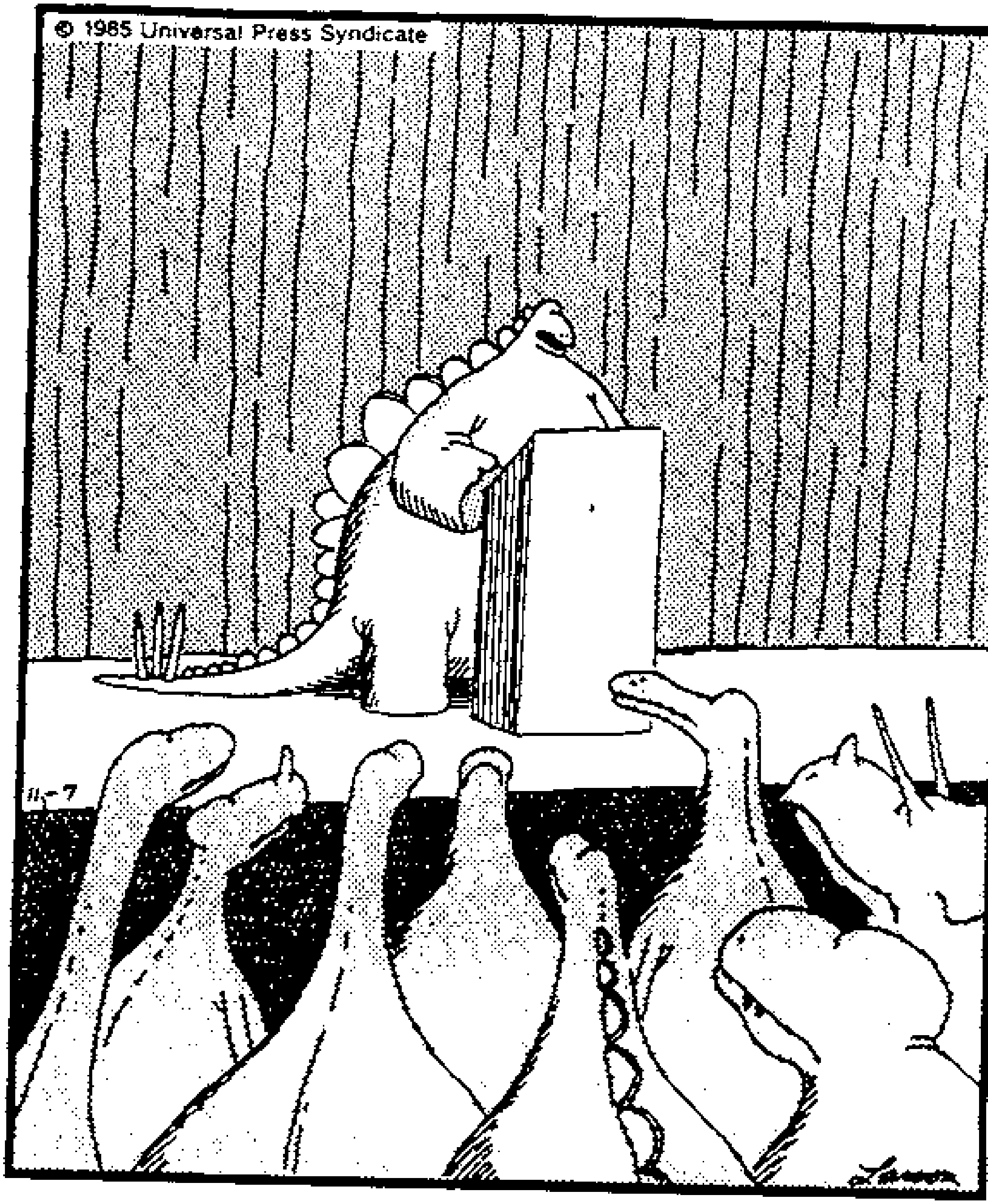
- The NSSL should purchase necessary equipment for monitoring soil moisture and temperature and loan said equipment to states based on proposals or Approved ongoing studies within a state or among states.

- Minimum of 10 years of study site data needed!

- Procedure integration into NCSS soil documentation procedures should be done by Ron Paetzold.

- Standardized acquisition of the following minimum data sets from most of the 400 RAWS sites, SNOTEL sites, and major field research center location in West.

1. Monthly maximum & minimum temp at 1cm & mean monthly temp at 25cm to 50cm depth.
2. Date as which soil freeze and thaws at 25cm.
3. Data at which moisture sensing block (gypsum blocks) indicate soils has become dry (>15 bar) and moist (less that 15 bar) at 25cm & 50cm depths.



"The picture's pretty bleak, gentlemen . . . . The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

Recommendations: Committee 2
Soil Interpretations
1990 Conference: Fairbanks, AK

Larry Munn, Chair

1. The format used to publish soil surveys should be changed to two documents. One document will contain the soil maps, mapping unit descriptions, description of the survey area, discussion of the methodology used in making the survey, descriptions of representative pedons, and documentation of the soils data base collected during the course of the survey. It will provide a discussion of the reliability of the survey information and will include for each representative soil a list of soil properties which affect management, but will NOT contain interpretations. The second document will contain descriptions of mapping units and representative pedons, a discussion of the variability and reliability of the data base, and the interpretations.

2. Interpretations should be developed on a state or regional basis to meet the needs of the identified users of the soil survey. It is EXTREMELY important that clear and thorough documentation be provided of the process by which the interpretations were developed. This is particularly important for interpretations which rely heavily on local expertise and judgement. Interpretations to be made should be a part of the MOU for the survey.

3. An attempt should be made to capture as much as possible of the expertise and "feel" for the soils of the survey area which is developed by the soil survey party during the course of the survey. Computer data storage and retrieval capabilities should allow this to an extent not previously possible. Fieldnotes, transect data, etc. should all be saved.

4. The interpretations document should be updated, and republished, as required to meet changing needs of the users of the survey and to reflect changes in technology. Again, the process used to develop new interpretations and the limits of reliability of the data base must be fully documented.

5. Finally, interpretations should never be developed or released without an accompanying discussion of the reliability of the data base from which they were developed; and the logic process used in their development.

WESTERN REGIONAL TECHNICAL WORK PLANNING CONFERENCE
FAIRBANKS, ALASKA
JUNE 18-22, 1990

Final Soil Quality Standards Task Force Report - 7/90

CHARGES

1. Explore kinds of standards that may be needed by NCSS cooperators. Consider a replacement soil quality standard for T in erosion equations (e.g., soil loss tolerance).

2. Develop proposed guidelines for the development of soil quality standards with close attention to terminology.

3. Develop a presentation for the ASA symposium on soil quality standards

DEFINITIONS

Soil quality standards - The stated quantitative or qualitative threshold values for soil properties or conditions established to maintain or improve the health, suitability or productive potential of a soil.

Soil quality standards provide a means of comparing the present condition of a soil with its inherent potential (or other reference) to fulfill a specific function. Soil quality standards are different from, and should not be confused with soil potential ratings or soil interpretations.

Soil productivity potential - The inherent capacity of a soil to support the growth of plants, plant communities, or a sequence of plant communities.

Soil hydrologic function - The inherent capacity of a soil to intake, retain and transmit water.

Soil environmental health - The inherent capacity of a soil to absorb, filter or degrade added chemicals, heavy metals or organic compounds.

KINDS OF SOIL QUALITY STANDARDS

The soil quality standards to be developed are organized below under categories that relate to plant growth, water flow, and human and animal health and safety. Some soil properties or conditions might apply to more than one land use or category, although the threshold values may differ. The categories are useful for helping to clarify the purpose or effects of specific soil properties, conditions or thresholds.

Soil productivity potential - Develop soil quality standards for the production of vegetation for the following uses:

- Forestry
- Grazing
- Irrigated cropland
- Non-irrigated cropland.
- Other vegetation uses where healthy or productive vegetation is desired (e.g., riparian areas, windbreaks, campgrounds, greenbelts, parks and wilderness areas).

Soil hydrologic function - Develop soil quality standards for "Watershed" purposes related to water quality and supply (e.g., municipal watersheds, riparian areas, groundwater recharge areas, wildlands, and areas where soil productivity standards are applied).

Soil environmental health - Develop soil quality standards for purposes related to human and animal health and safety (e.g., pesticides, heavy metals, atmospheric deposition, effluent, sludge, and salt).

DEVELOPMENT OF SOIL QUALITY STANDARDS

The development of soil quality standards follows a process of (1) setting objectives, (2) identifying pertinent soil properties and conditions, (3) selecting threshold values, and (4) determining the area to which the standards apply.

1. Setting soil quality standard objectives. Soil quality standards serve a stated purpose that is derived from laws, regulations. policy or management plans.

As a" example, in the Forest Service, legislation and implementing regulations specified the need to maintain long-term land productivity and not allow significant change or permanent impairment of the productivity of the land. To satisfy these goals, Forest Service policy defines significant change as a 15 percent reduction in inherent soil productivity potential, which is used as a basis for setting threshold values for soil properties or conditions. Fifteen percent was selected because variability in non-soil related factors (insects, disease, plant physiology, etc.) could account for up to about that amount of stand growth variation before the effects of changes in soil properties or conditions could be measureable in practical terms. This does not infer that a 15 percent reduction in productivity is acceptable. It refers to a" amount where the effects of changes in soil peroperties become measurable, and thereby provide a signal to evaluate the need to modify management practices. Establishing objectives for other uses might follow a similar rationale.

The following are examples of goals and objective* for soil quality standards:

Soil productivity potential

Goal: Maintain or improve long-term soil productivity

Objective: Changes in soil properties or conditions do not result in a significant change in long-term soil productivity. This may be defined as changes that cause no more than a 15 percent reduction in potential for forestry, but may be defined differently for cropland, grazing, or other vegetative growth.

Soil hydrologic function

Goal: Maintain or improve water quality and groundwater supply.

Objective: Change in soil properties or conditions does not cause a significant increase in surface runoff.

Soil environmental health

Goal: Human and animal health, soil productivity potential and soil hydrologic function are not adversely affected by t-he addition of chemicals and organic compounds to the soil.

Objective: Change in soil properties or conditions does not significantly reduce the capacity of a soil to adsorb, filter, immobilize, or degrade added chemicals, heavy metals or organic compounds. Or, the addition of chemicals, heavy metals or organic compound* to the soil dies not prevent meeting soil productivity and hydrologic function objectives.

2. Identifying pertinent soil properties and conditions: Soil properties and conditions are selected on the basis of being those commonly affected by management activities, and that when altered, directly or indirectly relate to changes in soil productivity potential, soil hydrologic function or soil environmental health. For practical reasons, the selected soil properties and conditions and their threshold values should be observable or easily measured. For simplification, they can be *elected to serve as surrogates or indices of the status of other properties or conditions. For example. changes in soil productivity potential (non-cropland for this example) can occur due to compaction, puddling, displacement, erosion, burning, loss of organic matter and others. To help shorten the list, soil cover, soil porosity and organic matter (on and in the soil) can be used to reflect the status of these and related soil properties and conditions. Soil cover (living vegetation, rock fragments and surface organic matter) can be used to reflect erosion status. Soil porosity status can be used to indicate change in water and gaseous movement caused by compaction or puddling. Surface organic matter status can be used to indicate potential change in nutrient supply, soil organism habitat, soil moisture supply and other physical and chemical properties caused by burning and other forms of

organic matter removal. Soil organic matter status can be used to indicate potential change in nutrient content, moisture supply and compaction resilience caused by displacement (scalping, piling, etc.), erosion or oxidation.

Examples of soil properties and conditions for the following uses:

Soil productivity

Forestry	Soil cover, soil porosity, surface and soil organic matter.
Grazing	Soil cover, soil porosity and soil organic matter.
Irrigated cropland	Soil organic matter, soil porosity and pH/salinity.
Non-irrigated cropland	Soil cover, soil organic matter, and soil porosity.
Other vegetation	Soil cover, soil porosity, surface and soil organic matter.
Soil hydrologic function	Soil cover (when present), soil structure and/or soil porosity at soil surface (infers infiltration).
Soil environmental health	Soil organic matter, pH and soil cover

The same soil property or condition may apply to more than one use or kind of soil qulaity standard. However, the threshold values may be different. For practical application, the "umber of soil properties or conditions identified for use should be kept to a minimum. Other "important" soil properties or conditions might best be handled on a regional, MLRA or local basis (e.g. soil moisture regimes changes).

3. Selecting threshold values: Threshold values are based on those changes in soil properties and conditions that would result in not achieving the stated soil quality objectives. For example, a threshold value for porosity is equated as close as possible to a 15 percent reduction in productivity. Threshold values are based on research and current technology. It may be necessary in some cases, to base values on limited knowledge and a consensus of professional judgement until monitoring and research can provide validation or better values. Reactivation of the benchmark soil concept to guide monitoring and research may be one way to help provide long-term refinement and verification of soil quality standards.

Soil properties, conditions and thresholds should be selected so that they can represent a variety of soils rather than specific kinds of soil. For example, a soil quality standard for soil organic matter content for the purpose of soil displacement (mechanical soil loss) might state, organic matter content is at least 85 percent of its original total in the upper 12 inches. This could apply to all soils regardless of organic matter distribution. With this approach, a 15 percent loss in soil organic matter might equate to a 1/4 inch of soil for a "thin" A horizon and 1 inch for a "thick" A horizon.

Examples of threshold values:

Soil cover — Soil cover is sufficient to prevent accelerated erosion rates from exceeding soil formation rates over time.

Sufficient cover may be defined by standard erosion models and locally calibrated erosion hazard rating methods. T values should be consistent: with the rate of soil formation from bedrock for shallow and moderately deep soils and the rate of A horizon formation for deep soils (see "Strategies for Determining Soil-Loss Tolerance", E.B. Alexander, Env.Mgt., Vol. 12, No. 6, 1988 and "The Basis for Soil Loss Tolerances". D.L. Schertz, Jour. of Soil & Water Cons., 38:10-14, 1983).

Soil porosity — Soil porosity is at least 90 percent of its natural condition.

Incremental increases in bulk density does not necessarily cause incremental decreases in plant growth. The incremental effect is different for different plants, soils, and environments. Increments of increase, based on a percentage of the initial bulk density, actually become greater in absolute value as the initial bulk density increases. To set limits of allowable bulk denisty increase that are responsive to effects on plant growth, the increments of allowable increase should become smaller in absolute value as bulk denisty increases (Alexander and Poff, 1985. Soil Disturbance and Compaction in Wildland Management. USDA, Forest Service, Pacific Southwest Region, Earth Resources Monograph 8). This can be accomplished by basing the allowable increments on decreases in total soil porosity using the following formula.

$$Dbc-0.1\ Dp + 0.9\ Dbi$$

Where Dp is the mea" particle density, and Dbi and Dbc are the initial and the compacted bulk densities. respectively.

