Edited by:

Dr. Joey Shaw
Assistant Professor
Auburn University

Julie Best
Public Affairs Specialist
Natural Resources
Conservation Service

Dr. William E. Puckett
State Soil Scientist
Natural Resources
Conservation Service

Welcome to the CD-ROM of the Proceedings of the Southern Regional Soil Survey Conference held in Auburn, AL from June 18-22rd, 2000. This CD has been prepared through a cooperative effort between the Natural Resource Conservation Service and Auburn University. All of the software necessary to guide you through the individual presentations is included on this CD. Instructions for operation are on the back of the CD cover. Questions or comments can be directed to Joey Shaw (jnshaw@acesag.auburn.edu), Bill Puckett (bill.puckett@al.usda.gov), or Julie Best (julie.best@al.usda.gov).

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Southern Region Soils Conference - 2000
Auburn, AL.
Sunday, June 18th thru Thursday, June 22nd

Sunday, June 18th	2:00 PM - 5:00 PM	Registration at Auburn Hotel and Conference Center
Monday, June 19th	9:00 AM - 1:00 PM	Registration
	10:00 AM -11:30 AM	Open discussion in Conference Room

Moderator: ***Darwin Newton***
State Soil Scientist
NRCS
Nashville, Tennessee

1:00-1:15	Welcome ***Richard Guthrie*** Associate Dean, College of Agriculture Auburn University, AL
1:15-1:45	***Joey Shaw*** *and* ***Bill Puckett*** Conference Overview
1:45-2:15	Training Soil Scientists ***Tom Hallmark*** Professor Texas A&M University College Station, TX
2:15-2:30	Discussion
2:30-3:00	Break
3:00-3:30	Future of Our Profession ***Dr. Randy Brown*** Department of Soil Science University of Florida Gainesville, FL

3:30-3:45	Alabama Professional Soil Classifiers ***Lawrence McGhee*** Soil Scientist USDA-NRCS Alexander City, AL
3:45-4:15	A Century of the Experiment Station and the NCSS ***Ben Hajek*** Professor Emeritus Auburn University, AL
4:15-4:30	Discussion
4:45-5:45	Agency and University Meetings
6:00-8:00	Social/Mixer-Auburn Hotel Conference Center

Tuesday, June 20th

Moderator: ***Mary Collins***
Professor
University of Florida
Gainesville, FL

8:00-8:20	National Cooperative Soil Survey Program ***Maurice Mausbach*** Deputy Chief for Soil Survey and Resource Assessment USDA-NRCS Washington, DC
8:20-8:40	USDA-Forest Service ***Jerry Ragus*** Soil Resource Inventory USDA-Forest Service Atlanta, GA
8:40-9:00	National Soil Survey Center ***Berman Hudson*** National Leader for Interpretations USDA-Soil Survey Center Lincoln, NE

9:00-9:45 NRCS-Soil Quality Institute
Use-dependent databases
Lee Norfleet
Soil Scientist
Auburn, AL

9:45-10:00 Discussion

10:00-10:30 Break

10:30-10:35 Introduction to technical sessions
Joey Shaw

Clean Water Action Plan/Animal Waste Issues

10:35-10:55 Regulatory Perspectives
Richard Hulcher
Chief, Permits/Compliance Unit
Alabama Department of Environmental Management
Montgomery, AL

10:55-11:15 Extension Perspectives
Ted Tyson
Professor
Auburn University, AL

11:15-11:35 Research Perspectives
Wesley Wood
Eminent Scholar
Auburn University, AL

11:35-11:45 Discussion

11:45-1:00 Luncheon at AHCC
Charles Mitchell
Professor
Agronomy and Soils
Auburn University, AL

Moderator: ***Moye Rutledge***
Professor
University of Arkansas
Fayetteville, AR

1:00-1:10	**Forestry - Brief Introduction by Joey Shaw**
1:10-1:30	Industry ***John Torbert*** Soil Productivity Manager Mead Coated Paper Phenix City, AL
1:30-2:00	Soil Mapping in Timber Lands ***Joe Schuster*** Soil Scientist Ecological Resource Consultants Panama City Beach, FL
2:00-2:20	US Forest Service ***Emily Carter*** Research Soil Scientist Auburn, AL
2:20-2:35	Discussion
2:35-2:55	Break
2:55-3:00	**On-site sewage disposal** **Brief introduction by Moye Rutledge**
3:00-3:20	Alabama Department of Public Health ***David Gray*** Soil Scientist Montgomery, AL
3:20-3:40	Research ***David Lindbo*** Professor North Carolina State University Plymouth, NC

Tuesday, continued

3:40-4:00 On-site Certification in Georgia
Larry West
Professor
University of Georgia
Athens, GA

4:00-4:15 Discussion

Wednesday, June 21st

Moderator: ***Bill Smith***
Professor
Clemson University
Clemson, South Carolina

Innovations in Pedology

8:00-8:20 ***Michael L Golden*** (PEN)
State Soil Scientist/MO9 Team Leader
USDA-NRCS
Temple, TX

8:20-8:40 Auburn University Digitizing Project
John Beck
Research Associate
Auburn University, AL

8:40-9:20 Expert Knowledge
A-Xing Zhu
Assistant Professor
University of Wisconsin
Madison, WI

9:20-9:40 Soil Surveys on National Park Lands
Pete Biggam
Soil Scientist
National Park Service
Fort Collins, CO

9:40-10:00 Digital Map Finishing
Darwin Newton
State Soil Scientist
USDA-NRCS
Nashville, TN

10:00-10:30 Break

Wednesday, continued

10:30-10:50	German Soil Portection Law ***Heinrich Höper*** Soil Survey of Lower Saxony Bremen, Germany
10:50-11:10	Mine Reclamation Project ***Janice Branson*** University of Tennessee Knoxville, TN
11:10-11:30	Soil Taxonomy Update ***Warren Lynn*** Soil Survey Center Lincoln, NE

Lunch 11:30 -1:00

1:00-3:30	Business Meeting- ***Berman Hudson*** -First old business-breakout groups/action items from 1998 -Committee reports
3:30-3:45	Break
3:45-4:00	Field Trip Overview ***Joey Shaw & Bill Puckett***
4:00-4:15	Conference Wrap-up **Joey Shaw and Bill Puckett**

Wednesday evening Social and
Barbecue Supper

Thursday, June 22nd **Field Trip** **7:30 - 11:30**

Educating Soil Scientists

C. T. Hallmark
Soil & Crop Sciences
Texas A&M University

It is insufficient to address only the education of soil scientists. One must obtain a broader view from recruitment of potential students through the education, mentoring and training process with a vision of what will be required of soil scientists in the future. This necessitates an understanding of the changing demographics of our population, and an appraisal of attitudes, expectations, and future realities.

Changes in American demographics during the 20th Century are obvious. In 1900, the celebrated birth of our soil survey, 40% of the nation's 75 million people were farmers. Today, our population stands at about 320 million and less than 2% are "on the farm". Most live in an urban or interurban setting and are two- or three-generations removed from the land. For them, "agriculture is no longer viewed as an institution or life style to be accorded special protection" (Miller, 1995). It is largely a group that has not known hunger, and their interests and social agenda tend toward crime prevention, economic competitiveness, education, health care, global change, and environmental quality. "Food security and diversity are assumed, thus, society has little or no incentive to continue to fuel the cornucopia that produces this bounty – kind of like 'why worry about agriculture as long as we have supermarkets?' " (Miller, 1995)

These shifts in demographics and attitudes affect the very fabric of society and can be seen in politics, impacting agencies and our education system, especially the land-grant system. Consider the composition of state and U.S. legislators and subsequent committee assignments. Table 1 illustrates the influence of urban centers in Texas on the legislative process, even on committees that in the past would have been sought and dominated by the agricultural community. Similar examples could be used from every state represented in these meetings. The membership of the Natural Resources Committee includes three lawmakers from San Antonio, the largest city in our nation to obtain its drinking water entirely from groundwater. That aquifer is also the source of irrigation for the "winter garden" of Texas, and the subject of a number of court cases to maintain minimum flow through aquifer-fed springs for the benefit of endangered species. The continued growth of San Antonio, their reluctance to develop alternate water sources, and their political position, will result in irrigation waters diverted to fuel the city's expansion.

Table 1. Selected committee composition in the 1999 Texas House of Representatives

Committee	Number from Urban Centers	Total No.
Education (Subcommittee)	3	5
Environmental Regulation	6	9
Land and Resource Management	5	9
Natural Resources	5	9

Agriculture is commonly viewed by the public as a competitor for natural resources. Little connection is made between natural resources and a dependable supply of high-quality food at reasonable prices. "They view Colleges of Agriculture as concerned with the special interests of farming and agribusiness, not with food supply and nutrition" (Miller, 1995). Further, the public sees these colleges as irrelevant to their lives.

These changing demographics and attitudes of the public have resulted in numerous changes in education. Public education (K-12) continues to receive increased funding but remains under fire for low achievement scores, especially in math and science as compared to other developed countries. Universities have been required to do more with fewer real dollars, even during periods of enrollment growth, necessitating reallocating dollars into colleges where enrollments are growing at the expense of colleges with little or minimal growth. In our land-grant universities, growth has been in Colleges of Business, Liberal Arts, and Education. Our Colleges of Agriculture found themselves in an identity crises, tied to a clientele and curricula of which the public viewed as irrelevant to their lives, outdated, and unworthy of support. Faced with dwindling support, colleges sought to restructure, broaden missions, rename and respond to the new realities. Among others, themes of activity included urban issues, natural resources, the environment, and biotechnology. Research, extension, and teaching activities and resources, shifted, but the public was reluctant to accept these at face value often viewing agriculture as the problem rather than a partner in solutions. They viewed the colleges as industry spokesmen, biased, and performing research funded largely from grants by agri-businesses with a vested interest. Both colleges and agri-businesses have excalibrated this perception with highly visible announcements of "partnerships", partnerships that are equated with bias in the eyes of Mr. Public Q. Citizen.

This preamble is necessary to set the stage for a discussion of educating soil scientists. It gives a picture of the realities of our times. The future soil scientist will be drawn from a limited segment of society's pool, must be recruited, educated, mentored, nurtured, and equipped to meet the demands of the future. Compared to yesterday, today's high school graduate has less contact with the land and natural resources, is environmentally aware but consumer driven, is computer and technology wise with little interest in "causes". The typical graduate will be urban, have little or no concept of soil science, and be counseled in high school by professionals with an inadequate understanding of career choices in soil science (and agriculture). Choices of major are usually in areas of exposure during high school and are highly influenced by respected individuals with whom they have developed a close relationship. Many will enter higher education through a community college to ease the transition to a large university and reduce the expense of their college education. Most will change majors after exposure to lower-level classes either because they find other pursuits more interesting, or because performance in the first major is poor. Often, the student selecting a major in areas of the environment is more interested in policy and issues, and poorly equipped to handle the math and science of soils-based curricula.

Recruitment can be along a number of avenues and be directed at both pre-college and college students. It is often more effective when directed to college students because (1) they are

searching for the right major, (2) they are already admitted, and (3) they can be quickly inserted into stimulating courses/activities that will cultivate their professional growth. Opportunities for recruitment are given in Table 2, a list that is not considered exhaustive.

Table 2. Recruitments Opportunities

Pre-College Target
4-H, FFA judging, leadership activities
Career Days, on and off campus
Science Fairs
Employment, summer apprentice programs
Summer camps
College Student Target
Introductory courses
Advertisements through general studies
"Pizza and the environment" promotions
Transfer Career Day
Student promotions
Contacts at community colleges

Of the list in Table 2, involvement with youth activities, specifically 4-H and FFA, has proven to be most productive in recruitment of the pre-college pool. As the individual responsible for soils/land judging for four high school contests per year, I have the opportunity to observe the contestants, encourage them to consider soil science and be available to answer questions. But, what really brings high school soil judgers into soil science is a respect for the soils coach, and an interest that develops from that relationship. If there were one recruitment activity for endorsement by our discipline, my vote would be involvement as a coach for soil/land judging.

Once the recruited student arrives in the soils classroom, a number of endeavors add significantly to his/her development as a student and as a scientist. These include curriculum (courses required and elected), internships and activities (such as clubs, field trips, collegiate soil judging).

If we consider the traditional curricula of soil scientists by USDA or ARCPACS, we see courses required of the perspective soil scientist steeped in tradition and that has changed little over the past generation (Table 3).

Table 3. Courses Recognized by Category for Hiring of Soil Scientists in the Federal Government

CORE SUBJECTS	DIVERSITY SUBJECTS
Soil geomorphology	Geology
Soil classification	Forestry
Soil chemistry	Regional planning
Soil microbiology	Plant science
Soil Physics	Crop production
Soil Fertility	Computer science
Soil-Plant relationships	Technical writing
Soil Genesis/morphology	Irrigation/drainage
Soil Survey	Aerial photo interpretation
	Statistics

The requirements for ARCAACS Certification are similar. Those of us who work with undergraduate students in a teaching environment recognize a problem of terminology – Into what category does a general soils course fit? How about Environmental Soil Science? Soil, Water and the Environment? But a more fundamental questions is not what was needed twenty years ago, but how do we prepare our students for soil science in the 21st century? What knowledge will be needed and what areas of science and technology must the future soil scientist master? Who are the groups needing soil information (and education)?

These questions lead us naturally into a consideration of the future of soil science, a subject that will be addressed by the next speaker. We are not trying to "steal" that subject, but will use Dr. Brown's comments to augment some of the curricula changes for evaluating soil scientist.

Two timely articles appeared in the May 2000 NCSS Newsletter, articles by T. E. Calhoun (One View of the Future) and Horace Smith and Berman Hudson (Soil Survey in the Twenty-First Century). I recommend both articles because they also underscore that the future soil scientist will be working with different tools, interfacing with different users, and answering/addressing new questions. A few areas for future soil scientists would include: precision agriculture (site specific management), geographic information systems, quantifying and expressing spatial variability, best management practices, maximum daily loading rates for maintaining water quality, emphasizing an environmentally benign agriculture, and mitigating greenhouse gas through soil carbon sequestration.

Do we have the correct curricula to prepare students to address these new directions? At the least, we need to add to the diversity subjects to include courses in ecology, precision agriculture, waste management, GIS, hydrology, watershed management, and public speaking. Today's list of diversity subjects are still strongly agricultural production oriented yet much of our future will be in the soil science of watersheds, ecosystems, and agro-ecosystems to address needs of a more urban society. Our future soil scientists must be able to make that transition, and must have the tools to address these new endeavors. A sophisticated suburban population will demand attention, and will be impatient toward any government agency or institution that is not using the most up-to-date technologies. We must remember and act upon the words of David Thornburg – "We must prepare students for their future, not our past."

REFERENCES

Miller, F. P. 1995. Forces driving changes in Colleges of Agriculture. J. Nat. Resour. Life Sci. Educ. 24: 9-13.

Professional Soil Classifiers of Alabama
Lawrence E. McGhee, PSC

The Professional Soil Classifiers Association of Alabama is a professional organization for individuals interested in soil classification and related issues in the state of Alabama. Interested persons can become an affiliate member or can become a registered member by complying with the qualification of the Professional Soil Classifiers Registration Act and Amended Act.

The Professional Soil Classifiers Registration Act was passed in 1981. The Act was amended in 1991 to include the qualification requirements. The State Board of Registration for the Registered Professional Soil Classifiers is the Alabama Soil and Water Conservation Committee. A five-member advisory council comprised of four professional soil classifiers and one administrative officer from the State Soil and Water Conservation Committee advises this Committee.

Currently, there are 50 registered professional soil classifiers practicing in the state of Alabama. Some activities classifiers are involved include:

Site Evaluation
Soil Mapping
Wetland Delineation
Percolation Test
Soil Interpretation Ratings
Predevelopment Soil Evaluation
Training

Additional information can be obtained by visiting the Professional Soil Classifiers of Alabama on the web at www.ag.auburn.edu/aaes/alrichome/PSCA/pscasite.html

Professional Soil Classifiers Association of Alabama

Lawrence McGhee

Professional Soil Classifier

State of Alabama

- Professional Soil Classifiers Association
- Professional Soil Classifiers Registration Act and Amended Act

Legislation

- *Professional Soil Classifiers Registration Act No. 81-766 1981*
- *Professional Soil Classifiers Registration Amended Act Act No. 91-582 1991*

State Board of Registration For Registered Professional Soil Classifiers

Alabama Soil and Water Conservation Committee

Advisory Council (5 Members)

4 - PSC

1 -Admin. Officer of AL Soil and Water Conservation Committee

Registered Soil Classifiers in Alabama

- Currently 50 Registered PSC in the State of Alabama

Soil Classification

The soil science evaluation of the nature, physiochemical properties, formation, taxonomic classification, and general land use suitability on the basis of these parameters within a soil management criteria; it shall specifically include the mapping and identification of surficial and subsurface soil profiles, and the soil management interpretation of these data.

Soil Classification centers on soils as the biochemically weathered part of the earth's crust, the collection of natural bodies on the earth's surface, supporting plants, with a lower limit at the deeper of either the unconsolidated mineral or organic material lying within the zone of rooting of the native perennial plants; or where horizons impervious to roots have developed the upper few feet of the earth's crust having properties differing from the underlying rock material as a result of interactions between climate, living organisms, parent material, and relief.

Soil Classifiers Activities

- Site Evaluations
- Soil Mapping
- Wetland Delineation
- Percolation Test
- Soil Interpretation Rating
- Predevelopment Soil Evaluations
- Training

Visit the Professional Soil Classifiers Association of Alabama on the Web At:

www.ag.auburn.edu/aaes/alrichome/PSCA/pscasite.html

Role of State Agencies in Soil Survey: 100 Years of Cooperation

Ben F. Hajek, Professor Emeritus[1]

Almost from the onset, soil survey in the US was a cooperative effort between federal and state agencies. States were participating in field mapping and correlation before 1905. In Alabama, soil surveys published in 1902 - 1905 did not indicate any participation by the state. The State Department of Agriculture and Industries was listed as a cooperator on a survey published in 1907. This Alabama agency continued to employ soil scientists as late as 1960.

Any contributions of state experiment station personnel are overshadowed by federal agency personnel, especially during the early development days of the NCSS. Workers at state universities were concerned primarily with the soils as they related to production of crops. This was evident to WWI and somewhat beyond.

M.L. Cline (1977) indicated that communication between university faculty and federal scientists in the Bureau of Soils was seriously lacking prior to WWI. There was no forum common to the two groups. Following WWI, in 1920, a soil scientist group was formed. The organization which was made up of both federal and state scientists, held their first meeting in Chicago in 1923 and were fully functional by 1925. Proceedings of the American Association of Soil Survey Workers were published annually. This organization was the nucleus from which, in 1935, was formed the Soil Science Society Of America. Currently Division S-5 is a direct continuation of this 1920 group of soil scientists. Volume 1 (1936) of the Soil Science Society Proceedings, Division V, listed L.C. Wheeting of Washington State College as chairman and Past Chair was G.D. Scarseth of the Alabama Agricultural Experiment Station. The society had

[1]Ben F. Hajek, Agronomy and Soils Dept., Auburn Univ., Auburn Alabama 36849

$890.14 on deposit.

In 1952 the Bureau of Soils and the Soil Conservation Service soil survey, merged. Under the leadership of Dr. Charles Kellogg, the National Cooperative Soil Survey, as we know it today developed with full participation by many state and federal agencies in state, regional and national work planning conferences and various cooperative projects such as making regional and state soil association maps, and regional research projects and work groups.

I did not attempt to catalog and review all specific contributions made by scientists while employed by state experiment stations or other agencies. I have confined this to a few areas and will list some individuals as examples of the many who contributed and who gave a professional lifetime to the NCSS while employed by state agencies and working in close cooperation with soil survey field parties, state, regional, national and in many cases international soil staffs. The topics are loosely grouped into the following sections:

Development of Basic Understanding and Theories

Education, Publication and Training

Soil Mapping

Characterization and Support

Financial Support

Leadership

DEVELOPMENT OF BASIC UNDERSTANDING AND THEORIES

Eugene W Hilgard is the most noteworthy state employed scientist that significantly added to our knowledge of soils. He began his work in Mississippi from 1855 to 1873 before the US soil survey began. He worked a brief time in Michigan, 1973 to1975 and spent the rest of his career in California, 1875 to1906. He enumerated most of the theories of soil that the Russians

used as the foundation of their concepts.

Hilgard at the same time or earlier than the Russians recognized the correspondence among soil regions, biological regions, and climatic belts. His book, “Soils, Their Formation, Properties, Composition, and Relations to Climate and Plant Growth in the Humid and Arid Regions”, is a classic, published in 1911 after a long career of research in the eastern and western United States, is relevant today (may need to update nomenclature). His work did not receive adequate recognition. Marbut must have been aware of his work but chose to take tools developed in Russia to develop a system of soil classification for the United States (Cline, 1977). I cannot understand why Marbut gave absolutely no credit to Hilgard in his Introduction in Joffe’s book, “Pedology”, which is a significant contribution from Rutgers University.

In Joffe’s book Marbut makes a point to define Pedology as the only true and unique branch of “Soil Science”. Pedology is not a fundamental science as are math, chemistry and physics, it is an independent sciences dealing with a natural body “soil” the same as botany deals with the natural body “plants”, and zoology with “ animals”. Pedology has a unique nomenclature and starting with Hilgard and Duchieviev, pedology provides the basis for all other disciplines now collectively called soil science.

EDUCATION, PUBLICATION AND TRAINING

Dr. Hans Jenny’s, book “Factors of Soil Formation: A System of Quantitative Pedology” has provided a frame work for teaching pedology. He inspired us to think mathematically and logically about soil formation and about integrating soil forming factors to help explain the morphological nature of soils. Later his book “The Soil Resource: Origin and Behavior” published in 1980, provided quantitative examples of soil formation and is and excellent reference for any serious student of pedology.

For years many of us teaching soil morphology and classification did not have a classroom text. When I first started, as a student and an instructor I had The Soil Survey Manual, which was an excellent reference but not a teaching text. Stan Buol (NC State), Frances Hole (Wisconsin) and Ralph McCracken (NC State and Washington, D.C.) contributed significantly to soil survey by authoring the book, "Soil Genesis and Classification", now in its 4th edition. Later Del Fanning, Maryland, published "Soil Morphology, Genesis and Classification" also and excellent text. However, changes in Taxonomy necessitated editing as soon as it was published.. Dr. Fanning made his typed manuscript available before his book was published. The manuscript provided many complete lesson plans for instructors.

I am confident that anyone that has taken a course in soil classification learned, either directly by reading his publications or indirectly from literature citations, from Dr. M. Cline (Cornell, New York). His paper in Soil Science (vol. 67: 81-91) "Basic Principles of Soil Classification" provides a basis for understanding not only the basics of soil classification but also the logic in classifying things.

Starting in the 1950's Land Judging and Collegiate Soil Judging offered a new approach to teaching soil morphology, classification and interpretation. Teaching soil judging was a college and university function. Setting up contests was usually a joint state - federal activity. Today it is not uncommon for employers recruiting agronomy graduates for soil survey positions ask if they had participated in soil judging. Participating in soil judging attracted many women and men into careers in soil survey.

Graduate programs, M.S. and Ph.D. have provided the opportunity for Experiment Station faculty, students and federal soil scientists to participate in research from the identification of a problem or need, to sampling, analysis, and interpretation. Numerous students

became soil scientists after completing graduate studies. Many full-time soil scientists earned graduate degrees while working and adjusted schedule or while on leave-without-pay.

USDA-NRCS entered into agreements with several universities that conducted soil classification workshops, short courses, and formal courses that qualified for graduate credit.

It is in this realm, education, publication of research results, and participating in training soil scientists, that experiment stations have made their greatest contributions to the National Cooperative Soil Survey. They also provided early career employment opportunities to many scientists who moved on to federal agencies. The list includes:

Whitney

Marbut

Guy Smith

Charles Kellogg

Richard Arnold

Ralph McCracken

SOIL MAPPING

State agencies have participated in soil mapping by providing field soil scientists that mapped in state mapping parties or were attached to NRCS soil survey parties. Correlation and quality control were provided by NRCS, however experiment station faculty that had state responsibility for soil survey assisted in reviews and correlations. I use my state as an example, because Alabama became involved early in the survey. The first published soil survey that listed Alabama Department of Agriculture and Industries as a cooperator was published in 1907. Consequently cooperation must have started earlier. Alabama (Department of Agriculture and Industries) employed soil scientists into the early 1960's. I am aware that some states are still

employing soil scientists to accelerate the soil survey. This opportunity for early careers training also provided soil scientists that joined NRCS for a career in soil survey.

CHARACTERIZATION SUPPORT

Experiment station laboratories throughout the US provided and are providing soil characterization data. When Soil Taxonomy was adopted all regions of the US needed laboratory data to classify in the new system. The NRCS regional laboratories at that time were providing support both with field sampling and characterization however, state labs assumed, in some cases the entire characterization needs for surveys in their respective states. A survey by the laboratory subcommittee of Div. S-5 (Soil Science Society of America) conducted in the mid 1970's received responses from all regions of the United States. The results indicated that state laboratory data consisted from only particle-size to all data needed to classify soils. Particle size was the most frequently requested data probably because of family particle-size class limits and criteria for argillic horizons needed to classify soils.

APPROPRIATED FINANCIAL AND FACILITY SUPPORT

State support for soil survey includes more than actual field mapping and correlation. Funds are appropriated directly to be used by NRCS for soil survey activities. State and local agencies provide office space and office support staff. A major source of support are state appropriations to the state and local soil and water conservation committees.

LEADERSHIP

From the onset soil survey was a cooperative federal-state effort, and despite some breakdown in communication the cooperative has been successful. The success is primarily a tribute to individual state and federal soil scientists recognizing the need and benefits of cooperation and not administrative directives and policies. In contrast, Joe Nichols and I had the

opportunity to evaluate the soil survey program in another country. We found three agencies involved in soil survey with essentially no effective cooperation. I often wonder what happened to that program.

During the approximation phase of Soil Taxonomy, and following publication, Dr. Smith and his successors in the soil survey relied heavily on input and leadership for initial definition of classes and later for leadership in making major revisions in Soil Taxonomy. Marlin Cline stands out for his major contributions to soil classification during this period and later he headed the effort to revise the Soil Survey Manual. Major revisions to taxonomy were made under the leadership of the chairmen of ICOM- International Committees, for Oxisols, Stan Buol, North Carolina State University, Spodosols, Bob Rourke, University of Maine, Gelisols, James Bockheim, Wisconsin, Families, Ben Hajek, Auburn University, and currently, Antrophic soils, Ray Bryant, Cornell University. These were major efforts with experiment station leaders time being supported by their respective state teaching and research budgets. In today's committee, goal, strategic plan, and competitive grant society, I wonder if many experiment station pedologists today have the opportunity to contribute at this level.

In conclusion, I repeat that it is in the realm of education, publication of research results and books, and in direct participation in training soil scientists that experiment station personnel have made their greatest contributions to the National Cooperative Soil Survey.

Suggested Reading:

Arnold R. W, 1999. 100 years of soil survey in the USA. Bulletin of the International Union of Soil Science. p 40-43.

Cline, M.G. 1977. Historical highlights in soil genesis, morphology and classification. Soil Sci. Soc. Am. J. 41:250-254.

Miller, M.P. 1949. Progress of the soil survey in the United States since 1899. Soil Sci, Soc Am. J. 14: 1-4.

Simonson, R.W. 1986-1987. Historical aspects of soil survey and soil classification. Parts, I-VII. Soil Survey Horizons. 27 and 28: 52 p.

NATIONAL COOPERATIVE SOIL SURVEY PROGRAM

Maurice J. Mausbach

Southern Regional Soils Conference

June 18-22

SOIL SURVEY STATUS MAPPING

- Total area 2,313,207,929 acs

- Private land mapped----------91%
- Public lands mapped----------80%
- Indian lands mapped----------75%
- Total area mapped----------90%
- Total area updated----------4%
- Total area in need of updating----------41%

SOIL SURVEY STATUS MANUSCRIPTS

- Soil Survey Areas 3,253
- Soil survey areas published 2,485
- Soil survey areas being updated 597

SOIL SURVEY STATUS PERSONNEL

- Total Soil Scientists in Program 1,011
- NRCS soil scientists 941
- Non-NRCS soil scientists (est.) 70

SOIL SURVEY STATUS DIGITIZING

- No. of Surveys Tracked for SSURGO 1384
- Surveys digitized and SSURGO Certified 841
- Surveys certified during FY-99 366
- Surveys certified during FY-00 136

PERSONNEL AND STAFFING

- Dr. Sheryl Hallmark-Kunickis reports July 2
- Dr. Bob Ahrens Director NSSC
  - Dr. Berman Hudson - N.L. Interpretations
  - Dr. Dewayne Mays - Dir. Soil Survey Lab.
  - Dr. Carolyn Olson - N.L. Investigations
  - Jim Culver - N.L. Technical Services
  - Vacant - N.L. Soil Class. and Standards
- Dr. Craig Ditzler Director Soil Quality Instit.
- 675 > 45, 70 can retire now and 175 in 5 yrs.