Using this method, a 10 percent decrease in porosity corresponds with: about a 20 percent increase in bulk density for an initial density of 0.75; about a 15 percent: increase in bulk density for a" initial density of 1.1; and about a 10 percent increase in bulk density for an initial density of 1.2.

The previous examples demonstrate how a single soil quality standard or threshold value can be used to represent different kinds of soil. It may not be possible to develop threshold values that would satisfy most users needs. I" these cases, threshold values may be established regionally, locally or by MLRAs.

4. Determining the area to which the standards apply: It is not practical for all land dedicated to a specific use to meet soil quality standards. In order to conduct a land "se, it is usually necessary for some land to be occupied by such things as landings, skid trails, stock driveways, or bedding grounds. The minimum amount of land that should meet soil quality standards should be suggested for each land use. This would be a suggested minimum range to meet the spirit of land stewardship. Specific percentages might vary slightly due to regional differences and ownership policies. For example, at least 85 to 90 percent of the land dedicated to timber production would be expected to meet soil qaulity standards. The 85 percent would apply to areas using ground based harvest systems and 90 percent would apply to aerial based systems.

SUGGESTED ORGANIZATION FOR DEVELOPING SOIL QUALITY STANDARDS

The development of soil quality standards should be a true National Cooperative Soil Survey effort. NCSS should provide a visible national leadership role, including bringing together others in interdisciplinary task groups.

Four interdisciplinary task groups could be organized in the following manner:

Soil Quality Standard Task Groups	Leadership
Soil productivity	
Forestry Group	Forest Service
Grazing Group	Bureau of Land Management
Cropland Group	Soil Conservation Service
Soil environmental health Group	University

Soil hydrologic function might begin with one task group and progress through the others since it applies in each category. A coordinating committee composed of the Chair from each task group and a national leader (a real big shot, like a university administrator) could be formed to "level" the rationale, define sideboards and task group composition (e.g., include EPA on soil env. health), work out schedules, and among other things, promote the development and use of soil quality standards. Task group composition would include representation from each NCSS cooperator as appropriate. Soil scientists and other disciplines may be solicited from other federal, state, university, groups or individuals as necessary. Representatives from research should also be included (e.g.. ARS, Ag. Experiment Stations, and Forest Service Research).

PARTICIPATING TASK GROUP MEMBERS

Bob Meurisse
George Staidl
Carol Wettstein
Roger Poff, Chair apparent
Chuck Goudey, Chair in absentia

RECOMMENDATIONS

1. National NCSS priority be placed on adopting the concept, definition, and categories of soil quality standards contained in this report. Cooperators in the NCSS have the technical expertise and experience to develop practical Soil quality standards that have a sound scientific basis. It is important that the NCSS assume a leadership role in this effort before other less qualified groups take the lead.

2. A national steering committee be formed to coordinate the effort. As suggested in this report, the steering committee should assign four interdisciplinary task groups to develop goal and objective statements, select soil properties and conditions, and define threshold values that might apply nationally for forestry, cropland, grazing, and soil environmental health

3. Charge 3 be dropped. Individual papers on this subject are being presented at a S-5/S-7 symposium on soil quality standards during the 1990 ASA meetings. A timely presentation from this task group was not possible.

Task Force on Interpreting and Documentation
Soils Changed by Management
for the
West Regional Technical Work Planning Conference
Fairbanks, Alaska
June 18-22, 1990

SUMMARY

Members

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H. Ikawa, Professor, University of Hawaii
Ronald R. Hoppes, State Soil Scientist, California
James A. Carley, State Sol Scientist, Washington
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William Johnson, Asst. State Soil Scientist, Arizona

Objective

Generally, soil interpretations have concentrated on the natural soil condition. However, a National Work Planning Committee identified four major areas in which management induces changes to soils that affect its use: (a) soils changed by crop management, (2) soils changed by irrigation, (c) soils changed by drastic disturbance, and (d) soils changed by drainage. Physical and chemical properties may change both temporally and permanently.

Our charge is as follows:

a. Construct a plan to handle use dependent temporal information at a level of detail significant to the major models for erosion, chemical amendment fate, etc..

b. Develop procedures or framework to document the soil physical and chemical changes or modifications that influence long-term soil behavior changes.

c.. Draft a section for the National Soils Handbook to improve documentation of management altered soils for both when soils are being mapped and for when changes occur after publication.

The task force committee is made up of 15 members with an additional 4 added by the chairman. From these 19 members, 7 responses were received. The following summarizes their comments and recommendations:

It was almost unanimously agreed that there should be some method devised that could serve as a tool for collecting temporal and permanent information about soils. There was also some concern that if soils were not treated as natural bodies and mapped as such, the polygons could become "straight-line" del ineations. Is this acceptable? For example, areas leveled for building pads on steep slopes, irrigated cropland where salinity has been reduced to almost zero adjacent to rangeland that is very strongly saline, and/or the cooling of soils when the vegetation has been removed (forested) could have mapped areas delineated along straight field or area boundaries, perhaps within a larger area with natural curved boundaries. Because of the many and varied types of changes that could occur, either temporally, permanent or both, it is impossible for this committee to cover them all, therefore, I am attaching a copy of the national task force committee report which did an outstanding Job of addressing many of the different situations that exist, but by no means all of them. This report discusses each particular situation in more detail. Hopefully, the data presented here will trigger newideas of how to respond to our task force charge.

1. Construct a plan to handle use dependent temporal information at a level of detail significant to the major models for erosion, chemical amendment fats, etc.

   a. One method would be to handle the information in the mapping unit description of the soil handbook. Since all of a mapping unit oreven all of one polygon of a mapping unit may not be affected by changes caused by management techniques or practices, the conditions that exist under natural state should be described. It can then be stated that if this natural condition is altered (land leveling leaving cut and fill areas, leaching of salts via irrigation, increasing pH by continuous additions of lime, etc.) then new conditions become of concern. For example, consider the following statements in a mapping unit description.

   "These soils are naturally very strongly saline throughout a 60 inch profile. However, when put into cropland and irrigated, the salinity level can be reduced from 50 mmhos conductivity to as low as 1 mmhos conductivity. This very low salinity can be maintained by proper irrigation water management. If management is neglected or if area is not cropped, the salinity levels can return to near its natural condition."

The concensus is that the West Texas program, described by the National Task Force, is good but it appears to be more research oriented.

2. Develop procedures or framework to document the soil physical and chemical changes or modifications that influence long-term soil behavior changes.

This is probably the heart of treating temporal and/or permanent changes as a result of management, and the easiest to overlook. We tend to record soil information at a specific point in time, without regard to whether it is temporary or permanent. If there is a method whereby the changes (alterations or disturbances) could be identified and recorded <u>and also</u> how the change(s) affect classification <u>and</u> use/management.

This could be accomplished by the use of a modified SCS-FORM 232 or some other form. The main thing is to develop a form to record the data - one that is simple yet complete. Attached are three examples (Exhibits A, B, and C) of a f that addresses this. These are certainly not complete but does represent a start. We suggest forms be prepared, similar to the attached examples, for use in collecting data. The form developed should be a companion to the current Pedon Description Program form. Exhibits D, E, and F are examples of completed forms.

3. Draft a section for the National Soils Handbook to improve documentation of management altered soils for botn when soils are being mapped and for when changes occur after publication.

The National Soil Survey Interpretations Staff has been working on this subject. The attached Exhibit G is a draft of one proposal to address this charge.

Exhibit A

US Department of Agriculture
Soil Conservation Service

SURFACE SOIL TEMPORAL DESCRIPTION

SOIL SERIES REPRESENTED	DATE MO DAY YR	SITE ID ST COUNTY UNIT	S U B	MLRA	LATITUDE DEG MIN SEC	D I R	SURVEY ID	MAP UNIT SYMBOL	NOTE ID	TRANSECT ID	FIELD ID	LAB SAMPLE NUMBER

% SLOPE	ASPECT DEG.	SLOPE SHAPE	SLOPE LENGTH FOINT	TEXTURE (fine earth)	% COARSE FRAG (whole soil)	ELEVATION	RAINFALL FACTOR "R" USLE	CLIMATIC FACT. "C" WEQ	WEATHER STATION NUMBER	PERCENT MOISTURE AT WILTING POINT

CLIMATIC FACTORS:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	UNITS/AVERAGES
MONTHLY MEAN TEMP (F.)													
MONTHLY MEAN PPT (IN.)													
DAYS OF RAIN (>0.10 IN.)													
PERCENT POSSIBLE SUNSHINE													
GROUND COVER FACTORS:													
VEGETATIVE TYPE													
PERCENT VEGETATIVE SHADE													
MANAGEMENT FACTORS:													
FIELD OPERATION													
RIDGE SHAPE/ORIENTATION													
RIDGE HEIGHT													
RIDGE SPACING													
IRRIGATION (IN.)													
RESIDUE (SMALL GRAIN EQUIV.)													
SOIL FEATURES:													
SOIL STRUCTURE													
SOIL PERMEABILITY													
"K" FACTOR (ERODIBILITY)													
CRUST RESISTANCE/THICKNESS													
SURFACE RESISTANCE (CALIBRATED):													
PERCENT E.T. VALUE/CHANGE													
PERCENT DESTRUCTION VALUE/CHANGE													
PERCENT SILT VALUE/CHANGE													

[redacted]

US Department of Agriculture
Soil Conservation Service

DRASTICALLY DISTURBED SOIL DESCRIPTION

PRE DISTURBANCE CONDITION:

FORMER SOIL SERIES		PEDON CLASSIFICATION: D SO GG SG PSC MIN D+ TMP OTH	% SLOPE	ASPECT DEG.	SLOPE ABOVE	LENGTH TOTAL	INITIALS
WATER TABLE DEPTH DAYS K D	VEGETATIVE TYPE	VEGETATION:					

POST DISTURBANCE CONDITION:

NEW SOIL SERIES		PEDON CLASSIFICATION: D SO GG SG PSC MIN AX TMP OTH	% SLOPE	ASPECT DEG.	SLOPE ABOVE	LENGTH TOTAL	INITIALS
WATER TABLE DEPTH DAYS K D	VEGETATIVE TYPE	VEGETATION:					

ACTIVITY OR AMENDMENT WHICH DRASTICALLY ALTERED SOIL:

CHEMICAL:
ACID SULPHUR ACID FORMING FERTILIZER GYPSUM LIME SLUDGE MANURE OTHER

IRRIGATION:
DEEP LEACHING OVER IRRIGATION UNDER IRRIGATION SALINE/SODIC WATER

DRAINAGE:
LOWER WATER TABLE RAISE WATER TABLE FLOOD PROTECTION FLOOD INDUCEMENT OTHER

MECHANICAL:
LAND LEVELING SOIL SHAPING SUBSOILING DEEP CUTS DEEP FILLS MINING OTHER

OTHER:

MAGNITUDE OF DISTURBANCE (type and amount):

WHAT WAS ALTERED?:

HOW DID DISTURBANCE AFFECT CLASSIFICATION?:

IF ACTIVITY CEASED, WOULD SOIL RETURN TO PRE DISTURBANCE CONDITIONS IN:

0-5 YEARS 5-25 YEARS 25-50 YEARS GREATER THAN 50 YEARS NEVER

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EXHIBIT

EXAMPLE

DATE:

SOIL NAME:

MAP UNIT NAME:

ACRES AFFECTED:

SITE LOCATION:

TYPE OF CHANGE OR MODIFICATION:

PHYSICAL:

CHEMICAL:

BIOCHEMICAL:

OTHER MODIFICATION:

SOIL PROPERTY CHANGER:

DOCUMENTATION OF EFFECTS:

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL DESCRIPTION

SILNAC

SOIL SERIES REPRESENTED	DATE MO DAY YR	SITE ID ST COUNTY UNIT	SUB	MLRA	LATITUDE DEG MIN SEC	LONGITUDE DEG MIN SEC
ELEVIN (P)	11 15 89	12		41-3	31 9 5	114 0

SURVEY AREA ID	MAP UNIT SYMBOL	NOTE ID	TRANSECT ID	YIELD ID	PHOTO NUMBER	LAB SAMPLE NUMBER	DESC TYPE	PEDON TYPE	CORRELATED NAME
703	520		1		03 1 3 1		P D	M D	

SHP	SLOPE ASP DEG	SLOPE LENGTH ABOVE	TOTAL	MICRO	PHYS MAJ	LOC	PEDON CLASSIFICATION O SO	GG	SG	PSC	MIN	TMP
2 0 1 1	3			5	C F		D	A A	P A	US 08	0 5 6	3 7	1 8

PRECIP	WATERTABLE DEPTH	DAYS	LU	ST	HC	DR	ELEVATION	PARENT MATERIAL 1 W B M ORIG	2	3	4
			P			5	3 1 8 0	A V O			

TEMPERATURES °C AVERAGE AIR ANN	SUM	WINTER	AVERAGE SOIL ANN	SUM	WINTER	MST RGE	WEATHER STATION NO	CONTROL SECTION PSC	
						AR		001 020	5

DIAGNOSTIC FEATURES

DEPTH	KIND	DEPTH	KIND	DEPTH	KIND	DEPTH	KIND	DEPTH	KIND	FLOODING FRQ MO DAYS	PONDING
0 0 6 0	T O 1	5 0 3 2	C	0 0 0 1 6	M						N 01

VEGETATION SPECIES

1	2	3	4	5
6	7	8	9	10

GEOGRAPHICALLY ASSOCIATED SOILS

1	2
3	4

DESCRIBERS NAMES

LOCATION DESCRIPTION

PHOTO - 03 - 31

NOTES

SELEVIN TYPE

USTOLLIC PALEARGID

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	DEPTH UPPER	DEPTH LOWER	HORIZON DESIGNATION	DRY COLOR HUE	VAL	CHR	MOIST COLOR HUE	VAL	CHR	TEXTURE CLASS	MOD
1	000	001	A	5YR	4	4	5Y	3	3	SIL	GR
2	001	016	Bt1	5YR	3	4	5YR	3	4	SICL	GR
3	016	032	Btk12	5YR	4	4	5YR	3	4	SICL	GR
4	032	060	Btk13	7.5YR	4	4	7.5YR	7	4	SL	GR
5											
6											
7											
8											
9											
10											

FREE FORM NOTES

	Sand	Silt	Clay	
0-½	71.5	17	11.5	SL
½-16	48	12	40	SC
16-32	68	3	23	SCL
32-60	72	11	17	SL