BUDGET

- FY - 2000 budget
  - Soil Survey was level
- FY - 2001
  - Presidents budget was level
- FY - 2002 Developing Initiative
  - rebuild field infrastructure
  - hire soil scientists
  - Accelerate mapping (urban, Native American lands, MLRA concept, web based products

NASIS

- NASIS 5.0 Scheduled to be released November 2000
- Implemented a central server
- Windows Pedon 1.0 is scheduled for release August 2000 (will facilitate importing descriptions to NASIS)

SOIL SCIENCE INSTITUTE

- Held at Alabama A&M
- 35 participants
- Very successful session

OUTREACH

- Soil Science Scholars program
  - 5 1890 institutes
  - an Hispanic-serving institution
  - a Native American-serving institution
- Increased mapping on Native American Lands
- Urban interpretations to support envrionmental justice

INTERNATIONAL ACTIVITIES

- Actively involved - budget constraints
- Activities must related to and benefit the NCSS

1999 NATIONAL CONFERENCE HIGHLIGHTS

- Presentation in honor of Cr. Curtis Marbut
- 1st Soil Scientist of Year Award - Dr. Sam Indorante
- Panel on centennial memories
- Breakout discussions on
  - Data Aquisition for problem solving
  - Training and marketing SS for the future
  - Selling soil scient to society

SUPER MLRA PROJECT OFFICES

- Better staffed and equipped
- Locate on university campuses
- Locate relative to MLRA
- More stable less moving for staff
- Employ GIS specialists and other disciplines

SPECIAL PROJECTS AND INVESTIGATIONS

- Phasing out wet soil projects
- Subaqueous soils intitative started by late George Demas
- Initiating a ues-dependent database of near-surface and temporal soil properties
- Soil Phosphorus benchmark study with ARS, EPA, and Others

NEW INITIATIVES AND PRIORITIES

- Expert Systems
- Fuzzy logic
- GIS applications
- Digital map finishing
- Update Agriculture Handbook 296
- Emphasis on Technical Soil Services

Adding Value to Soil Surveys With a Dynamic Soil Properties Database

Lee Norfleet

Soil Quality Institute

The “Next Generation”: A Challenge and an Opportunity

- Starting with an existing survey and a charge to “update and modernize”.

What does this mean???

- Update classification?
- Draw new lines?
- Transects for map unit composition?
- Update yields?
- Describe to 2 meters, some deeper?
- Digitize for SSURGO?
- CD-Rom and web-based distribution?
- All are worthwhile goals.

Key is to:

Build on the existing product
so that modernized surveys are
BETTER
than the old ones, not just
DIFFERENT.

Two Views of Soil Properties

- ***Inherent*** **-** fixed, unlikely to change.
  - Texture, mineralogy, depth, color.
- ***Dynamic*** **-** respond to land use and management. (Especially in upper part of soil.)
  - Organic matter, bulk density, pH, aggregation, organisms, CEC, permeability.

Soil Survey Considerations

- Soil Taxonomy purposely avoids consideration of dynamic properties to achieve consistent taxonomic placement.
- Soil Maps can not effectively show spatial distribution of dynamic soil properties.
- Soil Databases can be used to record this information.

I will present 3 Examples:

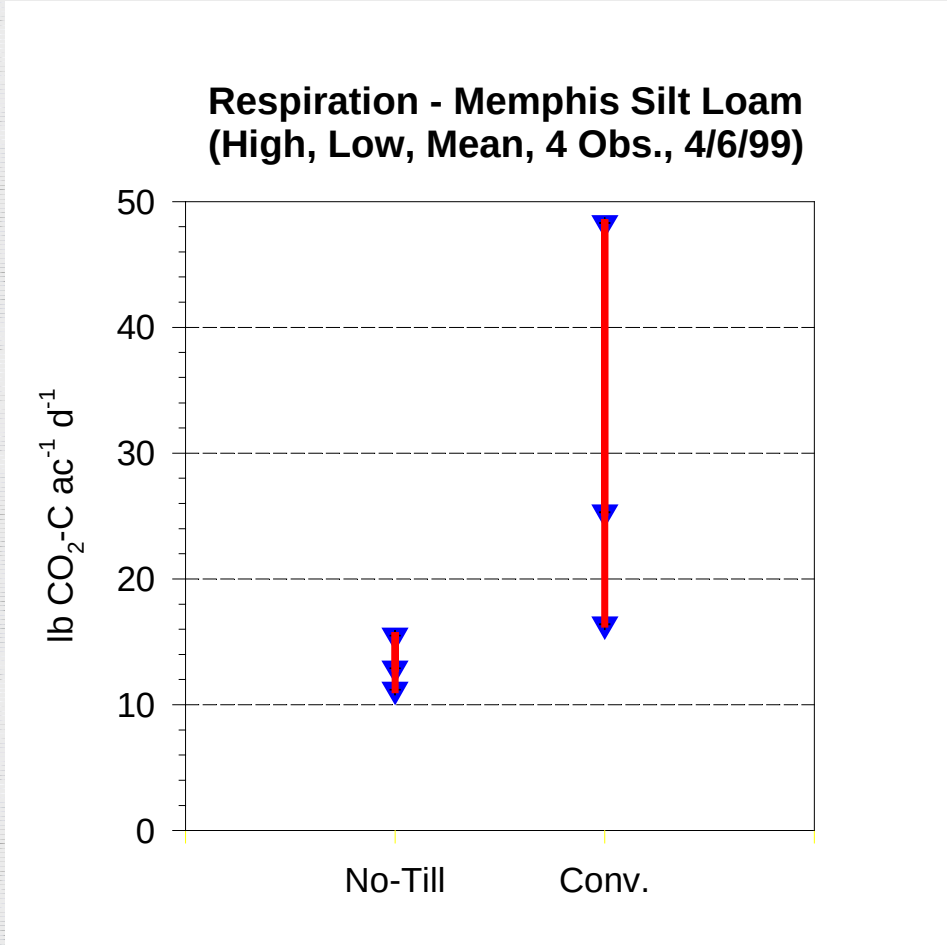
- Milan, TN exp. Station - Memphis, Sil.
- Auburn Univ. exp. Farm - Compass, LS
- Eastern Nebraska Data:
  - Aksarben and Monona series.

#1) Memphis Silt Loam - Milan, TN

- Fine-silty, mixed, active Typic Hapludalf
- Soil quality test kit used to compare effects of no-till and conventional tillage on experiment station plots.

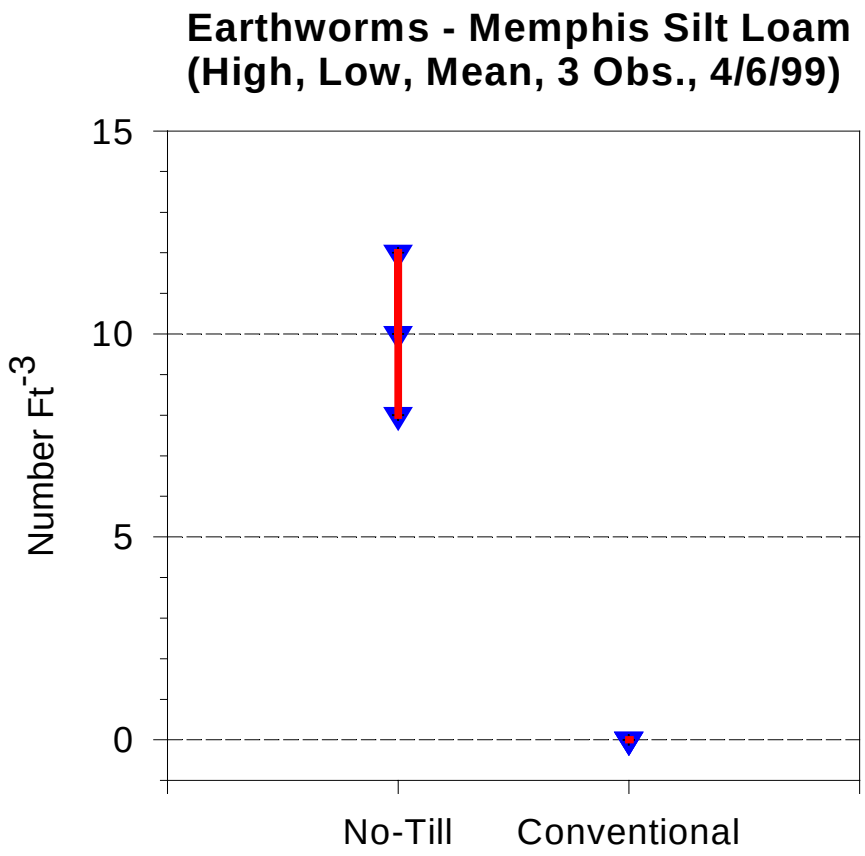
Biological Activity

- CO_2 evolution within 6-inch ring.
- Generally higher and more variable on conventionally tilled area.
- Organic matter is being consumed.



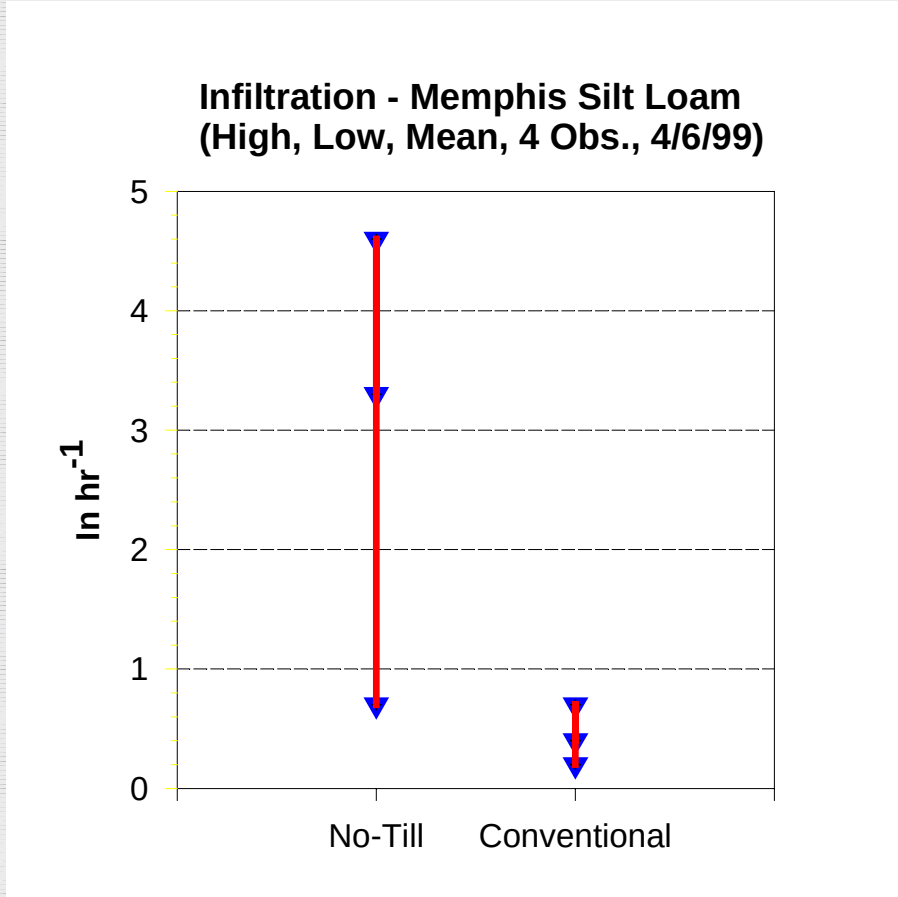
Biological Activity

- No earthworms observed in the conventionally tilled plots.

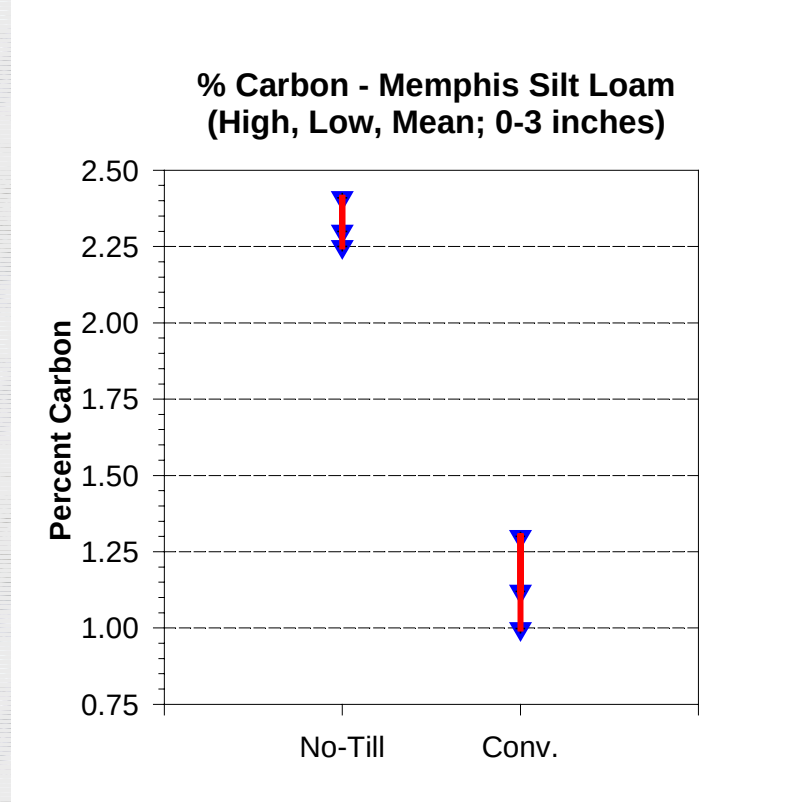


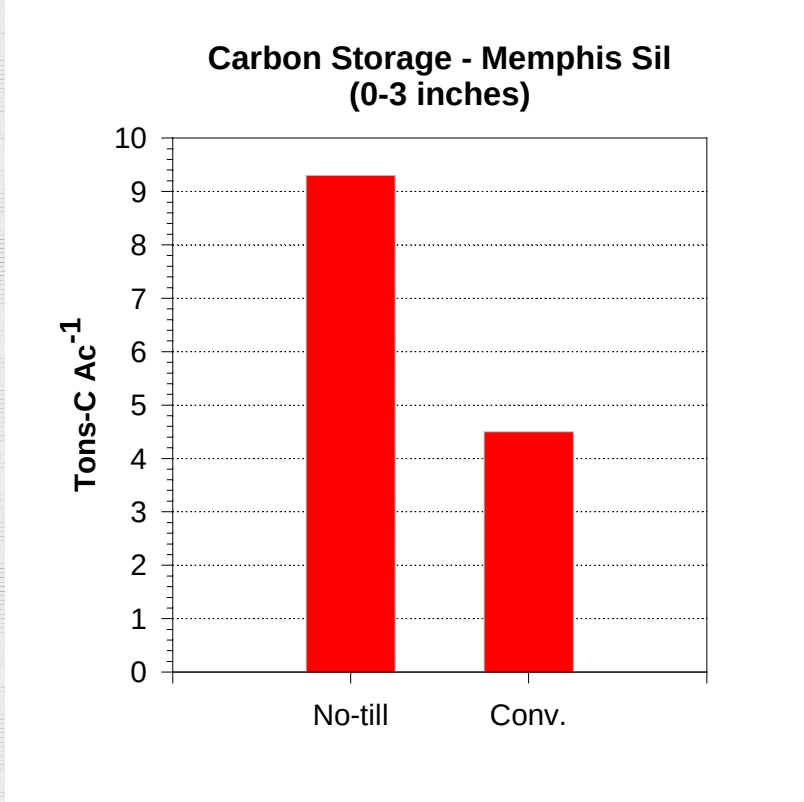
Water Movement Into Soil

- Single 6-inch ring.
- Generally lower and less variable on conventionally tilled plots.
- Currently not in NASIS, but a good indicator of soil quality.



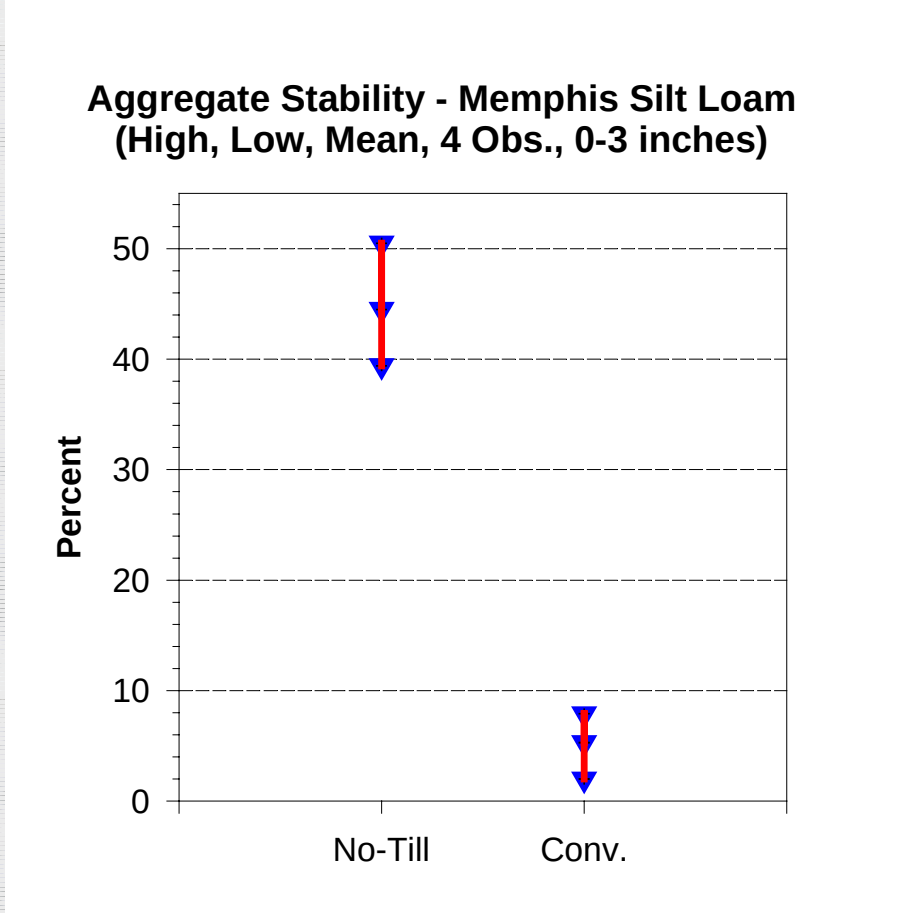
Carbon Content





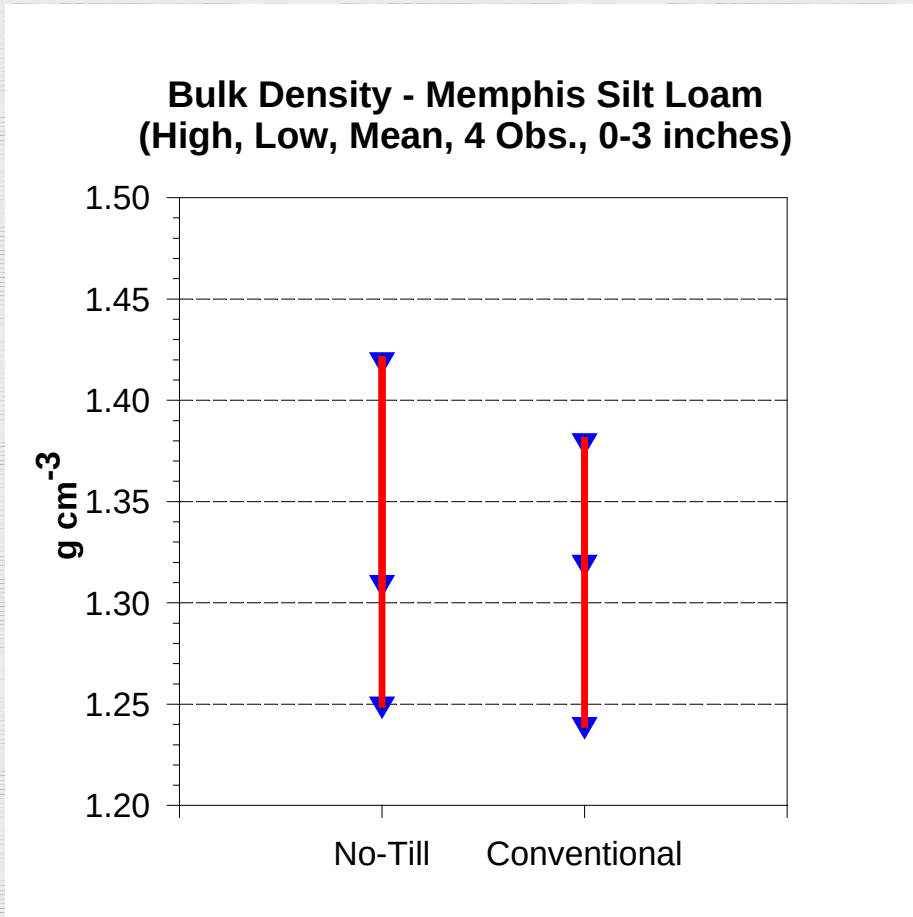
Stability of Peds

- Wet sieve procedure.
- Much greater aggregate stability under the no-till treatment.
- Currently not in NASIS, but a good indicator of soil quality.



Bulk Density

- 6-inch diameter core.
- Similar under both treatments.

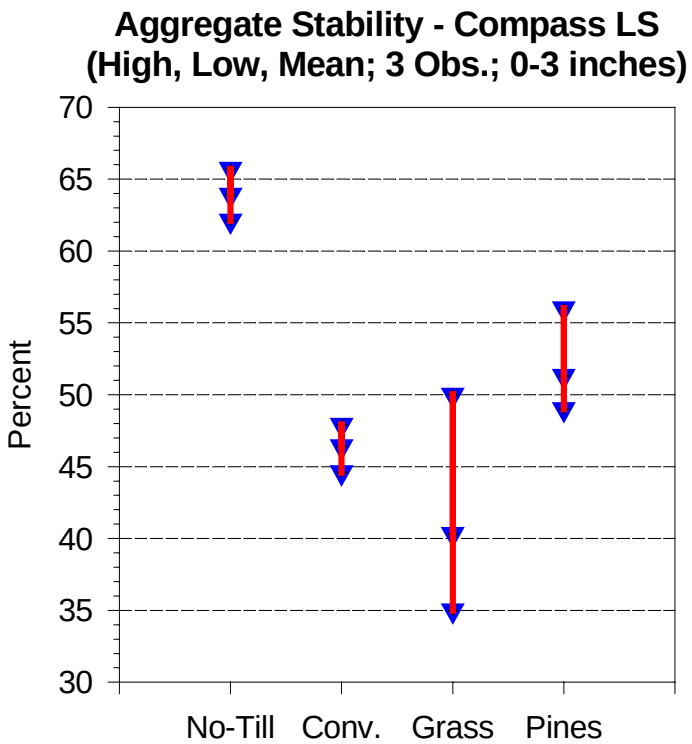


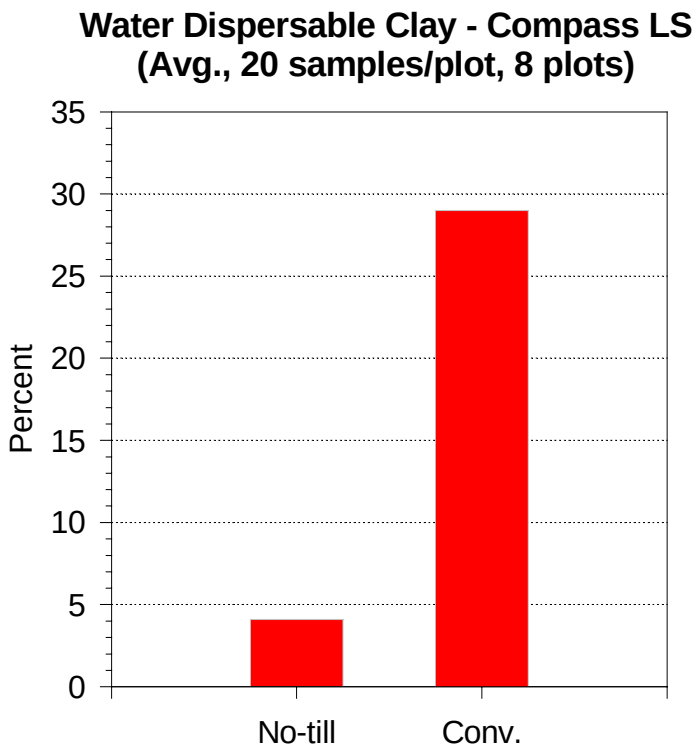
#2) Compass, Loamy Sand - Auburn, AL

Coarse-loamy, siliceous, subactive, thermic Plinthic, Paleudult

- Auburn University Experimental Farm
- Comparisons:
  - Conventional-till
  - No-till
  - Grass
  - Planted Pines

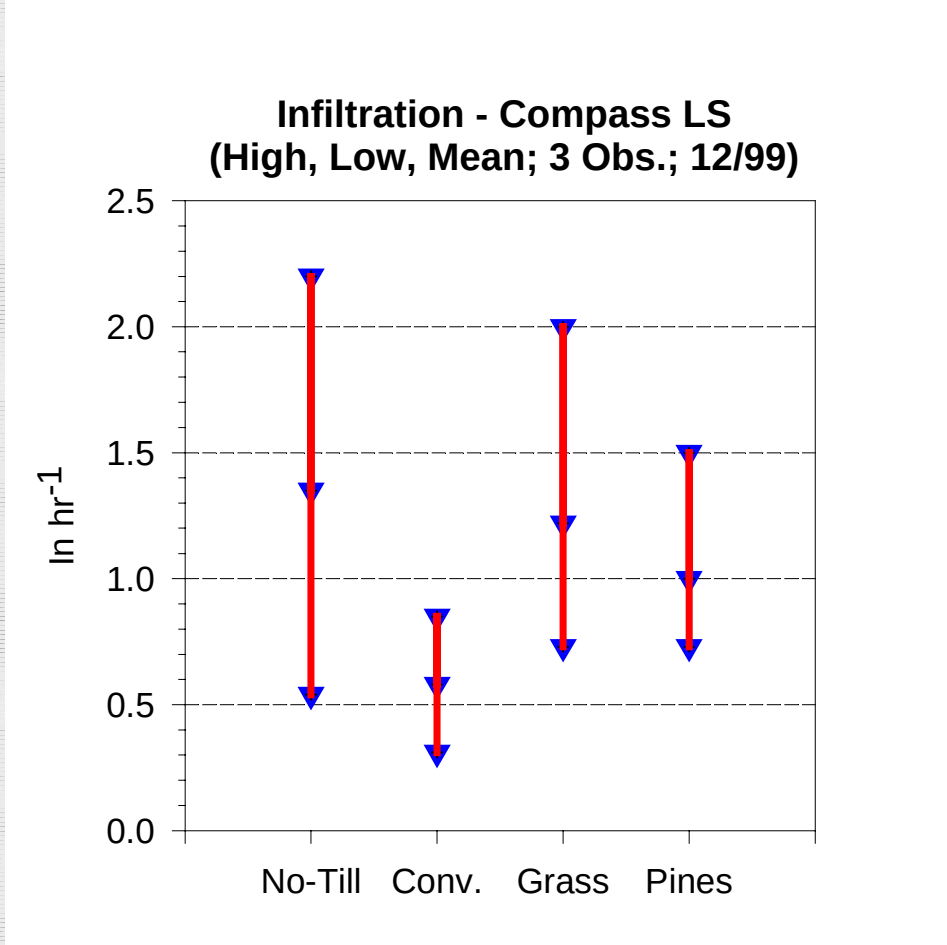
Stability of Peds





Water Movement (into soil)

- Cornell Infiltrometer.
- Slowest For Conventional Tillage.
- No-Till and Grass most variable.



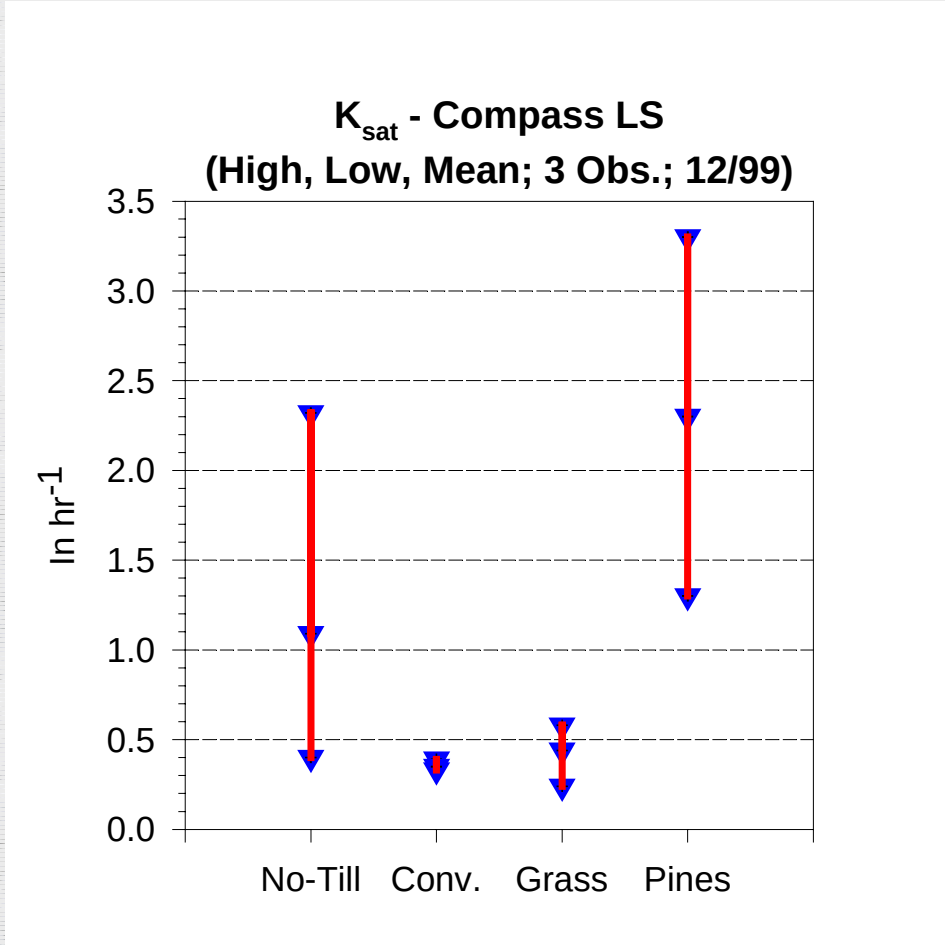
Water Movement (subsoil)

- Amoozemeter
- Slowest for conv. tillage and grass.
- Most variable for no-till and pines.