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Horizon	Structure SZ	Structure SHP	Consistence a) Dry / b) Moist / c) Other	a) ST / b) PL	CEM	RUP RES (a) / PENT RES (b)	Mottles (AB, SZ, CON, HUE, VAL, CHR)	Surface features KND	AB	CY	DST	LOC	HUE	VAL	CHR	Boundary
1	TN	PL	a) SL b) VFR	a) SO b) PO												AS
2	M / M	PR / SBK	a) SH b) FI	a) VS b) VP				A / A	3 / 3	C / C	D / D	LS / F				GW
3		MA	a) SH b) FR	a) S b) A				A / L	1 / 3	D / C	D / D	LS / S				GW
4		MA	a) H b) FR	a) S b) A				L	3	C	D	S				
5																
6																
7																
8																
9																
10																

FREE FORM NOTES

CaCO3 %

5 %

11 %

25 %

EFFERVESCENCE CL / AG / EX	FIELD MEASURED PROPERTIES KND	AMOUNT	FIELD MEASURED PROPERTIES KND	AMOUNT	WETNESS	HYDRO COND	ROOTS QT	SZ	LOC	PORES SHP	QT	SZ	CN	CONCENTRATIONS KND	QT	SHP	SZ	ROCK FRAGMENTS KND	%	RND	SZ	ROCK FRAGMENTS KND	%	RND	SZ
2 I	PC	72					3	11	T	IT	3	11						Y	65		1				
2 I	PC	72					2 / 3	23 / 2	T / T	TU	2	11						Y	410		1				
2 I	PC	78					3 / 2	12 / 13	T / T	TU	2	11						Y	615		1				
3 I	PC	82					1	11	T	IT	3	11		K3	2	2	2	Y	6 ⁻		1				

FREE FORM NOTES

US Department of Agriculture
Soil Conservation Service

SURFACE SOIL TEMPORAL DESCRIPTION

HW

SOIL SERIES REPRESENTED	DATE MO DAY YR	SITE ID ST COUNTY UNIT	S U B	MLRA	LATITUDE DEG MIN SEC	D I R	SURVEY ID	MAP UNIT SYMBOL	NOTE ID	TRANSECT ID	YIELD ID	LAB SAMPLE NUMBER
SELEVIN (P)	4-6-90	AZ 019		41-3	31-49-55	N	703	520		1		

% SLOPE	ASPECT DEG.	SLOPE LENGTH ABOVE	SLOPE LENGTH TOTAL	TEXTURE (fine earth)	% COARSE FRAG (whole soil)	ELEVATION	RAINFALL FACTOR "R" USLE	CLIMATIC FACT. "C" WEQ	WEATHER STATION NUMBER	PERCENT MOISTURE AT WILTING POINT
20	315	50	60	SC	65	3180	75	80	7619	* 18

CLIMATIC FACTORS:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS/AVERAGES
MONTHLY MEAN TEMP (F.)	48.8	51.1	54.7	61.4	68.5	76.9	80.7	78.2	74.8	66.7	57.0	49.7	64.0
MONTHLY MEAN PPT (IN.)	1.22	.99	.69	.27	.11	.24	3.96	3.70	1.95	.57	.98	2.29	16.87
DAYS OF RAIN (0.10 IN.)	3	2	2	1	0	0	7	7	4	1	2	4	33
PERCENT POSSIBLE SUNSHINE	75	85	85	90	95	95	80	85	90	90	90	80	87%

ABOVE GROUND FACTORS:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS/AVERAGES
VEGETATIVE TYPE	06	——									——	→	06
PERCENT VEGETATIVE SHADE	15E	16E	15E	20E	25E	30E	30E	30E	30E	25E	20M	15E	22.5% AV. 6E%

MANAGEMENT FACTORS:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS/AVERAGES
FIELD OPERATION	0	——											→
RIDGE SHAPE/ORIENTATION													
RIDGE HEIGHT													
RIDGE SPACING													
IRRIGATION (IN.)	0	——											→
RESIDUE (SMALL GRAIN EQUIV.)	100E	100E	< 50	——							→ 100E	100E	50 # AV.

SOIL FEATURES:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS/AVERAGES
SOIL STRUCTURE	4	——										→	4
SOIL PERMEABILITY	5	5	4	4	3	3	4	4	3	3	4	6	4 AV.
"I" FACTOR (WEQ)	.04	.02	.04	.04	.05	.08	.03	.04	.05	.08	.04	.02	.04 or I=4
CRUST RESISTANCE/THICKNESS	04/20	02/20	04/20	04/20	04/20	05/20	03/20	04/20	04/20	05/20	04/20	03/20	
SURFACE REFLECTANCE (MUNSELL):													
PERCENT C.C. VALUE/CHROMA	70 6/4	——											70 6/4
PERCENT RESIDUE VALUE/CHROMA	10 7/3	10 7/3	10 7/3	5 6/2	0	0	0	0	0	5 4/3	10 4/3	10 7/3	5% 6.4/2.7
PERCENT SOIL VALUE/CHROMA	20 3/3	20 3/3	20 3/3	25 3/3	30 4/4	30 4/4	30 3/3	30 3/3	30 4/4	25 4/4	20 4/4	20 3/3	25% 3.4/3.4 } 5.4/3

K? ... Av. Annual Val.

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EXHIBIT F

US Department of Agriculture
Soil Conservation Service

DRASTICALLY DISTURBED SOIL DESCRIPTION

PRE-DISTURBANCE CONDITION:

FORMER SOIL SERIES	PEDON CLASSIFICATION (O SO GG SG PSC MIN RX TMP DTH)	% SLOPE	ASPECT DEG.	SLOPE ABOVE	LENGTH TOTAL	INITIALS
SELEVIN (P)	PIARIPAIUS ∅8105.61371 . 1181 .	20	315	50	60	ccc

WATER TABLE DEPTH DAYS K D	VEGETATIVE TYPE	VEGETATION
—	06	curly mesquite, brittlebush, paloverde, ocotillo, lisium, catclaw, false mesquite, prickly pear, cholla

POST DISTURBANCE CONDITION:

NEW SOIL SERIES	PEDON CLASSIFICATION (O SO GG SG PSC MIN RX TMP DTH)	% SLOPE	ASPECT DEG.	SLOPE ABOVE	LENGTH TOTAL	INITIALS
______	EIORTOIXE∅4105∅34∅41181 .	1	0	50	60	ccc

WATER TABLE DEPTH DAYS K D	VEGETATIVE TYPE	VEGETATION
—	10	prickly pear cholla

ACTIVITY OR AMENDMENT WHICH DRASTICALLY ALTERED SOIL:

CHEMICAL:
__ACID __SULPHUR __ACID FORMING FERTILIZER GYPSUM __LIME SLUDGE MANURE __OTHER

IRRIGATION:
__DEEP LEACHING (lower water table) __OVER IRRIGATION (increase salinity) UNDER IRRIGATION __SALINE/SODIC WATER (increase salinity/sodicity)

DRAINAGE:
__LOWER WATER TABLE __RAISE WATER TABLE __FLOOD PROTECTION __FLOOD INDUCEMENT __OTHER

MECHANICAL:
X LAND LEVELING __SOIL SHAPPING __SUBSOILING X DEEP CUTS __DEEP FILLS __MINING OT lit n

OTHER:

MAGNITUDE OF DISTURBANCE (type and amount):
cut slope for Housing foundati..

WHAT WAS ALTERED?:
Argillic removED, slope changed, Hydrologic Group C to B, less runoff

HOW DID DISTURBANCE AFFECT CLASSIFICATION?:
change from Clayey-skeletal Paleargids to Loamy-skeletal Torriorthents

IF ACTIVITY CEASED WOULD SOIL RETURN TO PREDISTURBANCE CONDITIONS IN:
__0-5 YEARS 5-25 YEARS 25-50 YEARS GREATER THAN 50 YEARS X NEVER

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EXHIBIT G

DRAFT 3/5/90
WDB, BA

602.04 Maintenance

(a) The State Conservationist (or appropriate official in SCS) is responsible for the accuracy and quality of soil survey information that is provided to users from field office technical guides (FOTG), state soil survey databases, or soil survey reports.

(b) Published soil survey information may be revised, or new information added to section II of the FOTG and the computerized state soil survey database based on user need and demand.

602.04 1 General

Published soil survey information in the form of maps, interpretations and text may be adjusted after publication. The adjusted information is based on need for the revised information and the demand to develop new information. The Soil Conservation Service (SCS) along with other cooperators in the National Cooperative Soil Survey (NCSS) is responsible for dispensing reliable and useful soil survey information. The published information is adjusted or new information is developed because of a change in user needs, management induced change, change in mapping concepts, inconsistencies in previous mapping; or changes in expected roil behavior. Soil survey information is part of the technical assistance given to soil conservation district cooperators and as such should be reliable and useful.

(a) Soil survey maps. Section II of the FOTG contains the original file copy of the published soil survey maps. Pencil changes are noted on this copy depicting areas adjusted due to mapping inadequacy, areas altered by disturbance after publication that now behave differently, or areas that have changed because of program emphasis or need.

(b) New data needs. Temporal data, statistical information about contents of map units, representative values of soils, and soil potentials for localized use that are needed by modelers, GIS specialists, local units of government and others are developed through approval of the state soil scientist and by direction of the National Soil Survey Quality Assurance Staff. Material developed and approved is filed in the appropriate section of FOTG.

EXHIBIT 6 (CONT)

(c) Current data needs. Surveys not meeting todays user needs should be identified through periodic technical review. Interpretive tables need to be regenerated where interpretive criteria has changed. Where soils are renamed, soil survey update and approval procedures should be followed [NSH 601.03].

Areas of management altered soils, such as ripping of hardpans or terracing that change the behavior of soils for the life of the survey should be documented and new interpretations assigned by the state office after technical review. Revised or new information is filed in the appropriate section of the FOTG or referenced to the computerized soil survey database.

602.04-2 Quality control and review.

The state soil scientist periodically reviews maps, interpretations, and text in Section II of FOTG to maintain quality control. Section II of the FOTG is the official file copy of the soil survey publication.

Task Force Report on Interpreting and Documenting Soils Changed By Management

for the

Cooperative Soil Survey Conference
Lincoln, Nebraska
July 24-28. 1989

<u>MEMBERS:</u>

- W.D. Broderson, Soil Scientist, NSSIT, NSSC. SCS, Lincoln, Nebraska
- I. J. Jansen, Professor. University of Illinois
- J. C. Sencindiver, Associate Professor. West Virginia University
- K. K. Huffman, State Soil Scientist. Ohio
- D. J. Lytle, State Soil Scientist, Maine
- G. Chalfant, Soil Scientist, Forest Service. Winchester. Kentucky
- T. 0. Cook. Soil Management Specialist, SCS. Washington, DC
- D. S. Fanning, Prcfessot, University of Maryland
- C. E. Kelly, State Soil Scientist. Kentucky
- B. A. Buchannan, Associate Professor. New Mexico State University
- R. J. Southard, Associate Professor. University of California at Davis

<u>OBJECTIVES</u>

The charge put forth to this task force was to present the best ideas, thoughts. concerns and possible directions that would be useful in guiding soil survey in the years ahead. Comments and recommendations are designed to assist in the planning and implementation process by creating awareness. supporting allocations and appropriations. maintaining the solid foundation of our science, and improving the innovative and creative ways of bringing our knowledge to chose who need it and are able to effectively utilize it in making wise use of our resources.

I. Soils Changed by crop management

A. Erosion or overwash effects.

All too commonly discussion of erosion effects on soils doesn't get much beyond concluding that erosion is bad. Erosion is undesirable. and control thereof should always be a priority. but we must also evaluate kind and degree of erosion effects much more thoroughly than has bee." the practice.

Resource use potential is a function of what is left rather than how it came to be so. How I: came to be so is relevant to understanding how current soils relate to each other and to understanding what will happen to other soils if allowed to erode. Hence let's be diligent to retain the conceptual relationship between eroded and uneroded soils which were once much alike, but focus on what is left when attempting to evaluate and manage the eroded soil, rather than just on the fact that it is eroded.

Consider. at one extreme. a soil which in its undamaged state has a high quality A horizon underlain by a" adverse B horizon. A" example would be the Clarence soils (Aquic Argiudolls; fine. illitic. mesic) of east central Illinois. Clarence typically has a silty clay loam surface rich in organic matter. underlain by a silty clay B horizon (average clay content of the control section is 50 to 60 percent). When Clarence erodes, not only do you loose a high quality A horizon. but the underlying B horizon material is so high in clay that the soil is no longer suitable for row crop agriculture once the A horizon is gone. The damaged soil is not rebuildable under current technology. short of hauling new topsoil in.

The on-site consequences of erosion are quite different from the above on soils like Fayette series (Typic Hapludalfs: fine-silty, mixed, mesic). Fayette has a rather mediocre silt loam surface, relatively low in organic matter and a silty clay loam B horizon. The Fayette A horizon is worth trying to save, but the consequences of losing it are not nearly as serious as losing the Clarence A. Exposure of the Fayette B horizon to the surface through erosion will degrade the tilth and make management somewhat more difficult than on the uneroded Fayerte. Even when all of the A horizon is gone. however, one is still left uith a quality soil. Erosion does damage Fayette. but unlike eroded Clarence. eroded Fayerte will still be a productive soil which can be improved over time through careful management.

Many soils fall somewhere between those two extremes in terms of the way they are affected by erosion. In all cases erosion control must be 3 priority concern. both because of effects on the soil and because of off-site effects. Different control strategies might be appropriate for the above two soils, however. and more attention to the way in which individual soils are affected by erosion will put conservationists in a position to devise the most effective strategy for each site.

Chris Smith remarked that we need to mention and officially acknowledge that erosion is not always negative as far as on-site considerations are concerned. Off-site is another matter. We must define why we are concerned with erosion in our discussions.

Similar principles apply for the effects of overwash. Overwash which is high quality material might not detract from and could even improve soils, though it might destroy the crop which is there at the time the overwash is delivered and render the area temporarily incapable of supporting machine traffic. Low quality overwash, such as excessively sandy materials. would degrade any soil whose properties were superior to that of the overwash.

B. Changes in soil physical properties.

1. Compaction due to tillage and machine traffic.

2. Effects of cropping on soil structure. There seems to be a need to identify under what conditions soil properties exist. Example - bulk density, organic matter. etc. should be tied to cropping systems.

C. Changes in soil chemical and biochemical properties.

1. Effects of tillage and cropping.

Warren Lynn remarked that pH changes the suite of organisms that populate the soil. Clearing and cultural practices change soil layer organism populations, ie. earth worms, fungi and bacterial population changes.