0.2-0.6 = mod. Slow

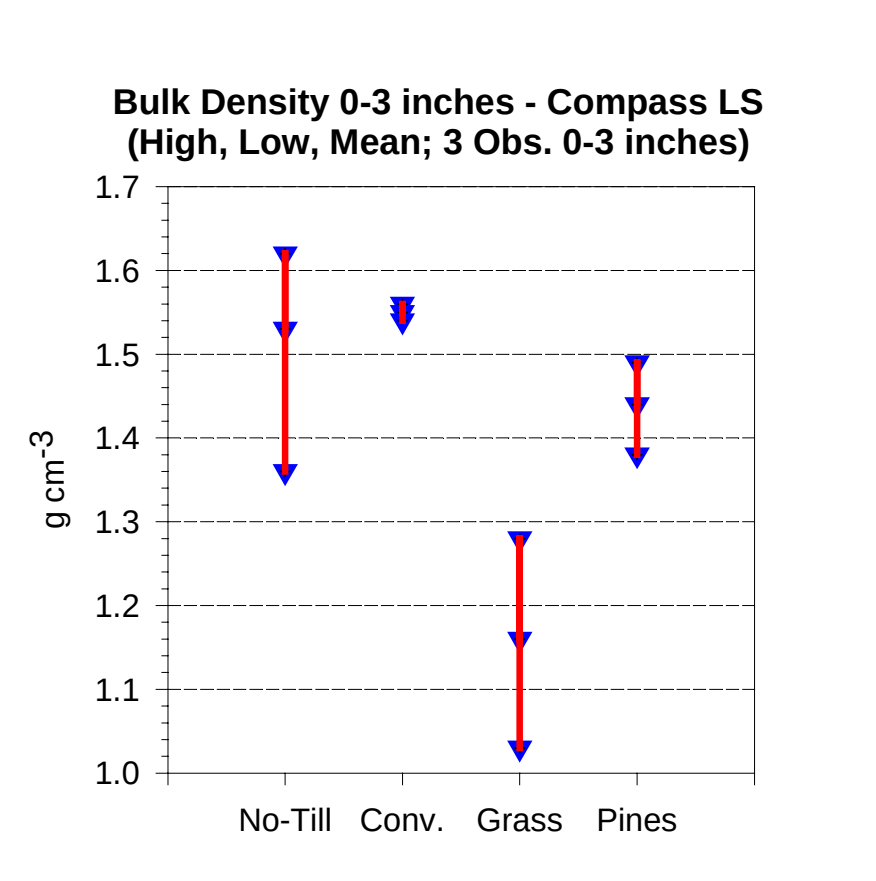
0.6-2.0 = moderate

2.0-6.0 = mod. rapid



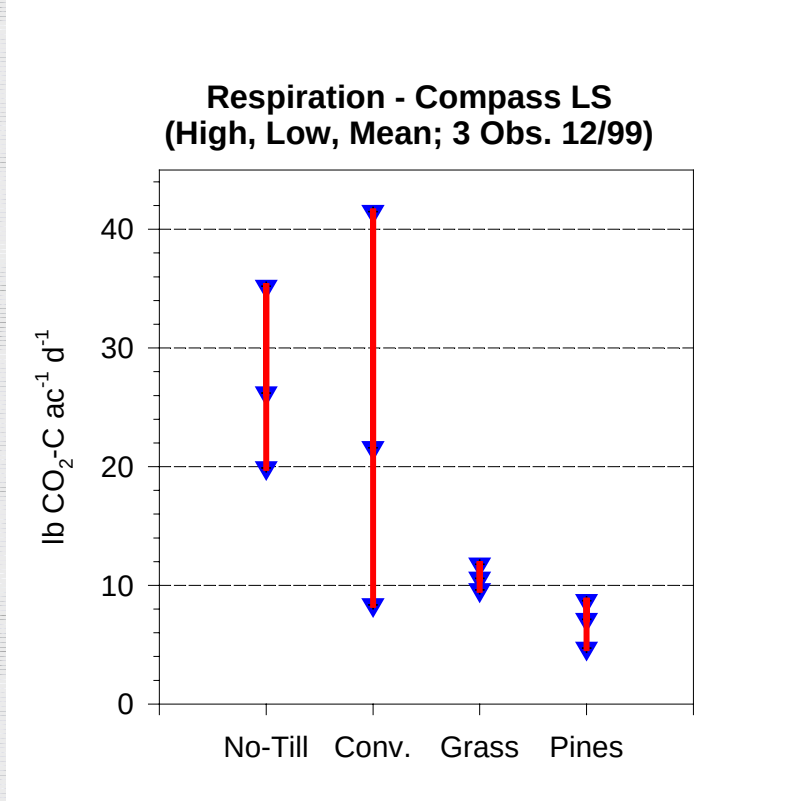
Bulk Density

- Low variability for conventional tillage (on the day sampled).
- Grass appears to be lowest.

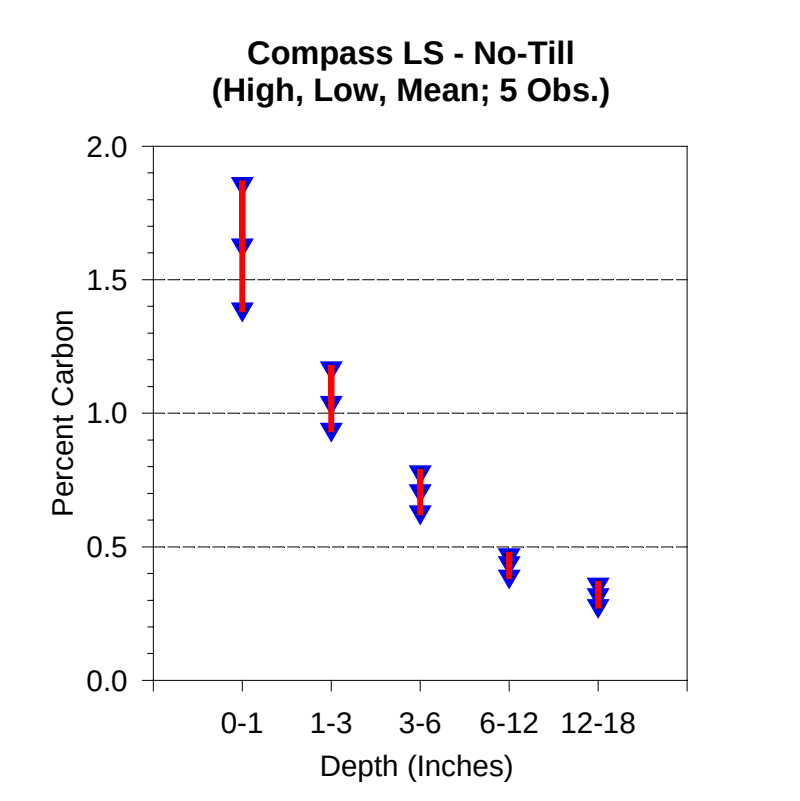


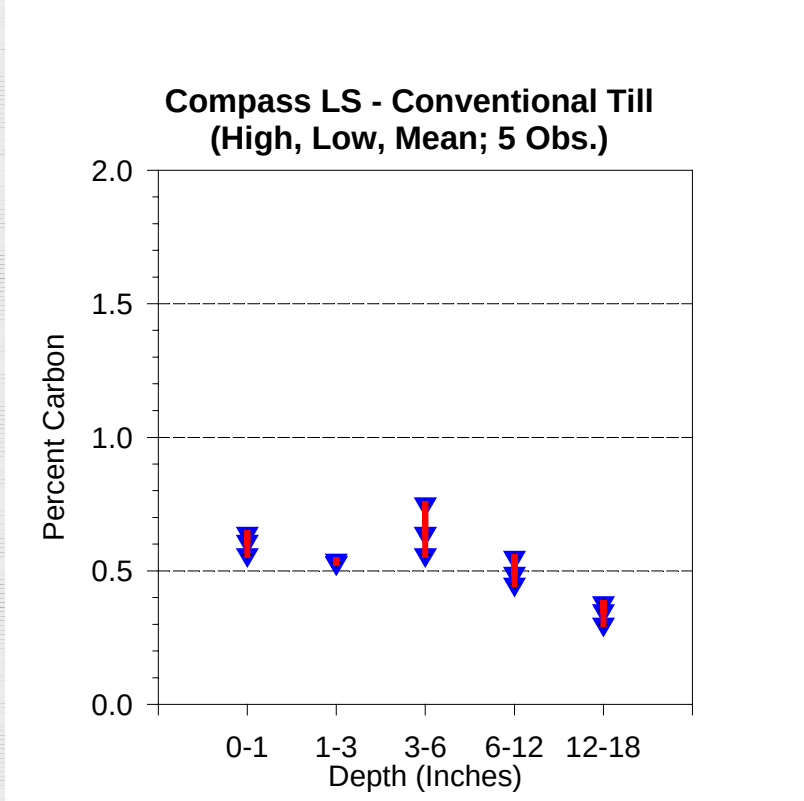
Biological Activity

- Noticeably higher and more variable in cropland than for grass or trees on this day.



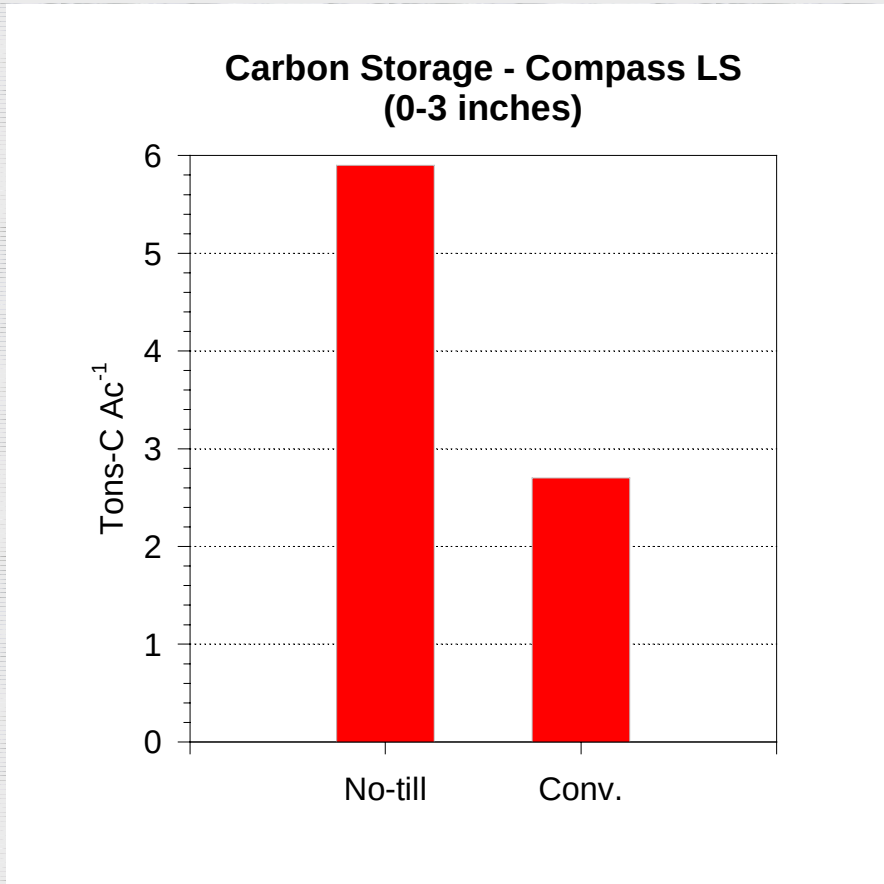
Cropland Carbon Distribution





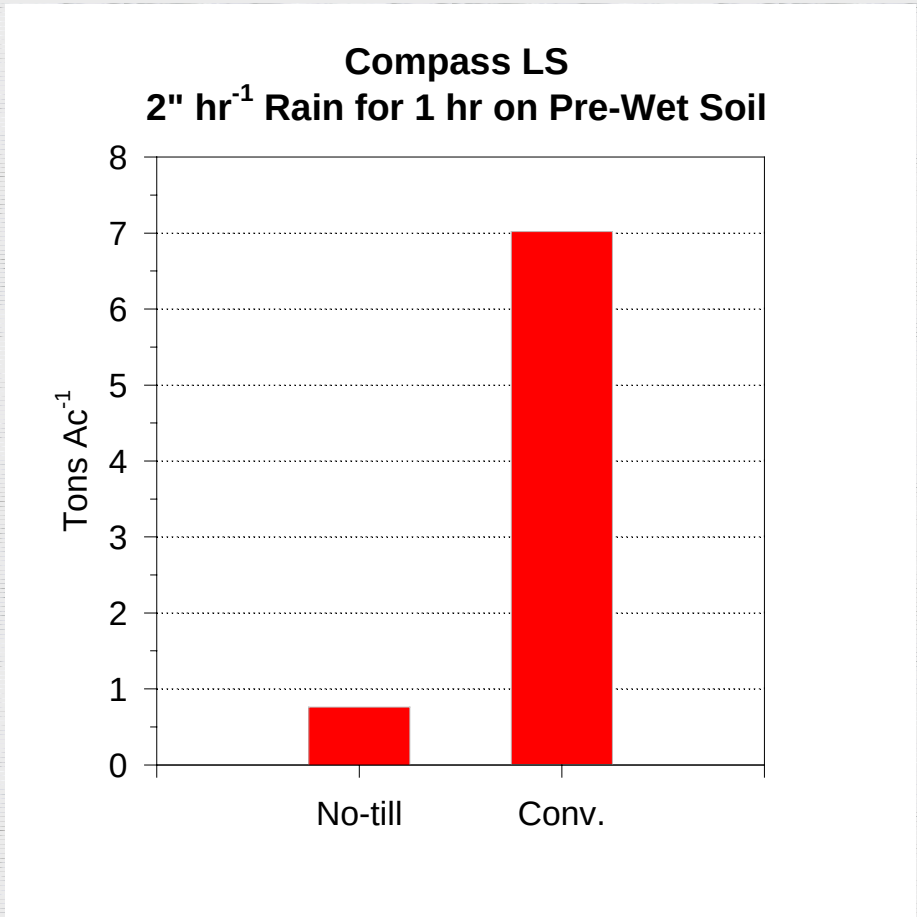
Carbon Storage

- 10 years of no-till has led to a doubling of carbon (OM) in the upper 3 inches in this sandy, southeastern soil.



Soil Erosion

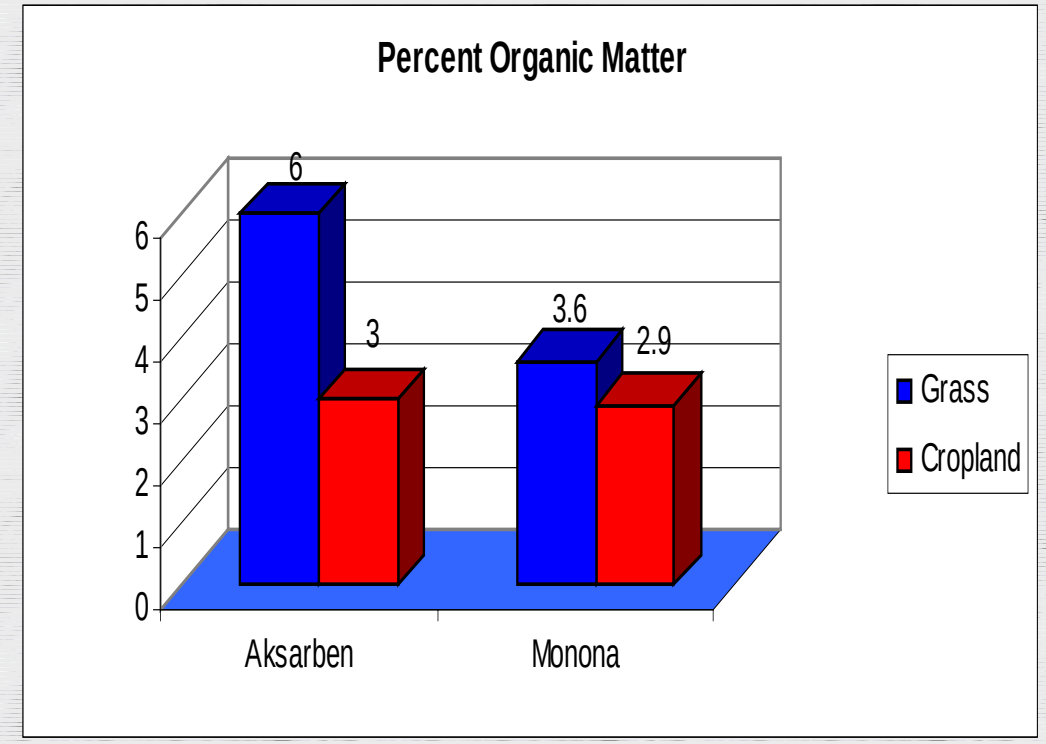
- Dramatic soil loss reduction due to residue cover, more stable peds, higher OM, and increased infiltration.



#3) Eastern Nebraska Data

- Aksarben - Fine, smectitic, mesic Typic Argiudoll.
- Monona - Fine-silty, mixed, superactive, mesic Typic Hapludoll.
- Comparisons of cropland and grassland.

Organic Matter

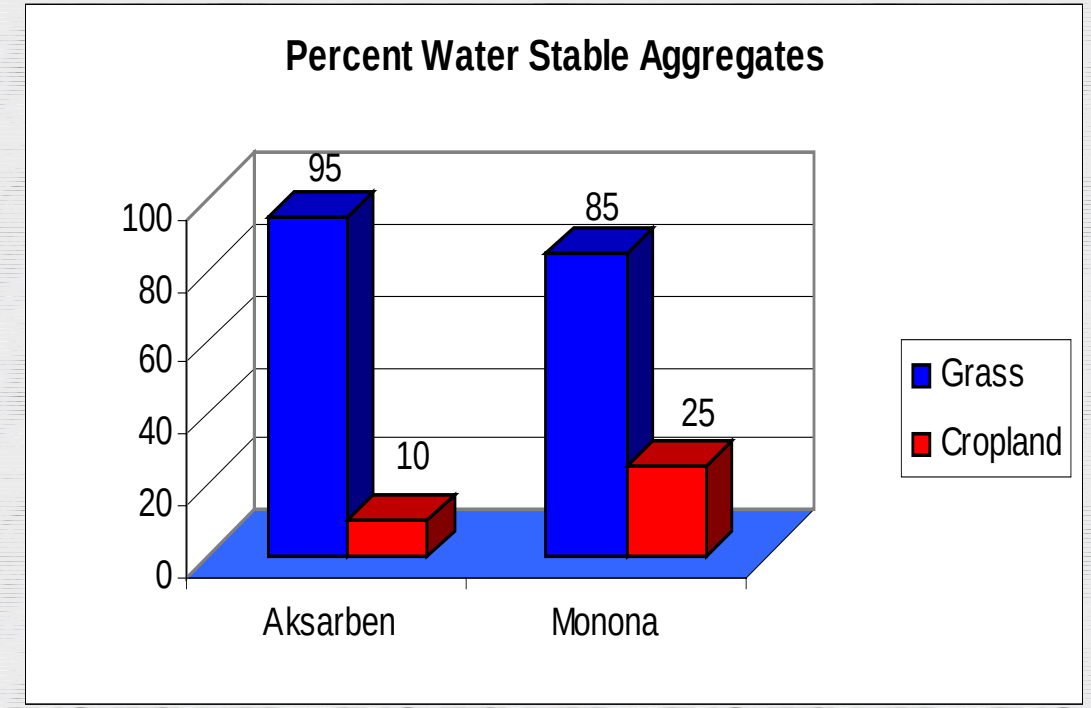


Current Database

Aksarben 2-4

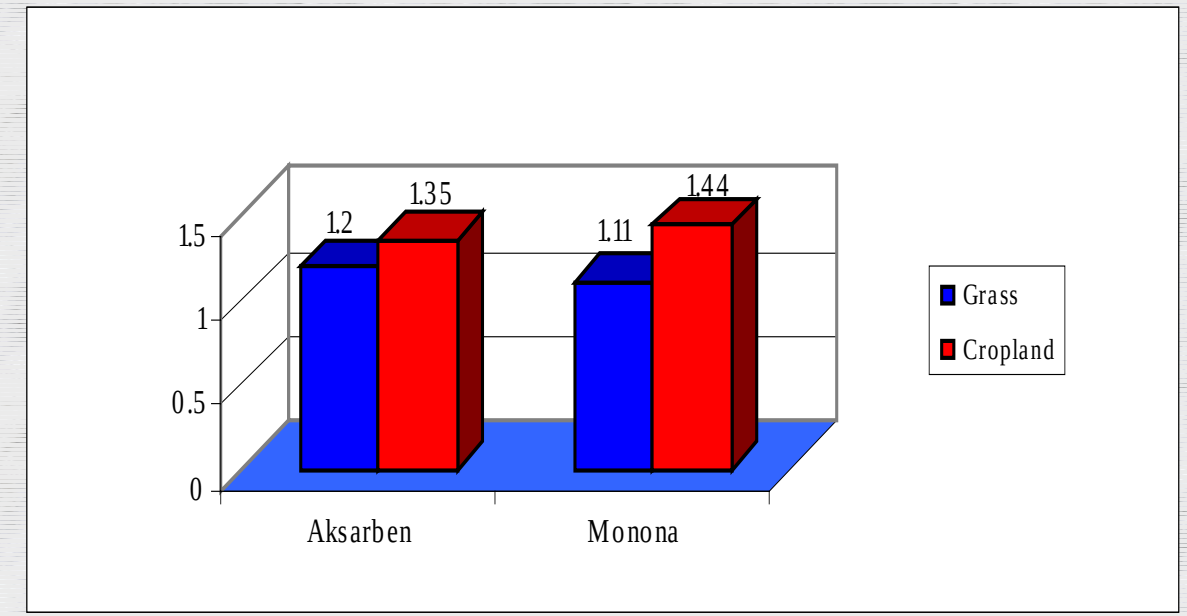
Monona 2-4

Aggregate Stability



Not in current database.

Bulk Density

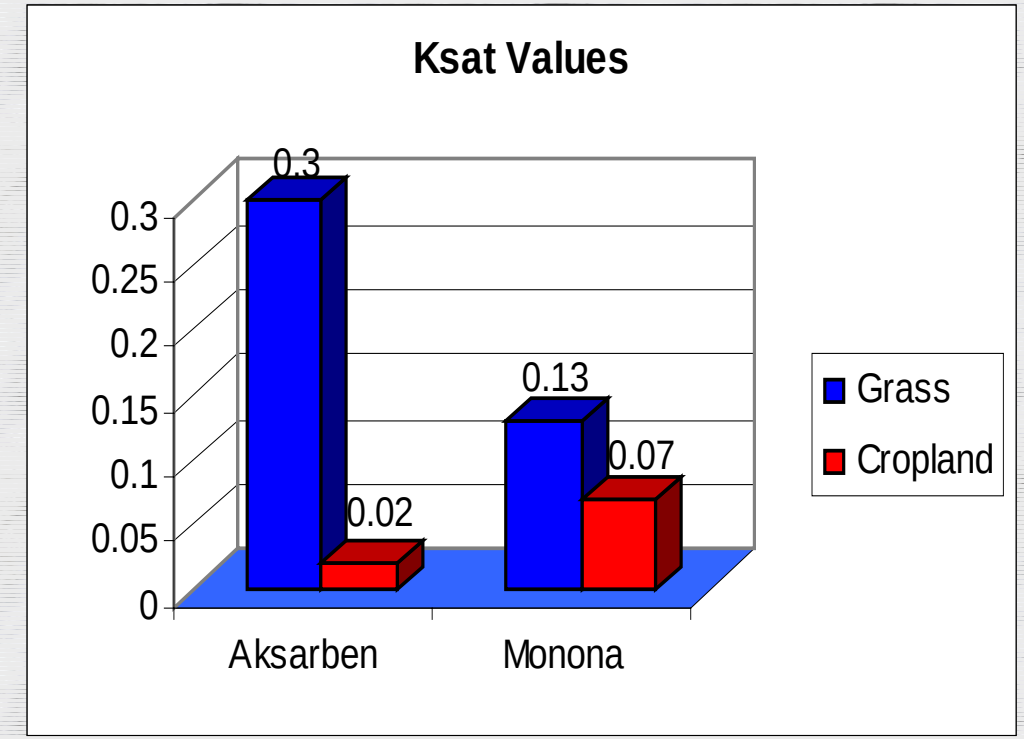


<u>Current Database</u>

Aksarben 1.35-1.55

Monona 1.25-1.30

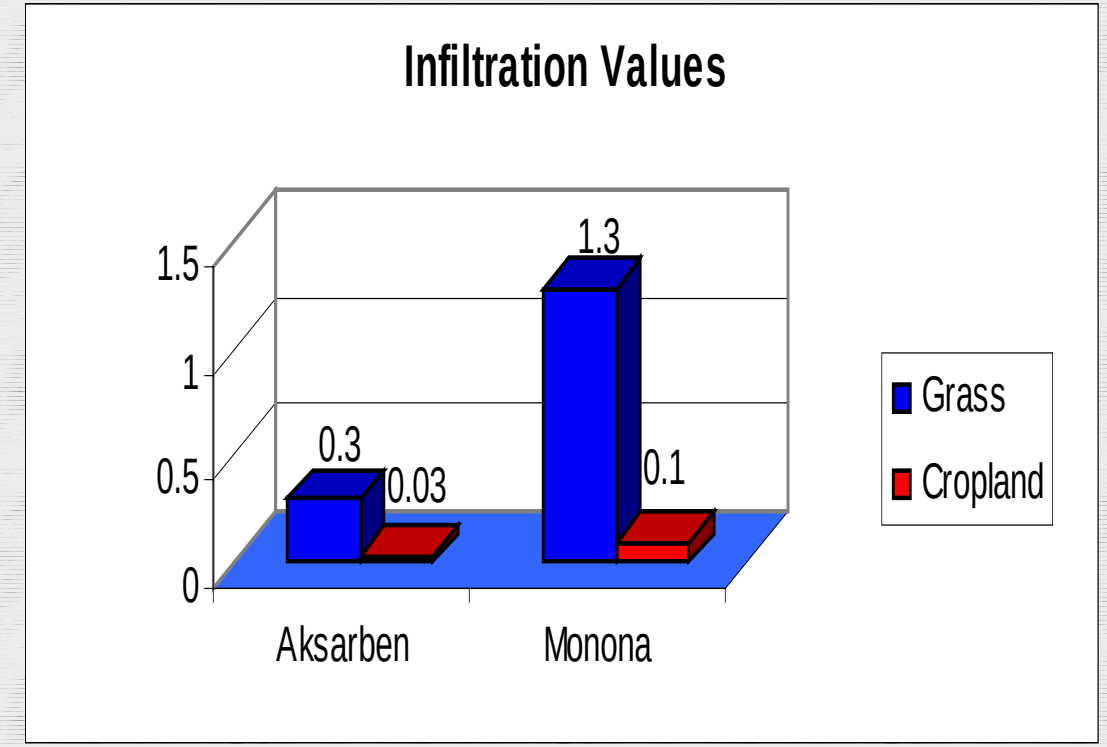
Hydraulic Conductivity



Current Database

Aksarben	0.6-2.0
Monona	0.6-2.0

Infiltration



Not in current database.

Advantages of a Dynamic Properties Data Set.

- Greater flexibility in interpretations.
- Improved derivative property information.
- Greater utility at the field level.
- Greater utility at the regional and national level for use in modeling.

More flexibility in making interpretations.

Potential Pesticide loss.

	Aksarben	
	Leaching	Runoff
Grass	Low	Int.
Cropland	V. Low	High
Database	Int.	Int.

Improved Derivative Information.

Hydrologic Group

	Aksarben	Monona
Grass	B	B
Cropland	D	C
Database	B	B

K factor

	Aksarben	Monona
Grass	.32	.27
Cropland	.44	.43
Database	.32	.32

Improved Value at the Field level

- “If I change to no-till, will it affect the potential for pesticides to enter my farm pond?”
- “What is the potential for sequestering carbon in the soils on my farm?”

Improved watershed/regional Assessment Capabilities.

- “What are the current baseline carbon levels in the region?”
- “What effect would increasing no-till from 25% to 50% of the cropland in a watershed have on water quality and flooding?”

Where do we go from here?

- Select a few pilot projects with states and MO's to work with NSSC & SQI in FY '01.
  - Preferably new updates with emphasis on data and interpretations.
- Identify properties to be included.
- Obtain equipment, provide training.

Where do we go from here?

- Sample key soils under contrasting land use and management combinations.
- Extend information to similar soils.
- Incorporate data in NASIS.
- Include information in soil survey reports.