2. Effects of liming and fertilizer usage on chemical properties.

Del Fanning reports that liming is causing conversion of some Ultisols to Alfisols, which he refers to as cultural Alfisols.1 Some Dystrochrepts are also being converted to Eutrochrepts.

Dave Lewis reports that additions of NH_4^+ based fertilizer is lowering pH levels in Nebraska soils. Calcareous zones have also moved into deeper layers This has also been identified in Oklahoma and needs to be looked at a little more. The idea of reclassifying those areas has bee" considered. but nor done at present.

Chris Smith remarked that permanent changes snould be handled at higher levels f taxonomy. and transient levels as a map unit phase.

3. The crop removal factor.

Increase of saline/alkali soils in Montana and ND seem to be in areas where fallowed land exists. Irrigation may decrease this salinity.

D Subsidence of organic soils caused by drainage and cropping.

Aeration resulting from drainage and tillage of organic soils for crop production accelerates decomposition of organic matter. The resulting shrinkage can lover the surface to where the drainage system must be deepened, and can deplete the organic soil where it is relatively thin over mineral material. The rate of shrinkage can be reduced by periodic flooding, or by carefully maintaining the water table at the minimum depth needed for each time period.

Subsidence in other soils where the dissolution of gypsum. carbonate and the melting of ice lenses occur is of major importance to recognize.

E Management related temporal properties.

Bob Grossman argues for the need to construct a plan to handle use-dependent temporal information at a level of detail significant to the major models for erosion. chemical amendment fate, etc. Should these characteristics be modeled from invariant properties to the exclusion of measurement and generalization of these measurements in standard soil survey output? We have measurement procedures for crust. roughness. cover, etc. Bulk density of the tillage zone changes through the cropping season. Grossman and Pringle have reported on a program in West Texas that provides much more information on bulk density and other quantities.

A well developed use-dependent temporal data system could reduce the variability commonly associate with individual soils by separating out the effects of season and management. Soil property values relevant to a particular process or problem could be derived for the particular time and use conditions appropriate. In summary. the idea is to confine data to specified time and use conditions in order to enable greater specificity.

G. Surface horizon thickening or organic matter enrichment by long-term agriculture.

How many cultivated soils in the US and elsewhere have anthropic epipedons! How should they be classified. Del Fanning suggests that they should be placed in Mollisols, though they are now excluded

The classification of Anthropic epipedons as Mollisols should be made only if other soil properties classify as Mollisol. John Whitty remarked that the Anthropic epipedon definition in Soil Taxonomy is not correct. It was suggested that the P factor of 250ppm is off by a factor of 10 or so, but that no data exists to determine what the levels should be. Anthropic epipedons could apply to areas where sludge and chicken manure are added.

Ii. Soils changed by irrigation.

A. Cut and fill effects of grading and leveling are considered under disturbed soils.

B. Chemical and physical effects related to quality of irrigation water.

1. Accumulation of soluble salts.
2. Elevated pH and consequent micronutrient effects.
3. Dispersion of soil clays.

C. Irrigation related soil profile modification.

1. Translocation of soil constituents by irrigation water.
2. Irrigation induced organic matter enrichment.

D. Wind erosion damage on irrigated soils

E. Effects on soils of flooding for rice production (Contributed by Dr. Ii. Don Scott. University of Arkansas)

Flooding of soil results in changes in several soil physical, chemical and microbiological properties that influence the quality of a soil es a medium for plant growth. The nature. pattern, and extent of the changes depends on the physical and chemical properties of the soil and the duration of submergence. Flooded or waterlogged soils have high water contents, and as a result. have restricted gas exchange between the soil and the atmosphere. The amounts of oxygen and nitrogen in soil ace roughly inversely proportional to the soil water content on a volume basis, and thus, waterlogged soils are characterized by the absence or near absence of oxygen and nitrogen. Flooding, thus restricts soil aeration. resulting in depressed oxygen and nitrogen availability to plant roots and soil microorganisms.

Under flooded conditions in the field, oxygen and nitrogen are gradually reduced by downward transport in the soil profile with the moving water. upward movement through bubbles, and by extraction by plant roots. nodules and soil microorganisms. If the soil contains sufficient organic matter and is microbiologically active, waterlogging will be followed by the disappearance of oxygen and the reduction of the soil. The rate of reduction is directly related to the amount of fresh organic matter present. soil temperature. microorganism and plant root activity, soil chemical status, and the duration of the flooded condition. Oxygen diffusing into a flooded soil may be consumed as a result of (i) microbial respiration where it is used as an electron acceptor. (ii) chemical oxidation of reduced ions such as Fe and Mn, (iii) biological oxidation of NH_4 and carbon, and (v) oxidation of sulfides. Given sufficient flood duration these processes result in the development of an oxidized layer at the soil surface. The thickness of this layer represents a balance between oxygen diffusion into the soil and its consumption chemically and biochemically.

Flooding also affect: the thermal properties of the soil. Saturated soil has higher albedo values. heat capacities. thermal conductivities and thermal diffusivities. Usually wet soils are cooler than dry soils which impacts the rates of gaseous transport.

chemical and biochemical changes. release of nutrients, production of physiologically active organic compounds. and plant growth.

Prolonged flooding destroys soil structure by disrupting the aggregates. The breakdown of aggregates is a result of reduction in cohesion with the increase 1" water content. deflocculation of clay as a result of dilution of the soil solution, pressure of entrapped air. stresses caused by uneven swelling, and destruction of cementing agents. Flooding decreases water movement in soils of low permeability because of dispersion of soil particles, swelling aggregate destruction, and perhaps clogging of pores by microbial slime. In nonswelling soils, flooding increases internal drainage by increasing hydraulic conductivity. Flooded soils are characterized by increased concentrations in the soil solution of reduced ions such as Fe^{2+}, Mn^{2+}, NH_4^+, and SZ-. These ions subsequently become more available for plant uptake. The physical-chemical status of a flooded soil system has been characterized by the oxidation-reduction potential (Eh) which is a measure of the electron availability. Values of Eh are dependent on soil properties such as pH, Fe and Mn content. and previous history of anaerobiosis. In general, reduction increases as Eh decreased. However, due to the complexities of soils. the relation between Eh and elemental concentration is not unique.

Frequently. under anaerobic conditions organic substrates are not decomposed completely to carbon dioxide. Incompletely oxidized intermediate and end products can. therefore, accumulate in waterlogged soils. These compounds, which include lactic acid, ethylene. ethanol, acetaldehyde and aliphatic acids. may be present in abnormally high concentrations under anaerobic conditions and may affect plant growth.

Warren Lynn added that wetland rice cultural practices internationally and domestically may differ. An international soil correlation meeting to be held in Louisiana and Texas will be scheduled in 1990.

III. Soils changed by drastic disturbance.

A. Deep ripping or plowing.

Various forms of deep tillage have been practiced on extensive areas in some regions. The effects ore in some instances primarily disruption, temporary or permanent, of soil horizons, such as duripans. Varying amounts of mixing of material among horizons is also likely. and in some instances the mixing is such that diagnostic horizons are obliterated.

Soil performance effects.

Taxonomic significance.

The 1967 NTWPC in New Orleans recommended that:

Soils with original diagnostic. horizons mixed by ripping, deep plowing. etc., sufficiently to destroy the original normal sequence. but not to the extent that the fragments or parts of the horizons can no longer be identified, will be classified in the suborder Arents of the order, Entisols.

1. The soils are to be recognized as Named soils and classified with existing or new series.

2. Naming of mapping units will follow conventions presently in use.

3. The position of fragments of diagnostic horizons within the soil profile and the nature of these fragments should be considered as criteria for soil series.

4. The geographic extent of Arents is to be limited to the areas where disturbance or mixing originally occurs.

B. Cuts and fills related to field leveling or construction.

(The following draws heavily on Terry Cook's comments).

On fairly level lands on the West Coast. extensive areas have been leveled using laser equipment to establish dead flat fields. Wet basin land areas originally having native salt grass species and wet land vegetation has been drained. reclaimed, and individual fields leveled; leaving chick cut and fill areas. These soils today are not salty and have been completely reshaped from their native state.

In moderately to strongly sloping O-15 or 20%) extensive areas with abrupt argillic horizons. duripans. etc.. within a depth of 40 inches. have been leveled to <1% slopes. The results are O-15 foot cuts at one end of a field. possibly only minor alteration in the center. and up to >15 foot fills at the other end of the field. When duripans have been destroyed, removed, and deposited over extensive areas: the classification. interpretations. and use and management that have been used in the past ace irrelevant. New criteria need to be developed to furnish the user of soil survey information with adequate data to provide proper planning alternatives.

Another part of 'shaped soils' are those areas of soils on slopes of >15% up to >50% that are cut and filled for **housing pads.** These areas have been cut to several feet into the bedrock or consolidated material and then filled to make level pads for building sites. This practice takes place in other countries as they cut terraces on very Steep slopes to grow local crops. such as, rice. beans, cassava, etc. As an example. **much** of the island of Java in Indonesia has been manipulated by terracing. The description of the soils. criteria for interpretations. and soil behavior is totally different than 'old traditional' methods or procedures.

Construction related cuts and fills **produce** conditions very similar to those following strip mining. where similar geologic materials **end** up exposed to the surface.

Soil performance effects.

Taxonomic significance

The 1967 NTWPC in New Orleans recommended that:

Shaped soils should be considered as phases of soil taxonomic units resulting from smoothing, leveling, and grading in which:

A Diagnostic horizons required within pedons have not been destroyed or interrupted. or

B. Diagnostic horizons have not been buried to depths of more than 20 inches.

The use of shaped phases of soils. because of present standards and criteria for soil classification, will therefore be limited in most instances to the soils in orders in which smoothing, grading, or leveling operations are not apt to destroy features diagnostic for any of the soils involved in more than 50 percent of the area under consideration.

For materials consisting of mechanical mixtures of sola and parent materials from soils without discernible fragments of diagnostic horizons, and artificial fills with no diagnostic horizons or buried diagnostic horizons if they are buried deeper than 20 inches. or if they are buried to depths between 12 and 20 inches and the thickness of the buried solum is less than half the thickness of the overlying deposits. they recommend:

...be classified in the Fluvent and Orthent suborders of the order Entisols.

A. The soils are to be recognized as Named soils and classified with existing or new soil series if characteristics enable classification at this level of the system.

B. Naming of mapping units will follow conventions presently in use.

The 1967 committee recommended excluding hauled (moved) materials from Arents, but did nor specifically provide a place for those which may have 'discernible fragments of diagnostic horizons.'

The 1969 committee meeting in Charleston, South Carolina, basically confirmed the position of the 1967 committee, but added that heterogenous earthy material with a wide range of texture and/or other characteristics, from cut and fill or other operations. be treated as a miscellaneous land type lather than attempting to classify them.

C. Landfills.

Land fills have some similarities to construction fills and mine soils. but differ because of the buried refuse. Decomposition of the refuse Over rime commonly causes differential settlement at rhe surface. Seepage from the fills is also commonly contaminated by materials from the refuse. Generation of volatile gases is common on these sites and causes an explosion hazard in any structures built on them which can crap those gases.

D. Land construction with dredged materials or land exposure through diking and drainage.

Soils built by extending the land with dredged sediments commonly have a high n-value and consequent lov bearing strength. Marine sediments might also develop sulfuric horizons unless precautions are taken to prevent that.

The Dutch have been highly successful in exposing new land for productive agriculture through diking and drainage.

E. Surface mining and reclamation

a. Coal

b. Other minerals, clay. topsoil, sand/gravel. limestone. and shale.

Characteristics of reclaimed land are more a function of reclamation practices and available materials for soil construction than of the mineral being mined. There are rather considerable differences in Illinois between reclaimed coal strip mine lands and reclaimed limestone quarry lands. but those differences are almost totally a result of differences in the applicable reclamation laws.

The first step in evaluating. interpreting, or documenting minesoils regardless of the mineral being mined is LO begin with thorough premining analyses of the soil and rock overburden. Knowledge of premining soil series and geology including lithology, mineralogy, and geochemistry will he in the prediction of minesoil properties and evaluation of land use suitability. Richard M Smith has written extensively on this subject. Overburden analyses will help to determine if the original topsoil should be saved or if a better substitute is available. A horizons are thin in Appalachian coal fields and are commonly removed in the forest clearing operations in preparation for mining. Then the -topsoil' which is stockpiled and saved is actualiy B and C horizons and some Cc materials.

F. Chemical soil problems

1. Toxic materials.

John Sencindiver points out chat mining may expose pyritic materials which develop acidity upon weathering. These acid products become **acid mine drainage (AMD) when leached by precipitation.** AMD is the biggest environmental problem faced by the coal industry in West Virginia and much of Appalachia. Establishment of vegetation is generally no longer a problem. Acid minesoils and poor vegetation establishment occur on only a very small proportion of the mine sites, today. uhen these acid problems do occur. they generally only affect a small portion of any site. operators are required by law to bury **and/or** treat acid materials and most are doing a good job of this.

Well-vegetated sites may still have a major MD problem. and many studies have been conducted on this problem. Bactericides have been used to control the Thiobacillus organisms, but these treatments are generally short-lived. Clay seals and synthetic (PVC) seals over acid materials have been cried. Clay seals may leak if not applied properly and PVC liners are very expensive.

The most promising treatment currently being studied in West Virginia is rock phosphate. WVU professors in geology and chemical engineering have been studying this treatment process for several years. They are now in the process of establishing some scale model backfill piles on surface mines where different rates of rock phosphate will be applied. The phosphate in the rock phosphate reacts with ferric iron in the system and removes this iron so that it is not available to oxidize pyrite. Removal of Fe **drastically reduces pyrite oxidation.**

2. Base rich soil materials.
   a. Hign calcium soil materials.
   b. Soil materials high in gypsum
   c. Sodic soil materials.
   d. Saline sail materials.

3. Managing soil fertility.

G. Soil physical problems.

Physical properties of minesoils always vary from those of the pre-mine soils, and properties of topsoiled minesoils differ from those which were not topsoiled.3,4,5 Hnottavange and Sencindiver have reported changes in the pore-size distribution when soils are disturbed.6 Minesoil macropores drained by gravity flow were 57% (by volume) less than macropores of the native soils. Also, microporosity (1000-90um) was 352 less for the minesoils.

Extreme textures. excessively sandy or clayey, and excessive rock fragments can be controlled by careful selection of suitable materials for soil construction, where suitable materials are available. It is generally safe to assume materials available from the pre-mine soils will assure that the constructed soil can be as good texturally as the original soil. Alternative materials in the overburden might be as good or better. texturally. than those of the natural soil. Similar principles apply where the concern is duripan. petrocalcic, or ironstone materials.

Physical problems associated vith dispersed clay are a consequence of the chemical nature of the materials used in soil construction. Again, material selection is the key. where non-sodic materials are available. Some related problems might not be avoidable. For example, even when sodic materials are carefully segregated and buried in the substratum. piping might become a problem as water moves through and mobilizes dispersed clay from the sodic layers.

The other. and perhaps most challenging. physical problem is structural in nature. It is a combination of high bulk density/low porosity, high soil strength, and lack of a macropore network. It results from lack of or disruption of natural soil structure and either severe compaction of the materials during soil construction. or failure to disrupt masses of high-strength. high-bulk density material from deep in the over burden as it is being moved and placed in the new soil.

Work in Illinois and elsewhere has made IL clear that natural soil structure is no: essential for a soil to be productive, so long as modest soil strength and an adequate macropore network can be established artificially. Such is nor easily accomplished. however.
The most conspicuous success in Illinois is where a mine has dug material from the highwall with a bucket-wheel excavator, transported it around the pit by belt, and placed in with a spreader which was able to control placement such that only minimal smoothing was needed after placement. The resulting soil commonly has an artificial

(fritted) structure and has proven to be productive for row crops.7

The equipment used at that mine is so inflexible. chat it is nor likely to be used for a significant portion of acreage mined, and hence is not an adequate solution to the problem. There is reason to believe. however, that similar results can be accomplished with well planned rear-dump truck handling system. Truck traffic should be confined to the base level to avoid compaction of soil material after placemenc.8

The other alternative is to alleviate compaction through some form of deep tillage after the new soil is in place. The problem with this approach is the depth to which treatment is necessary. Many options are available for loosening soils through tillage to a depth of 45 cm or so. There are a few tillage options which have proven successful to 90cm, but natural soils in the central corn belt commonly support root systems down to 120cm or 150cm.

Early attempts to till to more than 100cm in these soils were not very successful. At those depths one tended to get plastic flow around the tillage instrument and no significant physical improvement of the soil. A recently designed machine looks quite promising for tillage to about 120cm. It employs a tvo-lift tillage approach and imparts a very considerable vertical lift component to the lower soil materials. Field crop productivity experiments are underway in Illinois to evaluate several available tillage options. Early results look promising, but it is certainly too early to conclude that the problem has been solved.

H. Slope stability on reclaimed soils.

1. Erosion

2. Mass movement.

Glenn Kelley reports that most spoil material will eventually move down slope if i: is placed on slopes of 20 to '5 percent or greater, particularly when spoil is placed on outslopes with little toe-slope support.

3. Importance of soil materials on slope % and length (grouping guidelines needed). Slope length should be kept to a minimum, but often difficult co get operators to understand this.

Management techniques

1. Cropping sequence/rotation.

Keith Huffman suggests that quick-catch cover crops be seeded immediately to stabilize slopes against erosion. Rye works well for this purpose in Ohio. Introduction of deep rooted legumes will then enhance soil structure development and provide for infiltration and improved air/water relationships. A seeding mixture should be selected to fit the site and the planned use.9 A time of two to three years should be devoted to low intensity use with no or minimal harvesting of hay or pasturing.

2. Hybrid or variety selection.

Hybrid screening studies have revealed that those hybrids which perform best on natural soils do not necessarily perform best on minesoils. No hybrid has been found. however. which will adequately tolerated the physical and chemical problems common to many minesoils.

3. Identifying fertility needs.

4. Dealing with 'hoc spots.'

5. Residue management.

J. Classification of disturbed soils.

John Sencindiver contends chat classification of minesoils needs further study and evaluation. Host minesoils in eastern U.S. have been classified as Typic Udorthents. Seven minesoil series have been developed in West Virginia and others originating in surrounding stares are recognized in West Virginia. All of these series are loamy-Skeletal. mixed, mesic Typic Udorthents. The only difference in classification of the series at the family level comes at the soil reaction category. These minesoils are acid, nonacid, or calcareous. John contends that we need some means of identifying minesoils at a classification level higher than series. For example. Janelew silt loam. loamy-skeletal. mixed. calcareous. mesic Typic Udorthent does not tell the reader that Janelew is a minesoil. One must read the description of Janelew to determine that. A new term such as Spolents, Spolic Udorthents, or some other term would assist in documenting and interpreting minesoils.

Illinois initially classified a couple of minesoil series as Arents, because of the presence of identifiable fragments of diagnostic horizons from the pre-mine soil. Those fragments did represent a fairly small portion of the total soil volume and the regional correlators at the time argued for reclassifying them as Orthents. They wanted to use Arents only when the fragments of diagnostic horizons were at least 20% by volume. That didn't seem like a very big issue to us at the time so we agreed. It became a much bigger issue, however, when a year or two later we were asked (by regional correlators) to delete all reference to fragments of diagnostic horizons in soil descriptions for a publication (or change the classification), because Orthents weren't supposed to have any. The more contentious among us argue that we either need to abide by the class criteria and classify all soils with such fragments as Arents, or change the criteria so that some minimum **percent by** volume is officially part of the class concept. A third alternative is to follow John's suggestion above and set up a new **suborder** for drastically disturbed soils. **Above** all, we should be free to describe the soils as we find them, rather to make them fit a predetermined class concept.

The concern over how to handle Arents is not new. The committee on criteria for classification and nomenclature of **made soils at the National** Technical Work-Planning Conference in New Orleans in 1967 recommended that

> "**the** recognition of Arents be confined to soils mixed in place so that fragments of a diagnostic horizon transported by dump truck to a new area would not be the basis for the recognition of Arents in the new site. In addition, a significant number of fragments of a diagnostic horizon should be present to justify the classification of Arent."

The definition of Arents was never adjusted to provide for those suggestions, but the above recommendation might well have been behind the 20% rule-of-Thumb. Perhaps the solution is to develop a procedure whereby recommendations from national committees would be either 1) formally accepted, in which case any needed adjustments to class concepts, etc. would be made, or 2) rejected, in which case no one would feel obliged to attempt implementation of something at variance with current class definitions, etc.

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RECOMMENDATIONS

1. Docummenting change. General agreement by all that soil survey probably cannot adddress all levels of soil modification. The framework for documenting and interpreting both (a) short term changes or temporal properties and (b) long term changes or longer than the life of the survey needs to be made.

   (a) One of the principle needs is to construct a plan to handle use-dependent temporal information at a level of detail significant to the major models for os/ion, chemical amunendment fate, etc. A data lection program in West Texas has prove" successful and could be adopted for use in other areas.

(b) Another need is the documentation of change made to the soils physical or chemical makeup that influences its behavior. Continued vigil to document soils modified after soil survey completion needs to be stressed. Procedures or ocher structural framework should suggest and support to what degree we document change (ie. do we consider only those properties normally identified in mapping).

2. Recommend that NCSS classify a few soils. where sludge and chicken manure added, as Mollisols. Collection of data to define levels of P for an Anthropic epipedon is needed.

3. Recommend that NCSS identify under what conditions the soil survey data applies. Different cropping systems should present differences in the data.

4. Recommend that NCSS improve procedures to document management altered soil. Possibly a special section specifically for this could be included as a suplement to the Soil Survey Manual of included in the National Soils Handbook.

USDA FOREST SERVICE REPORT

(Presented by R. T. Meurisse, Regional Soil Scientist Pacific NW Region)

Pete Avers, Washington Office soil scientist unable to attend because of conflict with Southern Conference at Puerto Rico.

Forest Service Budgets-Soil and Water Program:

Following is a comparison of the national program budget for FY 90 and 91. (Thous. $)

	FY	Operations	Improvements	Inventory	Total
Final	90	32,374	10,777	7,177	50,328
Tentative	91	49,875	5,227	5,583	60,685

Soil Survey Activities

We are experiencing considerable volatility from year to year, especially in the soil inventory program. Also, Regional variations can be great.

Soil surveys are being conducted in a variety of ways to meet agency needs.
- Some are done internally by Forest Service personnel;
- Some are done by contracting (considerable amounts in some Regions);
- Many are cost share with SCS.

In December, 1989, a national meeting of soil scientists and plant ecologists from each Region was held in Tucson, Arizona to discuss concepts and direction for Ecological Classification and Inventory. National policy direction and guidance will be issued. It was agreed that soil inventory will be the basis for Ecological Unit Inventory. Delineations will be Ecological Land Units (ELU). Thisis similar to Soil Landscape Units as discussed by Fred Peterson. The intent is to define mapping units with consideration for potential natural vegetation, landforms, as well as soils. Several Regions already do this, so there will be little or no change. Others will be giving it more emphasis than currently being done. This concept is similar to range site.

Data base management and Geographic Information Systems (GIS), or spatial information management are major topics of discussion in the Forest Service. A variety of systems and stages of development are under way by the Regions. Also, steps are underway to link directly with SCS data at Ames. Emphasis is on OSEDS, SOI-5, and SOI-6.

Special cooperative studies with NCSS cooperators are active in the Regions. Following are some examples (there may be others):

Southwestern Region (R3)-Andisol pedogenesis;
Soil Climate.
Rocky Mountain (R2)-Mollisols and effect on aspen regeneration.
Pacific Northwest (R6)-Geologic investigation to determine soil-bedrock relationships and slope stability in Curry County.

Alaska (R10)-Path and rate of Spodosol development on moraines;
-Organic soil properties and temperature regimes:
-Remote sensing to delineate soil areas by organic carbon content.

Soil Quality Standards
A national soil and water monitoring workshop was held in March of 1989. Most Regions are developing standards related to forest productivity and site quality. Standards are needed to ensure that goals and objectives are met.

Current Issues Affecting National Forest Management
Several issues which require special emphasis and Forest Service response, and requiring new or special soil information are:

*Long-term soil/site productivity-Several symposia have been held to address this. They are: Corvallis, OSU, 1987: Anchorage, 1987; Boise, 1990. Publications are available for the first two. The latter is expected this winter.
*Bio-diversity-This is still loosely defined, but needs to include functional diversity as well. Soil processes important.
*New perspectives in forestry-This is still being defined, but basically emphasizes socio-political and site-specific ecosystem ❑ aangement for uses and values that de-emphasize timber management.
*Forest and Range health-This has many facets including global climate change, acid deposition, productivity, diversity and sustainability of use.
*Water quality-This also includes cumulative effects on watersheds.
*Riparian area management-While not new, it continues to be an issue and includes wetlands.

Personnel
Employment of soil scientists is relatively stable, but with slight increases. There may be some downward trends in some Regions because of reduced commodity emphasis. There are two new Regional soil scientists in the West since the last conference in 1988. Mark Jensen is in the Northern Region (R1) at Missoula. Jerry Freeouf is in the Rocky Mountain Region (R2) at Denver. The Intermountain Region is hiring a correlator at Ogden. New hires are mostly through the Coop. education program. Some come from environmental sciences rather than the traditional agriculture schools.

INTERNATIONAL COMMITTEE ON THE

CLASSIFICATION OF SPOWSOLS

ICOMOD

CIRCULAR LETTER NUMBER 9

MARCH 23, 1990

249

TENTATIVE DEFINITION: SPODIC MATERIAL MORPHOLOGY

Spodic materials normally represent an illuvial B horizon that underlies an 0, A, Ap, or an albic horizon. Spodic material may be in the Ap horizon. In undisturbed areas they frequently underlie an albic horizon. Spodic materials may have the properties of an umbric epipedon.

If the spodic material rests directly on a duripan, fragipan, petroferric, paralithic or lithic contact less than 25 cm from the mineral soil surface, or the soil temperature is cryic or pergelic or it is frigid and soil particle size class is coarse-loamy, loamy-skeletal, or finer there is no minimum depth requirement.

Spodic materials normally have an optical density of oxalate extract (ODOE) that is at least two times the overlying E or A horizon, and a minimum ODOE value of 0.25 indicating accumulation of organic materials in the B horizon. They also show evidence of eluviation of iron and aluminum from the surface horizon and illuviation of these materials in the B horizon. Spodic materials have the morphological or chemical and physical properties that are listed.

PROPOSED SPODIC MATERIALS DEFINITION

Spodic soil materials must:

1. Meet the following in an illuvial horizon:

   a. Have one of the following color requirements:

      1. Have a dominant hue in a B subhorizon that is 7.5YR or redder, a value $\leq$ 5.5 and a chroma $\leq$ 6.5 in the matrix:

         OR,

      2. Hue is 10YR with a value and chroma $\leq$ 2.5, or a color of 10YR 3/1.

   OR,

   b. Have an horizon $\geq$ 2.5 cm thick laterally continuous in 50% ~~of~~ each pedon cemented by organic matter with some combination of either Fe or Al, or both, that has a color value < 3.5 and a chroma < 2.5.

   AND,

c. Meet at least one of the following morphologic or chemical requirements in the illuvial horizons:

1. Have in some B subhorizon beneath an albic horizon a value and chroma $\leq$ 3.5 in materials $\geq$ 20 cm thick and have a pH $\leq$ 5.5;

OR,

2. Have some sand grains with cracked coatings;

OR,

3. Have in some B subhorizon $\geq$ two times Fe,, than in the overlying E, A, or Ap horizon:

OR,

4. Have in some B subhorizon $\geq$ two times more Al_{ox} plus $FE_{ox}/2$ than in the overlying E, A, Ap horizon;

OR,

5. Have in some B subhorizon an ODOE value $\geq$ D.25 and at least two times more ODOE than in the overlying E, A, or Ap horizon.

OR,

2. Have an Ap horizon $\geq$ 20 cm thick, or when mixed to that thickness, that has some subhorizon that meets or exceeds both of the following chemical requirements:

a. $Al_{ox} + (Fe_{ox}/2) \geq 0.9$

AND

b. ODOE $\geq$ 0.15

TO BE ADDED TO ANDIC MATERIALS DEFINITION

Andic materials have a ratio of pyrophosphate extractable C (Cp) to organic C (OC) of $\leq$ 0.5 (Cp/OC $\leq$ 0.5) and a ratio of fulvic C (Cf) in pyrophosphate extract to pyrophosphate extractable C (Cp) of $\leq$ 0.5 (Cf/Cp $\leq$ 0.5).

I to (1990)

TENTATIVE DEFINITION OF SPODIC MATERIALS INTERGRADE CRITERIA

Meet all of the requirements for spodic materials except:

1. The lower boundary of the spodic material is < 25 cm below the mineral soil surface in soils with frigid sandy particle-size classes and in warmer soils; or,

2. They have at least 5 percent volcanic glass and andic soil properties throughout 35 cm in the upper 60 cm whether buried or not, with or without an albic horizon; or,

3. They have colors 10YR 4/4, 3/4 or 5/4 with or without an albic horizon.

PROPOSED KEY TO THE ORDER OF SPODOSOLS

ANDISOLS

Other soils that have:

1. Spodic materials that are at least 10 cm thick and meet two of the following requirements:

   a. Extend below 25 cm unless terminated by a duripan, fragipan, or petroferric, paralithic, or lithic contact at 25 cm or less: or have a cryic or pergelic soil temperature regime, or have a frigid soil temperature regime and the soil particle-size class is coarse-loamy, loamy-skeletal, or finer.