National Soil Survey Center

Horace Smith, Director
Soil Survey Division
National Headquarters

Bob Ahrens, Director
National Soil Survey Center

NATIONAL LEADERS

SOIL CLASSIFICATION & STANDARDS
Berman Hudson, Acting

LABORATORY
M. DeWayne Mays

INTERPRETATIONS
Berman Hudson

INVESTIGATIONS
Carolyn Olson

TECHNICAL SERVICES
Jim Culver

SOIL CLASSIFICATION & STANDARDS
Berman Hudson, Acting

- Revise Ag. Hnbk. 296; Land Resource Regions and Major Land Resource Areas of the U.S.
- Correct and revise Soil Survey Manual
- Soil classification file
- STATSGO (1:250,000 scale general soils map)
- Rationale to Taxonomy Amendments
- Soil survey planner (calendar)

SOIL SURVEY INTERPRETATIONS
Berman Hudson

- NASIS interpretation generator
- New interpretations
- Ecological site descriptions (range, woodland)
- Predictive equations for data population
- Use dependent soil property databases

SOIL SURVEY INVESTIGATIONS
Carolyn Olson

- Deep investigations research (> 2 meters)
  - protocols for describing soils
- Vertisols - morphology vs. climate to reflect paleo-environments
- Wet soils monitoring (Sharkey series)
- Predicting chemical properties of Andisols

SOIL SURVEY LABORATORY
M. DeWayne Mays

- Lab characterization - process about 7,000 samples
- Requests for extractable phosphorus and associated soil properties
- Trace metals
  - establish analytical standards to assess concentration
  - analyses of archived samples to assess background levels
- Soil Quality Institute - relate near surface properties to various cropping/management systems

SOIL SURVEY TECHNICAL SERVICES
Jim Culver

- Marketing
  - soil survey planner (calendar)
  - soils explorer
  - publications
- Federal Register / Farm Bill Programs
- WWW interactive interpretations development
- Formal soils training
- STATSGO (1:250,000 scale general soils map)

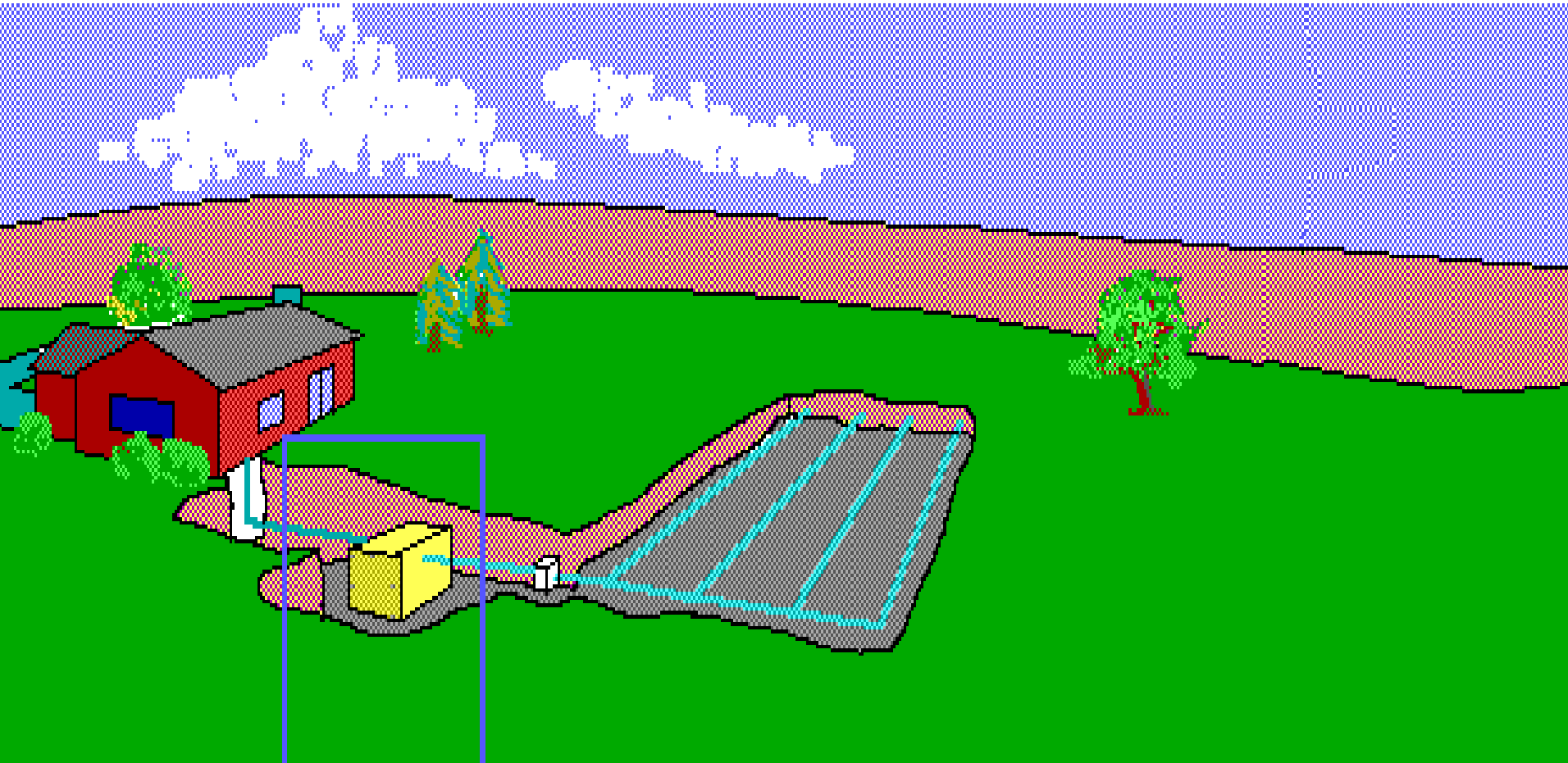
Products on the Web:

- **State Soils Photo Gallery**
- **Standards:**
  - Soil Survey Manual
  - National Soil Survey Handbook
  - Soil Taxonomy
  - Keys to Soil Taxonomy
  - Laboratory Procedures Manual
  - Laboratory Data Interpretation Manual
  - Hydric Soils
- **Field book for describing and sampling soils**
- **Soil Explorer - Soil Surveys on CD-ROM**
- **Soil Quality Information sheets**

Products on the Web:

- **Educational material**
  - "From the surface down"
  - Soil order photos and distribution maps
  - State soil fact sheets
  - Urban soils
  - Soil quality information sheets
- **NSSC forum**

ONSITE SEWAGE DISPOSAL AND SOIL SCIENCE – AN ADPH PERSPECTIVE



ONSITE USE STATISTICS

- U.S. - 25% OF HOUSEHOLDS
- AL - 50% OF HOUSEHOLDS

ESTIMATED FAILURES IN ALABAMA

- CONVENTIONAL - 15-30%
- MOUNDS - 30-50%
- NO STANDARDIZED MECHANISM
  - FOR REPORTING
  - CLASSIFYING
  - REPAIRING

IMPROVING THE SYSTEM

- SOIL TESTING
  - DE-EMPHASIZE USE
    - PERCOLATION TESTING
  - EMPHASIZE USE
    - SOIL MORPHOLOGY
    - DETAILED SOIL MAPS
    - EVALUATIONS BY PSCs

SOIL SCIENCE METHOD

- PLUSES
  - COMPREHENSIVE APPROACH - MORE & BETTER INFORMATION
  - REVEALS RELATIONSHIPS (SOILS, LANDSCAPES, HYDROLOGY, VEGETATION, ETC.)
  - RESULTS REPRODUCABLE
  - CONSISTENT REGARDLESS OF SEASON
- MINUSES
  - REQUIRES EXTENSIVE TRAINING & EXPERIENCE
  - SPECIALIZED PEOPLE – FEW IN NUMBER

CHALLENGES

- PROPOSAL FOR NEW RULES
  - SURVEYORS - PERCOLATION
  - ENGINEERS/GEOLOGISTS – UNIFIED
  - SOIL CLASSIFIERS
    - MORPHOLOGY
    - MAPPING
    - PERCS

The Object:

No more of these

The North Carolina Experience with Septic Systems

Research and Extension Programs

Septic Systems in North Carolina

- Used by 50% of population (3.5 million people)
- Vast majority are conventional, gravity systems
- Permits based on soil morphology and site evaluation
- Average life span 15 –18 years
- Soils end up being the largest treatment plant in the state

Research and Extension Program Areas

- Experimental/Innovative Systems
- Additives
- Hydrology
- Soil Morphology
- Watershed Scale Effects
- Management
- Soil and On-Site Wastewater Training Academy

Experimental/Innovative Systems

- Sand filter
- Peat filter
- Drip irrigation
- Tire chips vs gravel

Sand Filter (Hoover and others)

- Multiple sites and designs
- Success is directly proportional to maintenance

Peat Filter (Lindbo)

- Multiple sites
- Commercially available system
  - PURAFLO Peat BioFilter
- 3 years of data

Results

Parameter	Pump tank	Filter	Trench	Below Trench	Up slope	Down slope
			Gates			
Fecal Coli. cfu/100ml	109984	1424	425	<200	<200	<200
BOD mg/l	123	6	2.1	2.1	1.8	1.9
TSS mg/l	60	6	nd	nd	nd	nd
			New Hanover			
Fecal Coli. cfu/100ml	111803	<200	<200	<200	<200	<200
BOD mg/l	109	4	<1	<1	<1	<1
TSS mg/l	85	7	nd	nd	nd	nd

Results (cont.)

Parameter	Pump tank	Filter	Trench	Below Trench	Up slope	Down slope
			Gates			
TKN mg/l	25	4	1.4	1.6	1.1	0.9
-NH4 mg/l	17	1.5	0.2	0.2	0.6	0.4
-NO3 mg/l	.4	20	3	11	0.3	0.3
-PO4 mg/l	1.4	1.7	0.5	0.6	0.1	0.1
Tot. P mg/l	1.7	1.7	0.5	0.6	0.1	0.1
pH	6.8	6.7	6.2	6.3	5.9	5.2

Results (cont.)

Parameter	Pump tank	Filter	Trench	Below Trench	Up slope	Down slope
			New Hanover			
TKN mg/l	25.7	1.2	1.8	5.2	0.9	0.3
-NH4 mg/l	18.7	0.4	0.2	<0.1	0.4	0.4
-NO3 mg/l	0.3	17.4	14.7	0.9	4.2	0.3
-PO4 mg/l	2.9	2.9	0.9	0.4	0.2	0.4
Tot. P mg/l	3.2	2.9	0.9	0.5	0.3	0.5
pH	6.9	6.0	6.2	6.4	6.5	6.4

Tire Chips (Amoozegar)

- Laboratory Component
  - Physical assessment of tire chips
  - Leaching of tire chips vs gravel
    - Continuous
    - Intermittent
  - Analysis of organic and inorganic leachates
- Field Study
  - Side-by-side comparison

Tire Chips: Results

- Limited to 1 year of data
- Fe leached from tire chips
- Some organic components leached
  - Further characterization of these materials needed
  - More leaching in basic solutions
- After 1 year trench appeared to function adequately
- More info: www.p2pays.org/ref/03/02627.pdf

Additives (Hoover)

- Double blind study
- Four treatments
- Results
  - Additives had no affect on sludge level in tank

Hydrology

- Drainage
- Groundwater mounding
- Wastewater infiltration and K_{sat}

Wastewater Infiltration and K_{sat} (Amoozegar)

- Compared Infiltration and K_{sat}
  - 3 soils
  - 5 solutions
    - Kitchen wastewater (simulated)
    - Laundry wastewater (simulated)
    - Bathroom gray water (simulated)
    - Car wash (simulated)
    - Tap or well water
- Application of $CaCl_2$ as an amendment

Wastewater Infiltration and K_{sat}: Results

- Laundry wastewater had a negative impact
- In some cases, application of CaCl2 resulted in restoration of infiltration rate and K_{sat}
- More info:
  - NC water Resources Research Institute report no. 316
  - On-Site Watewater Treatment, Proc. 8th Nat. Symp. On Indiv. & Community Sewage Systems. ASAE, 1998

Soil Morphology

- Ditching effects
- Long-term WT/morphology simulation
- Sandy soils

Ditching Effects (Vepraskas)

- Goldsboro-Lynchburg-Rains-Pantego
- 4 transects located at varying distances from ditch
- Monitoring sites
  - Daily water table
  - Weekly temperature and redox

Ditching Effects: Results

- “Reddening” of profile nearest ditch
- Duration of saturation influenced
- Seasonal high water table similar at all sites

Long-term WT/Morphology Simulation (Vepraskas and others)

- 2 sites in Eastern NC
  - Ditched (4 transects with 13 pedons total)
  - Natural (2 transects with 9 pedons total)
- Monitoring at each pedon
  - Daily water table
  - Weekly temperature and redox
- 30 year simulation using DRAINMOD
  - Model calibrated for each pedon

Long-term WT/Morphology Simulation: Results

- Good, local rainfall data critical for model calibration
- Saturation and reduction correlated to both low and high chroma colors
- Data being used to develop well protocol for ESHWT determination for site evaluation

Sandy Soils (Lindbo and Vepraskas)

- Sandy soils are a recognized problem area by NCDENR-OSWW
- Monitor transects with wells and redox on the Outer Banks
- Determine what redox features other than low chroma features can be used to estimate seasonal high water table
- Model long-term trends

Watershed Scale Effects (Multiple Investigators)

- NPS pollution
  - Reduction at source
  - Natural denitrification
  - Cumulative impacts
- Dentirification barriers