   AND,

   b. The upper boundary is < 2 m below the soil surface if the soil has a sandy epipedon between 1 and 2 m thick.

   OR,

   c. The upper boundary is < 1 m below the soil surface.

2. Do not have an argillic or kandic horizon in or above the spodic materials.

3. Do not have a plaggen epipedon.

SPODOSOLS

PROPOSAL RATIONALE

The properties that are presented in Item 1a allow the use of soil color to determine that a B horizon is a potential designate as having spodic materials. It includes the Bhs, Bh, and Bs horizons. Item lb includes the ortstein in the definition of spodic materials.

Item 1c1 when combined with Item la or lb with the suggested colors would meet the spodic materials definition. The soil reaction class proposed as the upper limit for spodic material definition was derived from a review of 156 pedons in Maine and from the Northeast review of spodic soil materials in 1989 of which 126 were strongly acid or lower. Of those not meeting the acidity requirement, some had been managed intensively for agriculutre and had been limed and others had developed in sediments having a high pH.

The criteria in Item 1c2 is the same as was used for morphologic identification of illuvial materials in the previous definition of the spodic horizon. This will be used frequently with sandy spodic horizons.

The chemical criteria that are used in Items 1c3, 1c4, and 1c5 are used to show the eluvial/illuvial relationship expected to occur in the process of podzolization. Item 1c3 and 1c4 present the accumulation of iron and or aluminum in the B horizon. The use of the optical density of the oxalate extract shows the accumulation of fulvic acids in the B horizon as has been shown by Daly (1982) to be indicative of spodic horizons. Application of these criteria to 217 soils in the United States result in a good separation from other soil orders with the exception of materials having a spodic-like morphology but developing in tephra. These criteria are the result of modifications to ICOMOD 8 (1989) definitions combined with modifications proposed by Shoji (1990).

The proposal in Item 2 includes the Ap horizon in the spodic materials definition if some portion of the Ap meets certain chemical criteria. The limits proposed are based upon the Ap horizons in the soil review in the Northeast in the fall of 1988 and on samples taken from Aroostook County, Maine, potato fields at 9 locations in 1989. Based upon these data most of the soils would be considered to have spodic materials in the Ap. Those pedons not meeting the requirements may have been severely eroded or limed extensively. There is need for additional data to test this criteria and because of the limited data base it is possible that in time this section of the definition will be changed.

The addition of a definition to andic materials is to separate materials from andic that are spodic. The data for this separation are presented by Ito (1990) and show a good separation of the 2 materials based upon data from volcanic and nonvolcanic regions. This addition will alleviate the problem of discerning spodic materials that have developed in volcanic soils.

LITERATURE CITED

Daly, B.K. 1982. Identification of podzols and podozlized soils in New Zealand by relative absorbance of oxalate extracts of A and B horizons. Geoderma 24: 101-128.

International Committee on the Classification of Spodosols. 1989. Circular letter 8 and supplement.

Ito, T., S. Shoji, Y. Shirato and E. Ono. 1990. Differentiation of a spodic B horizon from a buried A horizon by a chemical procedure. Submitted for review and publication.

Shoji, S. and T. Ito. 1990. Classification of tephra-derived Spodosols. Submitted for review and publication

June 19, 1990

WRCC-30 officers

Past Chairman - Dr. Chien-Lu Ping, University of Alaska Fairbanks

Chairman - Dr. Larry Munn, University of Wyoming

Secretary - Dr. Eugene F. Kelly, Colorado State University

NSCDB Representative - Dr. David M. Hendricks, University of Arizona

other Participants -
Dr. William Allardice, University of California-Davis
Dr. Bruce Buchanan, New Mexico State University
Dr. LeRoy Daugherty, New Mexico State University
Dr. Maynard Fosberg, University of Idaho
Dr. Bruce E. Frazier, Washington State University
Dr. Robert Graham, University of California-Riverside
Dr. Gordon L. Huntington, University of California-Davis
Dr. Haruyoshi Ikawa, University of Hawaii
Dr. Gerald Nielson, Montana State University
Dr. Frederick Peterson, University of Nevada-Reno
Dr. Chien-Lu Ping, University of Alaska Fairbanks
Dr. Randal J. Southard, University of California-Davis

The following is a summary and the individual reports given by each of the Agricultural Experiment Station representatives on activities related to NCSS.

A. Agricultural Experiment Station Activities:

1. Soil Mapping

Several of the stations reported that soil mapping is conducted through contracts with State and Federal Agencies. California is in the proaess of mapping State and private land. Colorado is conducting a prototype "research area soil survey" at the Central Plains Experimental Range in cooperation with ARS and the SCS.

2. Soil Survey Reviews and Correlations

Most of the experiment stations participate in field reviews, correlations and reviews of preliminary soil survey reports.

3. Teaching and Research

Most of the Agricultural Experiment Station representatives are involved in teaohing undergraduate and graduate classes and field courses in areas of Soil Genesis, Soil Classification and Morphology. Soils Judging is also part of teaching responsibility at some of the universities.

Research projects in the area of Soil Genesis and classification is being conducted to evaluate differences between Andisols and Spodosols in Alaska, Arizona and California. Some of the stations have on-going soil climate researoh programs, namely, California, Colorado, and New Mexico. The fate and biogeochemical accumulation of toxic elements and eubstanaes is being investigated in California, New Mexico, Washington and Wyoming. Continuing research in revegetation is being conducted in Hawaii. Application of Geographic Information Systems at various spatial and temporal scales is being conducted in Colorado and Montana.

B. Concerns of the Agricultural Experiment Stations:

1. Most of the station8 reported a stabilized enrollment in soil sciences since the last report. The Universities appear to have high job placement success. Some expressed concern regarding the ability of the universities to maintain adequate enrollment to fill future available positions.

2. Some stations expressed aonoern with reorganization efforts by Universities and the role that Soil Science will play in new curriculums developed at these institutions. Reorganizations at University of Wyoming, Nevada-Reno were discussed.

3. Support for researah in soil genesis and classification is difficult. Most of the investigators have established joint research projeate that crossover into other disciplines in order to secure funding. Environmental (hazards, climate change) researah and not strict "agricultural applications" appear to be most suitable for funding at the national level. These research agendas may not meet the needs of the NCSS.

4. All members present voted to petition for authorization of an annual WRCC-30 meeting. Subject to authorization this meeting would take plaae in Moscow, Idaho in 1991. The 1992 work Planning Conference is scheduled to be held in Flagstaff, Arizona.

ALASKA

University of Alaska Fairbanks

Representative - Dr. Chein-Lu Ping

Current Activities : Dr. Ping is currently investigating the properties that differentiate the Andisols from the Spodosols in Alaska. Other Research activities include the following : 1) the study of C to organic matter ratios in Alaska soils, 2) studies of the properties and olassifiaation of Hydric soils, 3) relationships between soil organic matter and soil development and 4) archaeological applications of soils

ARIZONA

University of Arizona

Representative - Dr. David M. Hendricks

Current Activities : Dr. Hendrioks reported on his Soil Survey related research activities, at the University of Arizona. Dr. Hendricks is conducting studies of the Andisols in the Sunset Crater area as well as the San Francisco Volcanic Field. He is also conducting soils researah in northern California in the Mendocino area in collaboration with the Jet Propulsion Laboratory. Dr. Hendricks was also appointed as NSCDB representative replacing Dr W. Allardice.

CALIFORNIA

University of California at Davis

Representative - Dr. Randal J. Southard

Current Activities : Dr. Southard is currently involved in a Soil Survey project with the California State Forest Service to assist in mapping state and private property in portions of California. Dr. Southard is also supervising research activities not related to Soil Survey that inalude the following: 1) studies of soil properties and processes in the Mohave desert, 2) pedoturbation in Vertisols using Cs-137, 3) the use of Amino acid racemization to date soils.

Representative - Dr. William Allardice

Current Activities : As the past representative to NSCDBC, Mr. Allardice reported on the status of the National Soil Characterization Data Base and the activities of the NSCDB committee. Several generations of changes have occurred and he distributed a flow diagram whiah reflected the latest changes.

Representative - Dr. Gordon L. Huntington

Current Activities : Dr. Huntington has recently retired but remains an active member in the NCSS. His primary activities include participation in field reviews, the review of Soil Survey technical reports and the Story Index sections for Soil Surveys of California. Other activities include the following: 1) the development of a "Roadside Guide to Pedology" for portions of California similar to the Roadside series common in Geology, 2) work in promoting a State Soil for California.

University of California at Riverside

Representative - Dr. Robert Graham

Current Activities : Dr. Graham is conducting a number of research projects related to his specialization Soil Mineralogy. These projects include the following: 1) the pedogenic degradation of asbestos in soils, 2) evaluation of the Water Holding Capacity of Rocks, and 3) the influence of wildfires on soil mineral degradation.

COLORADO

Colorado State University

Representative - Dr. Eugene F. Kelly

Current Activities : Dr. Kelly is conducting Soil Survey research at the Central Plains Experimental Range in eastern Colorado in cooperation with the SCS, UDSA-ARS and Colorado State University. Dr. Kelly is also involved in field reviews and the review of Soil Survey reports. Other research activities include the following : 1) paleopedology at the shortgrass steppe LTER site, 2) soil-climate studies in the Wind River basin of Wyoming, 3) Isotope geochemistry of soil minerals, 4) Human influences on soil formation, and 5) the use of soil properties in archaeological applications.

HAWAII

University of Hawaii

Representative - Dr. Haruyoshi Ikawa

Current Activities : Dr. Ikawa is involved in an on-going research that focusses on the revegetation of native species in Hawaii. Other research activities inolude the influence of soil fertility, namely, P status on revegetation success and the establishment of loblolly pine along elevation transects.

IDAHO

University of Idaho

Representative - Dr. Maynard Fosberg

Current Activities : Dr. Fosberg has recently retired and is finishing up a number of projects before his new replacement arrives. Anita Falen and Dr. Fosberg have just completed a laboratory oharaoteriaation prooeedures manual. Dr. Fosberg's other research activities include the following : 1) Studies of the Jackson Hole loess, 2) volcanic ash and it's relationship to the development of Spodosols and Inoeptisols 3) work on third edition of a slide set to illustrate Soil Taxonomy, and 4) studies of soil loss vs wheat produation.

MONTANA

Montana State University

Representative - Dr. Gerald A. Nielson

Current Activities : Dr. Nielson is currently involved in the application of Remote sensing to soils management. Specifically, Geographic Information Systems and their application to soil management at a *number* of spatial scales. His laboratory produces about 2 products a week. His other research activities include the following : 1) applications *of* GIS to management of soils through precision fertilizer applications, 2) the development of a workshop on Precision farming in the 90's.

NEW MEXICO

New Mexico state University

Representative - Dr. Bruce Buchanan

Current Activities: Dr. Buchanan is currently involved in research that is designed to monitor soil climatic parameters. His research activities include the following: 1) A range management project designed to study the proliferation of Snakeweed in New Mexico, 2) a project to evaluate soil moisture measurements in the control section of soils vs single point measurements, 3) survey of mining areas to establish appropriate soil sampling schemes.

Representative - Dr. LeRoy A. Dougherty

Current Activities: Dr. Daugherty is currently Department head at NMSU. Dr. Daugherty supervised research that studied the role of microbial activity in the precipitation of calcite. Dr. Daugherty reported that the on funding that the University received to upgrade laboratories and the funding his program has received from NRC, DOB, WBRC.

NEVADA

University of Nevada-Reno

Representative - Dr. Frederick P. Peterson

Current Activities : Dr. Peterson will be retiring this year. He reported that he finished the Soil Temperature and Moisture studies and the SSIR report. He also noted that his publication of a landform classification scheme is now in the final stages of review at the national laboratory in Lincoln.

WASHINGTON

Washington state University

Representative - Dr. Bruce E. Frasier

Current Activities : Reported on projects in the Palouse region of Washington. These studies inaluded the following: 1) the Pleistocene stratigraphy of the palouse *region*, 2) use of soils in waste disposal, and 3) Use of geographic Information Systems to establish productivity units.

WYOMING

University of Wyoming

Representative - Dr. Larry Munn

Current Activities: Dr. Hunn is supervising a number of research projects. Some of the research problems as follows: 1) the use of soils to study prairie dog impact in Wyoming rangelands, 2) detailed studies of clay dunes and paleosols, 3) Biogeochemical accumulation of Selenium in soils of Wyoming.

Report by Charles Smith, USDA-CSRS

Dr. Smith reported on the Farm Bill and funding allocations for 1991 and 1992 fiscal years. He stressed the major areas of funding will be in the following areas: 1) Water Quality research, 2) Low Input Sustainable Agricultural Research, 3) High risk contaminants and naturally occurring contaminants.

WNTC BRIEF **OUTLINE** REPORT
BY
MARIO A. **VALVERDE**

Subjects: A. MLRA
. Pesticide Rating
C. Soil Survey Manuscripts
. Preliminary Field Tour/VIII International Soil Management Workshop (VIII ISMW)
. communication;

A. MLRA

1. Presently the WNTC has a copy of each state MLRA plan. Some states are showing differences from HB296. I'm asking the states in this category to forward descriptions not on file at the WNTC for tentative approval.

2. WNTC tentative plan is to update the regional MLRA map when the STATSGO project is completed.

3. The NSH guidelines and policies are in the process of being updated. These guidelines will show new responsibilities and new policies for updating. Policies emphasize interstate correlation before submitting changes to NTC. (see Attachment 1)

B. Pesticide Rating: A new policy is scheduled to be in place by August 15, 1990.

-New criteria is being developed and is now in circulation for review and comments by the WNTC staff.

-1 would like to remind you that the pesticide rating available through Ames has some limitations (see Attachment 2).

-The Goss model which originated these ratings does not consider 7 conditions and only 3 are showing as footnotes. Each state needs to adjust these ratings due to local conditions. Wc will provide some assistance as requested. (see Attachment 3)

C. Soil Survey Manuscripts: Review of manuscripts by NTC's is addressed by National Bulletin 430-O-7, dated February 28, 1990. (see Attachment 4)

The WNTC Soils Staff has been given the responsibility to coordinate the spot-checks.

The WNTC Director has the option to request manuscripts for spot-check. Main concern is manuscripts with a biology section but the state does not have a State Biologist.

To speed up the spot-check process, I would like to suggest that each manuscript include a list of the state disciplines involved in the review process with the initial of the reviewing persons. (see Attachment 5)

D. Preliminary Field Tour/VIII International Soil Management Workshop (VIII ISMW)

Purpose: To show how soil information makes a difference on the use, management and soil interpretations associated with each soil.

Preliminary Tour Route;
Day one: Portland to Klamath Fall-- Route--> Willamette Valley and Umpqua National Forest.
Day two: Klamath Fall--Route--> Davis California, Klamath National Wildlife Refuge, McCloud Flat (base of Mount Shasta) and Sacramento Valley.
Day three; Davis to Lake Tahoe--Route--> Sacramento Valley, California Delta, El Dorado National Forest.
Day four: Lake Tahoe to Winnemuca Nevada--Route--> Tahoe basin, Fallon, and Intermountain Basin and Range (BLM areas).
Day five: Winnemuca to Ontario Oregon--Route--> Intermountain Basin and Range--Nevada/Oregon.
Day six: Ontario to Pendleton via Northern Oregon mountain forest, Snake River Plains and Palousa Areas.
Day seven: Pendleton to Portland--Route-->Palouse, Columbia Basin and Plateau, and Columbia River Gorge.

E. Communication:

1. Issue regional soil Telenet users list.

2. Coordinate communications to all states via UNIX uuto or blast.

   - Set at WNTC soil 3B2 a login for each state .

   - Coordinate or set a login for WNTC soil staff in each state office soils computer.

Attch 1

Draft 5/90

Procedure for Revising

Agriculture Handbook No. 296 Land Resource Regions and Major Land Resource Areas of thr United States.

Background:

Major Land Resource Areas (MLRA's) have for many years served numerous program needs of the SCS and cooperating agencies. MLRA's continue to serve as a base for program planning and implementation, and as a means for displaying resource information (NATSGO) for the U.S. Currently the HLRA map of the United States exists in several formats. Numerous MLRA's have been proposed since AH 296 was revised and republished in 1981.
The initial draft of STATSGO, State Soil Geographic Data Base, will be complete for most of the U.S. by October 1990. One of the goals of the STATSGO project is to update the MLRA map of the U.S.

The following procedure will be used for a complete revision of AH 296 in Fiscal 1991 and 1992 with the intent of republishing in 1993. National Soils Handbook Section 605.11 (attached) will also be used a guidance: Section 605.11 may need to be revised to add clarification, especially with regard to states roles and how MLRA's arp developed.

1) National Cartographic Center (NCC) generates State MLRA map from S?A?SGO at scale of 1:5,000,000 and 1:250,000 and forwards to responsible National Technical Center (NTC) along vith a list of MLRA codes used on the State MLRA map.

2) NTC's requests state review of MLRA boundaries and requests documentation for MLRA's that occur on State MLRA map. but not on map in AH 296.

   Note: If state proposes additional MLRA's that do not occur in STATSGO or revisions in MLRA lines generated from STATSGO, then STATSGO is revise? and a new State MLRA map is generate: t NCC from STATSGO.

3) State Submits the following documentation to the Director NTC:

   a) Draft State MLRA map generated at NCC.
   b) Draft MLRA De::riptions.
   c) Documentation stating reasons for change.
   d) Letter(s) from surrounding State Conservationists concurring with change and documenting correct join.

4) NTC reviews documentation submitted by state and:

a) either returns to state for further documentation/revision or

b) routes to other NTC's for comment.

c) NTC incorporates comments forwards draft copies and documentation listed in 3 (a-d) to Director National Soil Survey Center (NSSC).

5) NSSC reviews documentation submitted by NTC and routes to Ecological Sciences Division and Resources Inventory Division national office for comment.

a) NSSC returns documentation to NTC for further documentation/revision or

b) Approves new or revised MLRA and makes changes in AH 296 and revises MLRA map.

c) NSSC/SCS republishes AH 296

The following assignments were made in Nat. Bulletin No. 430-3-5 (Z-8-83). Assigned responsibility ir.udes responsibility for updating the narrative des:ription in AH 296. These assigned responsibilities would be added to NSH 605.11.

Assigned Major Land Resource Areas by Regions and States

<u>Northeast Region</u>

New York	101, 140, 141, 142. 1496
Ha ine	143, 146
New Hampshire	144B
Connecticut	145
Pennsylvania	127, 147
West Virginia	126
New Jersey	149A
Virginia	148
Massachusetts	144A
Delaware	153C

South Region

Oklahoma	78, 80A, 84A
Texas	77, BOB. 81, 82, 83A, 83B, 83C, 83D 84B, 84C, 85. 86, 87, 133B, 150A, 150B, 1528
Arkansas	117, 118, 119. 131, 132
Louisiana	151
Tennessee	122. 123. 128
Mississippi	134
Alabama	129, 133A, 135
North Carolina	130
South Carolina	137. 153A, 153B
Georgia	136
Florida	138. 152A, 154, 155. 156A, 1566
Kentucky	120. 121. 125
Puerto Rico and Virgin Islands	270, 271. 272, 273

Midwest Region

Nebraska	64, 65, 71. 75. 106. 102B
Kansas	72. 73. 74, 76. 79. 112
Minnesota	57, 88, 89. 103
Iowa	104. 107,
Missouri	109, 115. 116A. 116B
Wisconsin	90. 91, 93. 95A, 95B. 105
Illinois	108, 110. 113. 114
Michigan	92. 94A, 94B, 96. 97. 96. 99
Indiana	111
Ohio	100. 124, 179,
South Dakota	53C, 55C, 58D, 60A, 61. 62. 63A

J

	63B, 66. 102A
North Dakota	53B, 54, 55A, 55B, 56, 58C

West Region

Washington	1, 3, 6, 7, 9
Oregon	2, 8, 10, 23
California	4, 5, 14, 15, 16, 17, 18, 19. 20 21. 22, 30, 31
Idaho	11. 12, 13. 25. 43
Montana	44, 46, 52, 53A, 58A, 59. 60B
Wyoming	32. 33. 34, 58A
Nevada	24, 26. 27, [29] 28B, 47
Utah	28A, 47
Colorado	48A, [48B] 49, 51, 67, 69
Arizona	35, 39, 40, 41
New Mexico	36. 37. 42, 70
Alaska	166, 169, 170, 171. 172 173. 174. 175. 176, 177, 178, 179. 180, 181. 182
Hawaii	157. 158, 159, 160, 161. 162, 163. 164, 165. 166, 167
Pacific Basin	190. 191. 192, 193. 194, 195, 196. 197. 198. 199, 200, 201, 202, 203

Atch 2

INTERIM SOIL RATINGS FOR DETERMINING WATER POLLUTION RISK FOR PESTICIDES STATE OREGON

SIR NUMBER	SERIES NAME	SURFACE TEXTURE	HYD GRP	LAYER DEPTH	ORG MAT	K FAC	WAT TAB DEPTH	SLP UPP	SOIL LEACH POTENTIAL	SOIL SURFACE LOSS POTENT
OR1315	WOLFPEAK	SL	B	11	2 - 6	.15	>6.0	35	INTERMEDIATE*	NOMINAL *
OR0565	WOLLENT	SIL	D	10	2 - 3	.43	4.5-1.0	3	NOMINAL	& NOMINAL
OR0626	WOLOT	SIL	B	29	1 - 5	.43	>6.0	12	NOMINAL	INTERMEDIATE
ID0088	WOLVERINE	S	A	16	0 - 1	.17	>6.0	30	HIGH *	NOMINAL *
ID0088	WOLVERINE	LS	A	16	0 - 1	.15	>6.0	30	HIGH *	NOMINAL *
ID0088	WOLVERINE	FS	A	16	0 - 1	.20	>6.0	30	HIGH *	NOMINAL *
OR0325	WOODBURN	SIL	C	17	3 - 5	.32	2.0-3.0	20	NOMINAL	* & INTERMEDIATE*
OR0141	WOODCOCK	ST-L	B	12	5 -10	.20	>6.0	60	INTERMEDIATE*	INTERMEDIATE*
OR0141	WOODCOCK	L	B	12	5 -10	.24	>6.0	60	INTERMEDIATE*	INTERMEDIATE*
OR0141	WOODCOCK	GR-L	B	12	5 -10	.20	>6.0	60	INTERMEDIATE*	INTERMEDIATE*
OR0315	WOODCOCK BEDROCK SUBSTRATUM	ST-L	B	16	5 -10	.17	>6.0	60	INTERMEDIATE*	NOMINAL *
OR0315	WOODCOCK BEDROCK SUBSTRATUM	ST-CL	B	16	5 -10	.17	>6.0	60	INTERMEDIATE*	NOMINAL *
OR1333	WOODCOCK WARM	ST-L	B	14	5 -10	.20	>6.0	60	INTERMEDIATE*	INTERMEDIATE*
CA0233	WOODSEYE	GRV-SL, GRV-COSL	D	7	1 - 4	.17	>6.0	90	NOMINAL *	INTERMEDIATE*
CA0233	WOODSEYE	GRV-L	D	7	1 - 4	.20	>6.0	90	NOMINAL *	INTERMEDIATE*
CA1749	WOODSEYE STONY	STV-L	D	12	1 - 4	.15	>6.0	80	NOMINAL *	INTERMEDIATE*
OR0116	WRENTHAM	SIL	C	12	3 - 5	.37	>6.0	70	NOMINAL *	INTERMEDIATE*
OR0255	WRIGHTMAN	L	C	11	1 - 3	.37	>6.0	25	NOMINAL .	INTERMEDIATE*
OR0255	WRIGHTMAN	SIL	C	11	1 - 3	.43	>6.0	25	NOMINAL *	INTERMEDIATE*
OR0117	WUKSI	CBV-LCOS, CBV-S	A	42	1 - 2	.10	>6.0	65	INTERMEDIATE*	NOMINAL *
OR0118	WYEAST	SIL	D	28	2 - 3	.49	1.0-2.0	12	NOMINAL	& HIGH
OR0205	WYETH	CB-L	B	17	3 - 5	.20	>6.0	75	NOMINAL *	INTERMEDIATE*
OR0205	WYETH	GRV-L	B	17	3 - 5	.10	>6.0	75	NOMINAL *	NOMINAL *
OR1066	XANADU	GRV-L	B	8	5 - 8	.10	>6.0	60	NOMINAL *	NOMINAL *

* SLOPES GREATER THAN 15 PERCENT REQUIRE LOCAL EVALUATION
\# ORGANIC SOILS AND SOILS WITH ORGANIC SURFACE LAYERS REQUIRE LOCAL EVALUATIONS
& WATER TABLE ABOVE 6 FEET MAY REQUIRE CONSIDERATION OF WATER RESOURCE USE

5. Soil parameters that influence pesticide half life.

1. [illegible] not included in formula
climate - storm size & frequency after application if soil has high leaching potential infiltration
2. Soil Temp. & moisture.
3. Time of Crop & method of application

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Atch 3

United States Department of Agriculture | Soil Conservation Service | P.O. Box 2890 Washington, D.C. 20013

November 14, 1986

NATIONAL BULLETIN NO. 430-9-3

SUBJECT: SO1 - SOIL RATINGS FOP PESTICIDE LEACHING AND SURFACE LOSS POTENTIALS

Purpose. To distribute interim methods used to develop pesticide leeching end ● urfece loss potentials for use :n section II-1 of the Field Office Technical Guide (FOTG) end Job Control Language (JCL) for obtaining ratings from the National Soil Survey Database et Ames, Iowa.

Expiration Date. This bulletin expires September 29, 1989.

Methods Used to Develop Ratings.--The general formulae end criteria used are described in ● ttechment 1. These interim ratings ● re to be used in section 11-l of the FOTG to develop soil-pesticide interaction ratings. Some ratings will need ● djuetmente based on local conditions as indicated by three footnotes.

- Slopes >15 percent require locel consideration for surface loss.

Organic ● oile end ● oile with organic ● urfece layers require local evaluations.

& Water table above 6 feet may require consideration of water resource use.

The ratings ● re adjusted for slopes of 2 percent or less. However, if ratings are devi.oped using only the SOI-5 data, local ● djuetments fr elopes will be necessary if SOI-5 slopes range from 0 to greater tha. 2 percent. In these cases, increase the ● urfece loss potential one class better. Do not make this adjustment if ratings are generated using both Map Unit Uee end SOI-5 data files.

The ratings are not adjusted for soils that have contrasting particle classes. States may need to make locel adjustments for these soils.

Job Control Language (JCL).--The JCL's (attachment 2) were distributed ● lectronicelly to ● tete remote numbers by the statistical labor tory et Iowa State University. The JCL has 'WATQUAL' as the identifier end provides for ratings using the SOI-5 record, the map unit use file (MUUF), or SOI-6's.

DIST:

MORE

Future Developments.--The pesticide leeching end surface lose potentials are interim ratings and are under continued development. If you have comments, concerns, or suggestions, please convey these to your NTC Soil Interpretations Staff. For questions, please contact 'Dr. Don Goes, National Soil Survey Center, National Soil Survey Laboratory, et FTS 541-5363 or commercial 402-437-5363.

Richard W. Arnold

RICHARD W. ARNOLD
Director, Soil Survey Division

Enclosures

ATTACHMENT 1

PESTICIDE - SOIL INTERACTION

Potentials For Loss

Don Goss

INTRODUCTION

This document describes a method used to evaluate the relative potential loss of pesticides from soils. Evaluation results are expressed as a relative potential for a specific pesticide to be lost when used on a soil series. lhe GLEAMS(1) model was used to estimate pesticide losses from a large combination of hypothetical pesticides and soils. The estimated pesticide losses were ranked according to the amount of pesticide lost. Algorithms using soil properties were developed to categorize soil series for leaching and surface water loss potential. Also, algorithms using pesticide properties were developed to categorize pesticides for leaching and surface water loss potential. The soil and pesticide categories are combined in a matrix to give a pesticide loss to surface water potential and a pesticide loss to leaching potential.

(1) GLEAMS: Ground Water Loading Effects of Agricultural Management Systems by R. A. Leonard, W. G. Xnisel, D. A. Still. Transactions of the ASAE Vol 30 No 5, pp1403 419, 1987.

BOUNDARIES OF CONSIDERATION

A pesticide loss is assumed to have occurred if the pesticide is leached below the root zone, or leaves the field boundary in solution or adsorbed on sediment suspended in runoff waters. Thus, the boundaries are the bottom of the root zone and the edge of the field.

FACTORS AFFECTING RISK POTENTIAL

The potential of losing pesticides from a field by surface water runoff or leaching below the root zone is a combined function of pesticide, soil, and climate factors. The pesticide loss assessments listed in this section have been developed by using a combination of soil and pesticide properties. The climatic factor has not been varied. The meteorological components used in the rating process are for evaluating potentials independent of climate and are not intended to represent any climatic zone. The primary goal was to determine the capacity of a soil to retain a pesticide at the point of application, regardless of management or climatic inputs.

FACTORS NOT INCLUDED IN PESTICIDE LOSS POTENTIAL

Climate was not a variable in the pesticide loss potential determination. Storm size and frequency immediately after pesticide application will impact the amount of pesticide lost .to surface runoff. This loss occurs as pesticide in solution and adsorbed on the sediment suspended in runoff waters. Another climate related impact occurs when pesticides that have a high leaching potential are applied on soils vith high infiltration rates. The pesticide will infiltrate below the root zone when a large or extended precipitation event occurs immediately after application. Therefore, the fact that a pesticide has been applied produces a potential for pesticide loss. This potential for loss occurs regardless of management practices that utilize pesticides.

Actual climatic data vas not used in the GLEAMS model because of the several hundred potential climates that would require evaluation. Over 24,000 iterations of the GLEAMS model were required to test the hypothetical soils and pesticides without varying the climate. The meteorological data used in the model to estimate pesticide losses was artificially generated to represent the most likely situations for pesticide loss mentioned above.

An indirect climatic influence not considered in this assessment is soil temperature and moisture during the period the pesticide resides in the soil. The persistence or half-life of a pesticide in a soil is partially dependent on soil moisture and temperature. The degradation of the pesticide is favored by warm and moist climates. The difference in half-life rates of the pesticide due to soil moisture and temperature has not been considered. The half-life for a given pesticide was assumed constant, regardless of climate or geographic location.

The t pe of crop was not considered. and the method of pestic ae application was not considered. The ~~soil was~~ 'assumed fallow and the application was to the soil surface. To consider each crop and method of application available for a pesticide is beyond the scope of this guide.

Some soil parameters that are thought to influence pesticide half-life rates or solubility have not been considered. These factors include soil pH, Aluminum content, elements toxic to microbes, and total soil surface area.

FACTORS CONSIDERED IN PESTICIDE LOSS WTENTIAL.

Soils have been categorized according to the relative potential for pesticide loss from the surface (soil surface loss potential), or the relative potential for pesticide loss to leaching (soil leaching potential). The pesticides have been categorized according to the same potentials (pesticide surface loss potential or pesticide leaching potential).

Break points for each category were based on the percent of pesticide applied lost to surface runoff or leaching. Multiple simulations of the GLEAMS model were used to estimate pesticide leaching below the root zone, and pesticide losses in runoff. The categories for soil potentials are:

High
Intermediate
Nominal

The categories for pesticide potentials are:

Large
Medium
Small
Total Use

The pesticide vas applied to the surface of a fallow soil sixteen, eight, four, and two days before, and on the day of the first major precipitation event. A 3.5 inch precipitation event was generated every second day for five events, and then a 1.0 inch event every other day for at least four times the half-life of the pesticide. The field was ten acres, square in shape, with a four percent slope. The rooting depth was set at 36 inches.

The pesticide variables tested were:

(1) half-life,
(2) solubility, and
(3) organic matter partitioning coefficient (KOc).

The soil variables tested were:

(1) surface horizon thickness,
(2) organic matter content of the surface horizon,
(3) surface texture,
(4) subsurface texture, and
(5) hydrologic soil group.

The estimated properties that vary with above inputs are:

(1) Effective saturated conductivity from texture and hydrologic group using Table A-6, pg. A-B. 1/ (Fallow)
(2) Bulk density from texture by NSSL method. The NSSL method utilizes the Pedon Data Base for predicting the most probable bulk density from texture.

(3) SCS curve number from Hydrologic soil group using Table A-4, page A-5. 1/ (Fallow, straight row)
(4) Porosity from [1 - (bulk density)/2.65)]*100.
(5) Field capacity from texture using Table A-3, pg. A-4. 1/
(6) Wilting point from texture using Table A-3, pg. h-4. 1/
(7) Soil evaporation parameter using Table A-3, pg. A-4. 1/
(8) Percent sand, silt, and clay from texture using Table B-4, pg. B-3. 1/

(1/) CREAMS A Field Scale Model for Chemicals, Runoff, and Erosion from Agricultural Management Systems; Conservation Research Report Number 26. USDA, Science and Education Administration. (which also applies to GLEAMS)

The climatic constraints used for this method of ranking are somewhat rigid considering the wide variety of climates where pesticides are used. The precipitation inputs into the model are highly improbable in most climates. An additional constraint is methods of pesticide application relative to true application methods of the pesticide. However, these ranking of soils and pesticides are relative with no absolute definition. The categories reflect a potential of how a soil and pesticide will interact. Pesticide losses from this model reflect only the relative ability of the soil to retain the pesticide at the point of application. The interplay of climate determines whether the leaching or surface loss potentials are reached in a given area.

DEVELOPMENT OF THE ALGORITHMS

Soil and pesticide categories were developed by using the results of multiple simulations using GLEANS. An algorithm was developed to rank soils and pesticides for losses due to infiltration and for losses due to surface runoff. These algorithms were developed by ranking GLEAMS estimated pesticide losses for leaching or runoff into three groups. The pesticide loss would occur if a large precipitation event occurs immediately after application. The largest loss group has the potential for unacceptable losses regardless of management. The lowest loss group has little potential for loss regardless of management. The intermediate loss group has the potential for unacceptable losses, but may be reduced to acceptable losses by management. Selection of soil and pesticide properties for the algorithms was based on Factorial Analysis or Stepwise Regression. Both methods selected the properties that most influenced pesticide loss.

Leaching Algorithms

The soils algorithm for ranking soils for potential loss to leaching are:

SOIL LEACHING POTENTIAL ALGORITHM

High:

If hydrologic group = A
and Organic Matter times horizon #1 depth <= 30 or
If hydrologic group = B
and Organic Matter times horizon #1 depth <= 5

Nominal:

If hydrologic group = A and
organic Hatter times horizon #1 depth >= 65 or
If hydrologic group = B and
Organic Matter times horizon #1 depth >= 45 or
If hydrologic group = C or
If hydrologic group = D.

Intermediate:

Everything else

The method of D.I. Gustafson (unpublished) was adopted and modified to rank pesticides (Groundwatar Ubiquity Score: A Simple Method of Assessing Pesticide Leachability). There are certain classes of pesticides that will probably never be leached. These pesticides will have a small leaching potential regardless of the soil type they are applied. This group of pesticides was ranked Total Use. The pesticide algorithm for ranking pesticides for potential loss to leaching are:

PESTICIDE LEACHING POTENTIAL ALGORITHM

Large:
If log(half-life)*(4 - log(KOc)) >= 2.8

Small:
If log(half-life)*(4 - log(KOc)) <= 1.8

Total Use:
If (solubility <1 or KOc >= 10000) and
half life c 10.

Medium:
Everything else

The loss of pesticides in surface runoff occurs in two phases, in the soluble and adsorbed phase. The current algorithm considers both phases combined. However, there is an advantage in separating these phases. This advantage is evident in considering management alternatives. Practices to manage water, the soluble phase, could be different than practices to manage sediment, the adsorbed phase. The algorithms for surface losses are not as definite as the algorithms for leaching. The number of factors corollary to surface losses are much greater than those to leaching losses. The algorithm for ranking soils for potential loss to runoff are:

SOIL SURFACE LOSS POTENTIAL ALGORITHM

High:
If log((soil k factor)*(hydrologic group)"') >= 2.8

Nominal:
If log((soil k factor)*(hydrologic group)"') <= 1.0

Intermediate:
Everything else

The algorithm for ranking pesticides for potential loss to runoff are:

PESTICIDE SURFACE LOSS POTENTIAL ALGORITHM

Large:
If log(half-life)*(1.23 - log(KOc)) <= -2.4

Small:
If log(half-life)*(1.23 -log(KOc))>= -0.4

Medium:
Everything else

Attch 4

United States Department of Agriculture
Soil Conservation Service
P.O. Box 2890
Washington, D.C.
20013

February 28, 1990

NATIONAL BULLETIN NO. 430-0- 7

SUBJECT: SOI - SOIL SURVEY MANUSCRIPTS

Purpose. To insure adequate review of soil survey manuscripts.

Expiration Date. This bulletin expires February 28, 1991.

The state conservationist is responsible for the technical accuracy of the information in soil survey manuscripts.

States have the responsibility to get a detailed technical review of manuscripts by all disciplines. as needed. This can be done through utilization of their staffs. Additional assistance from the NTC can be requested.

NTC technical staffs (soil conservationists, engineers, agronomists, range conservationists, 'etc.) need to assure that their state counterparts are exercising adequate quality control and technical review on the information being placed in the soil survey reports.

To perform quality assurance, NTC technical specialists need to periodically review samples of the soil survey manuscripts from each state. The NTC Directors my request states to periodically send manuscripts to them for review.

The NTC technical specialists spot-check manuscripts with the objective of providing technical oversight and determining if their counterparts need additional training to produce high quality reports. If deficiencies in manuscripts are found, the NTC technical specialists will identify training that will correct the deficiencies and make arrangements to provide training to the technical specialists in the state. The NTC technical specialists will not edit the manuscripts. They will return them to the state for edit.

Edgar H. Nelson

EDGAR H. NELSON
Associate Deputy Chief
for Technology

DIST: N, S. T

Atch 5

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service

WNTC-MGT-2
(Rev. 4/86

WNTC PROJECT CONTROL FORM

In:[1] Jan 1990 Out:

WNTC Review of:[2] Soil Survey ADAMS-WASHINTON AREA, IDAHO
(name of document, SCS location code 6 state, if applicable)

TO:[3] Distribution Date: April 23-90

Purpose of Review: Quality Assurance, spot-check

		Specialist	Type of Documentation	Comments Ret'd
ECS	X	Agronomist		
	X	Biologist	Week of 23rd	
		Environ. Spec.		
	X	Forester	[illegible] (Comments given to Soils 4/[illegible]/90)	
		Pleat Mat. Spec.		
	X	Range Cons.	Week of 23rd	D. [illegible]
	[illegible]	Recr. Spec.		
		Res. Cons.		
		Contract Specialist		
ENGR	X	~~Drainage Eng.~~	~~During week of 23rd~~ [illegible]	
	X	Engineer Geologist	During week of 23rd	
		Environmental Eng.		
~~Irrigation~~		~~Drainage Engineer~~		
	X	Erosion Control Eng.	Week of 23rd	
	X	Hydraulic Engineer		
	X	~~Landscape Architect~~ Soil Mechanics Eng.		
		Planning Eng.		
	X	Sed. Geologist	During week of 23rd [illegible]	
	X	Water Mgt. (Irr)	Week of 23rd	
ESSE		Cultural Res. Spec.		
		Proj. Economist		
		RB Economist		
PROC		RC&D Specialist		
		Water Res. Watershed		
		Water Res. RB & Sal.		
SOILS		Soil*		
		Rer. Inv. Spec.		
IRM		Inf. Resources Mgt.		
WSFS		YSFS		

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Comments to Review Leader MARIO A. VALVERDE by April 27, 90

SUGGESTED STATE SUPPLEMENT TO THE NATIONAL SOILS HANDBOOK

The soil survey manuscript is to be complete prior to submission to the State Office.

The project leader and area conservationist are to certify that: (1) the soil survey manuscript has had input by listed disciplines; (2) that the mappping is complete; (3) that the mapping matches adjoining soil surveys; (4) that soil map unit components have been compared to soil series; (5) that the district conservationist has tested the tables; and (6) that the manuscript is complete.

OVERRIDES

Many sources to problems:

- to rerate, Harvey must remove entries and rerate in 2 steps/sometimes

- when changing any entry on SIR, should rerate all ratings

- any printout that comes back is showing the computer rating where they are different than SIR

- anything older that 1985 that has a date prior to 1985 has not been rated to current criteria

- Harvey is rerating all of Oregon's (800) even recent SIRs

- Broderson and Ames are working out a procedure to eliminate Ames induced problems

- ratings since 1985 have programmed in all numerical footnotes so no need to do those by hand

- have asked NSSC to go thru all this at Interpretations Workshop

*** NSSL DATABASE ***
PEDON COUNTS
01/May/90

** WESTERN STATES **

STATE	TOTAL	PRE1978	<----- 1978-UP	W/TAX	NO TAX	DESCRIPTION	CORRELATED ----->
			1978 & UP				
ALASKA	344	80	264	29	235	207	28
ARIZONA	581	295	286	38	248	198	38
CALIFORNIA	1193	529	664	116	548	341	74
COLORADO	482	212	270	8	262	143	8
HAWAII	42	7	35	17	18	21	17
IDAHO	554	129	425	189	236	199	59
MONTANA	538	296	242	72	170	95	53
NEW MEXICO	360	137	231	94	137	104	72
NEVADA	600	261	339	14	325	181	14
OREGON	478	205	193	1	192	68	18
UTAH	458	265	193	4	189	122	1
WASHINGTON	504	162	342	25	317	151	25
WYOMING	412	191	221	9	212	93	10
GRAND TOTALS ------>	6554	2849	3705	616	3089	1923	417

TOTAL . . All of the pedons in the NSSL Database.
PRE1978.... Pedons sampled prior to 1978 by the NSSL and it's predecessor laboratories.
1978-UP . . . Pedons sampled by NSSL beginning in 1976.
W/TAX ..... Pedons classified by states or TSC's on NSSL Soil-8 forms returned to NSSL.
NO TAX .. Pedons not classified by states or TSC's.
DESCRIPTION Profile descriptions currently stored in the NSSL Database.
CORRELATED Pedons with a correlated series name shown on NSSL Soil-8 form returned to NSSL.

BUSINESS MEETING MINUTES:

1. Taxonomy Committee

New committee members elected and expiration date:

Jerry Freehouf, Forest Service, Colorado	1992
Larry Munn, University of Wyoming	1992
Richard Dierking, SCS, Portland, Oregon	1993
Tom Reedy, SCS, NSSQAS, Lincoln, Nebraska	1993

2. It was agreed to disband the Soil Interpretations Committee.

3. WRCC Committee members elected:

Larry Munn, University of Wyoming - Chairman
Gene Xelly, Colorado State University - Secretary

4. It was agreed that the 1992 conference be held in Flagstaff, Arizona.

Wayne Robbie - Conference Chairman
Dave Hendricks - Conference Co-Chairman
Davie Richmond - Secretary

Other committee members:

Bob Klink - BIA
Russ Kraft - BLM