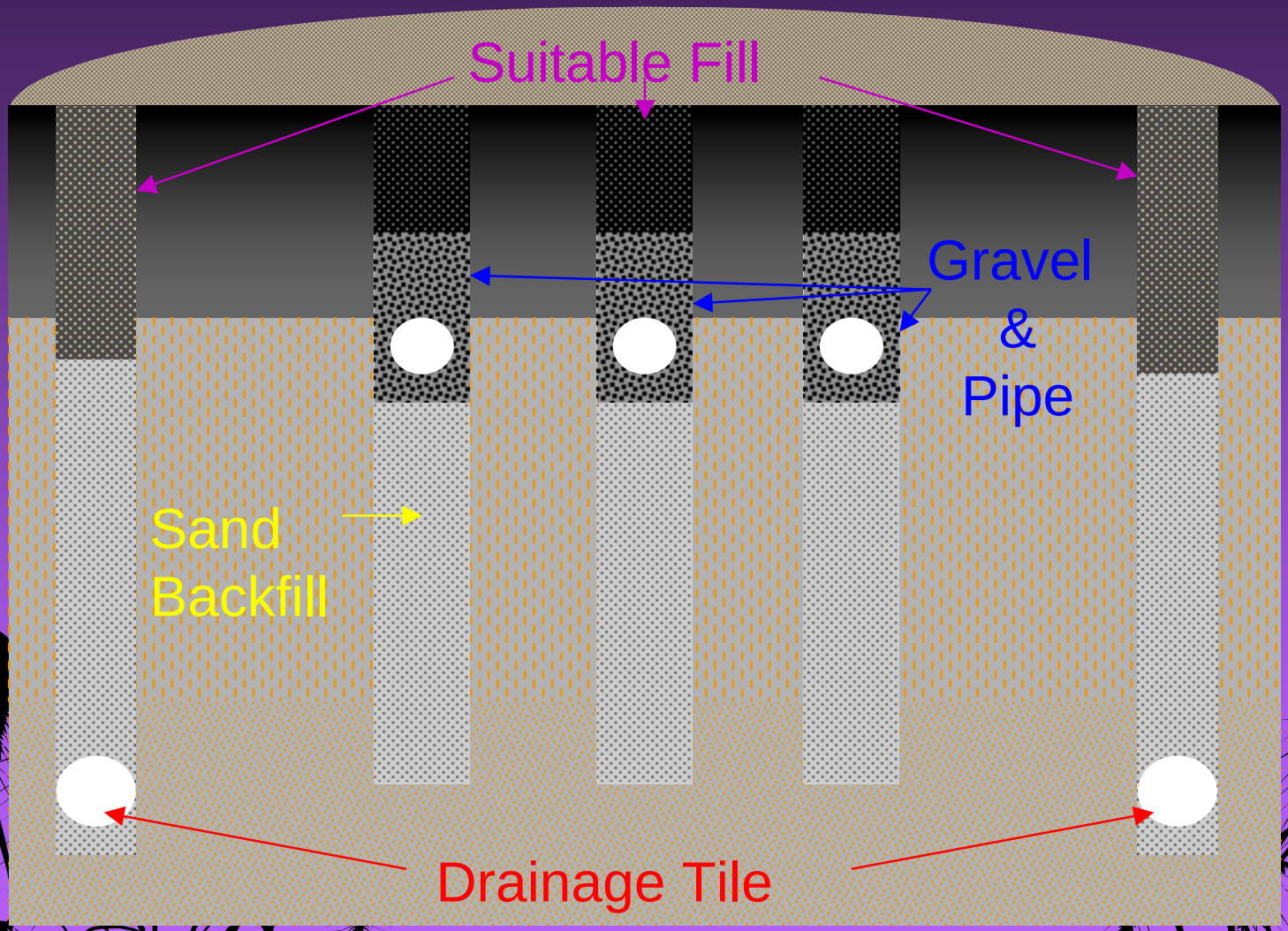
Management

- Evaluation of a public management entity
- Public perception of management
- Risk-based management

Evaluation of a Public Management Enity

- Evaluate Sand Lined Trench System
- Survey before Management, March 1991
- Survey after Management, March 1996

System Layout



Results of the March 18-22, 1991 survey

System Type	Surface discharge	Gray water discharge	Past failure	No surface failure	Total Systems
	----------% of systems ----------				
Conv.	23	5	6	66	100 (93)
SLT	19	0	12	70	100 (86)
All	21	3	9	68	100 (179)

Results of the March 25- April 3, 1996 Survey

System Type	Surface discharge	Gray water discharge	No surface failure	Total systems
	----------% of systems ----------			
Conv.	5	0	95	100 (19)
SLT	0	0	100	100 (72)
All	1	0	99	100 (91)

Reasons for improved performance

- Refinement and standardization of installation
- Management Entity
  - Potential problems identified and corrected prior to a surface failure
  - Homeowner awareness of the SLT system
- System age
  - Systems in this survey averaged 2.4 years old

Risk Assessment

- Determine the environmental conditions that will be affected
- Determine the risk to the environment
- Select the type of system based on performance standards that will pose an acceptable and manageable risk

Example of a ranking of ground and surface water receiving environments

Water Supply		Water Resource				
Ground Water		Surface Waters				GW
Site	*Critical Area*	*Primary Rec.*	*Shellfish Waters*	*Nutrient Sens.*	*2ndary Rec.*	*Poor Aquifier*
next to wellfield	within capture zone	beaches	comm. open waters	lakes, ponds. etc.	other surface waters	unprod. aquifers
SS	**SI&SO**	**PRW**	**SFW**	**NSW**	**OSW**	**Pc**
Detailed description of each environment						
→ Decreasing level of importance →						

Example of risk assessment matrix

Vulner-ability Rating	Water Supply		Water Resource			
	Ground Water		Surfac Water			GW
	Site	*Critical Area*	*Primary Rec.*	*Shellfish Waters*	*Nutrient Sens.*	*Poor Aquifer*
	SS	**SI & SO**	**PRW**	**SHW**	**NSW**	**Pc**
High	R5	R4	R3	R3	R2b	R1
Medium	R5	R4	R3	R3	R2b	R1
Low	R5	R3	R2a	R2a	R2b	R1

Example of treatment performance standards

Treatment Performance Standard	Description
TS1	Primary treatment
TS2	Secondary treatment
TS3	Tertiary treatment
TS4	Nutrient rduction
TS5	Tertiary treatment plus disifection

Example of treatment standards and risk matrix

Vertical Separation Distance %	Control Zone					
	R5	R4	R3	R2b	R2a	R1
	Treatment Performance Standard					
100	TS4	TS2	TS1	TS1 or TS4	TS1	TS1
75-99	TS5	TS2	TS2	TS1 or TS4	TS1	TS1
50-74	N/A	TS3	TS3	TS1 or TS4	TS2	TS1
25-49	N/A	TS4	TS4	TS1 or TS4	TS3	TS2
<25	N/A	TS5	TS5	TS4	TS4	TS3

Soils and On-Site Wastewater Training Academy

- Comprehensive, coordinated program of professional courses related to soil evaluation and wastewater treatment.
- Developed and sponsored in part by:
  - NCSU and NC A&T
  - NCCES
  - NCDENR
  - NCST
  - NC SSS
  - COWRA

Soils and On-Site Wastewater Training Academy

- Our goal is to provide a clearly designed program of instruction
  - Basic courses for novices
  - advanced level courses for career veterans
- The courses are divided into 6 distinct categories
  - Numbered like college courses
  - Some prerequisites or experience may be required

Soils and On-Site Wastewater Training Academy

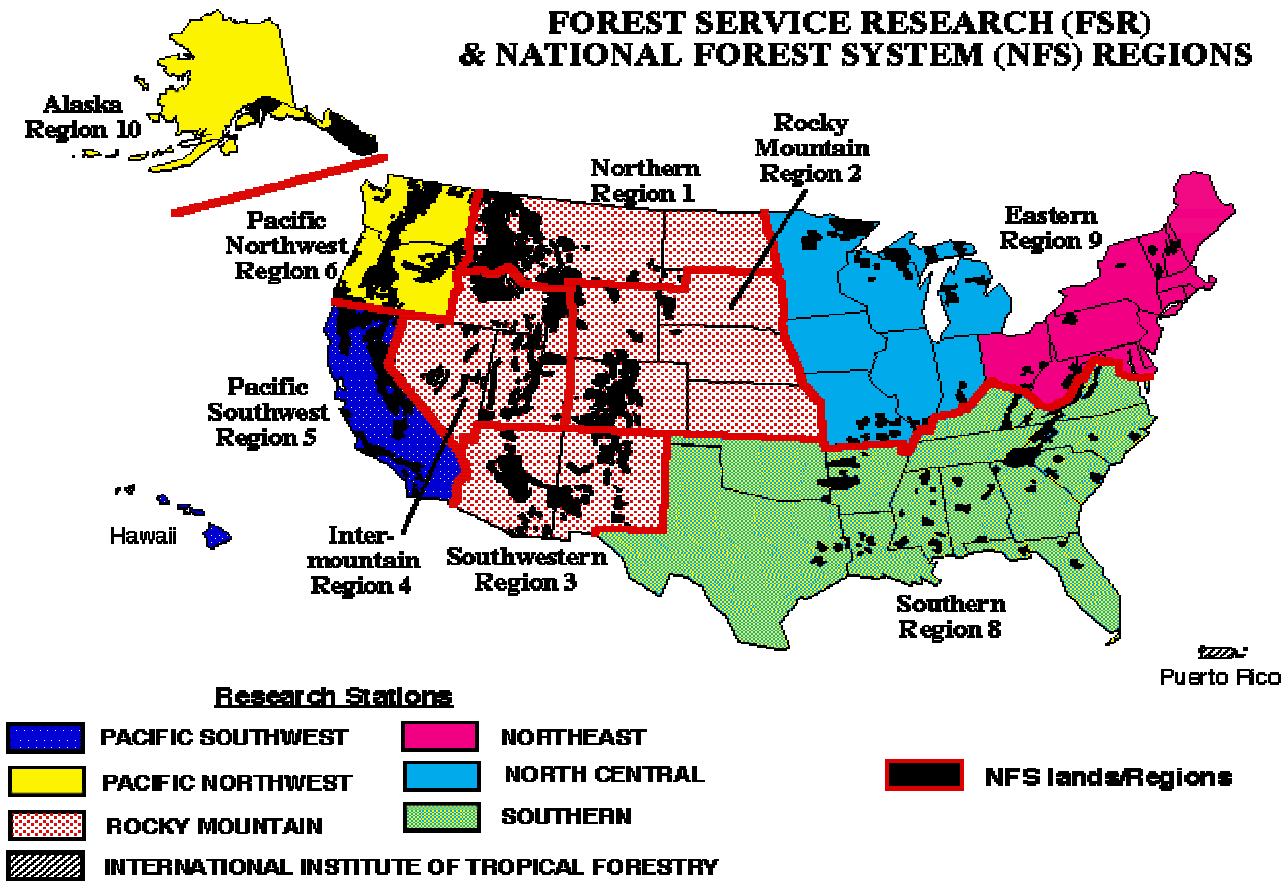
- Courses to be offered state wide
- Utilize training centers
  - Southeast Regional Training Center in Bolivia
  - Tidewater Training Center in Plymouth
  - National Land-based Technology and Watershed Protection Training Center, NCSU in Raleigh.
  - Guilford County On-site Wastewater Research and Education Center in Greensboro

Curriculum Sections

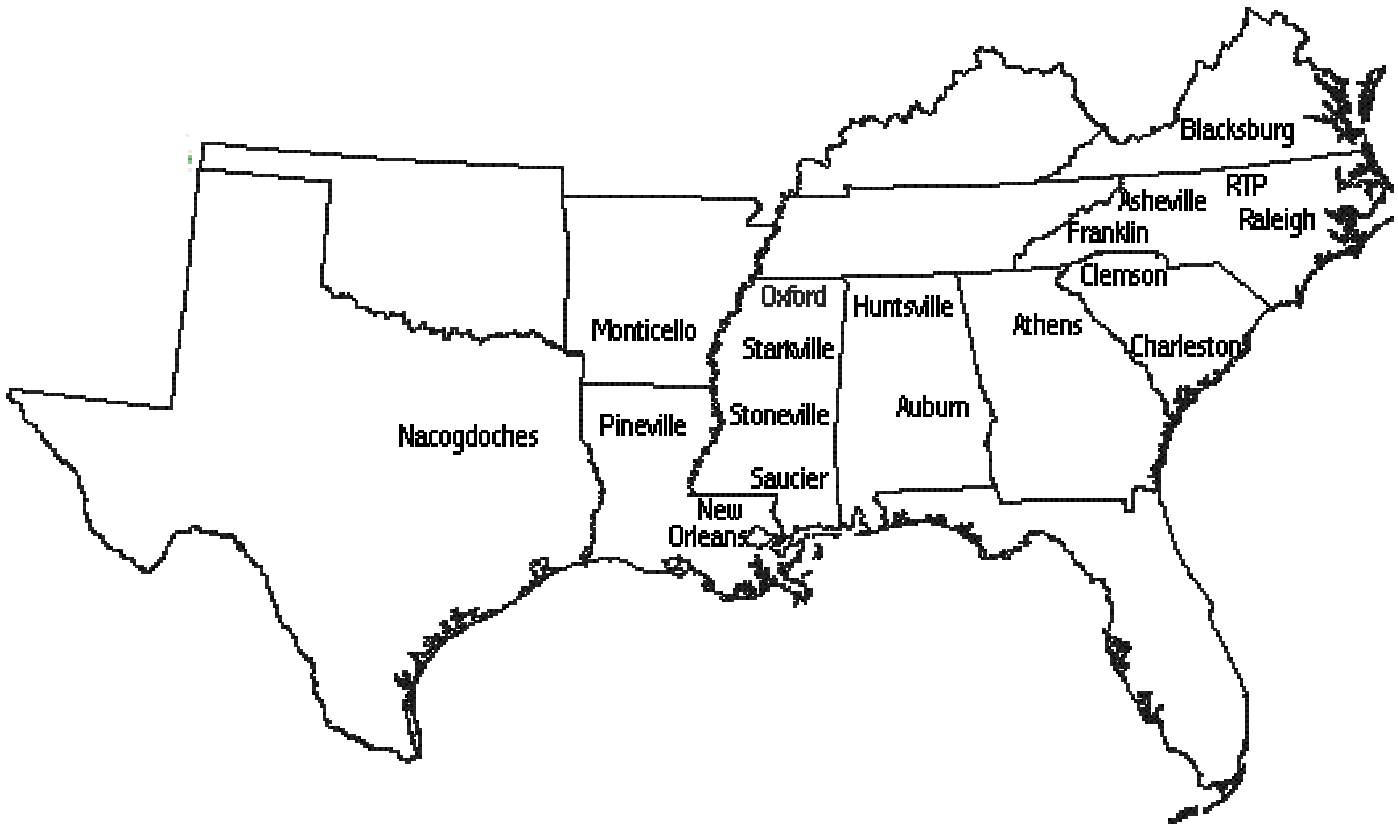
- Septic System Basics
- On-Site Wastewater
- Soil and Site Evaluation
- Operation and Maintenance
- Design
- Installation and Inspection

Soil Research
USDA Forest Service

USDA Forest Service
NFS and RS



Forest Service Research
Southern Research Station



G.W. Andrews Forestry Science Laboratory – USDA Forest Service

Biological/Engineering Systems Laboratory

- Interaction among Soil Factors, Forest Operations and Biological Response.
- Methods and Technologies to Minimize Impacts.
- Forest Operation Technologies
- Integration of Spatial Data – “Precision Forestry”

Research Projects

- Soil Compaction
- Soil Compaction Minimization
- Soil Erosion

Soil Compaction and Soil Disturbance

Soil Disturbance and Soil Properties South Carolina

	Bulk Density (Mg/m^3)	Cone Index (MPa)	Infiltration (in/hr.)	Air Porosity (%)
Log Deck	1.14	3.40	2.60	26.2
PST	1.08	2.80	2.70	23.1
SST	0.92	2.10	5.50	27.5
UND	0.75	1.10	25.2	38.5

Source: Hatchell, Ralston, Foil - 1970

Soil Disturbance
Wet Pine Flat – S. Carolina

	Disturbed (%)	Undisturbed (%)
High Soil Moisture	90.8	9.2
Low Soil Moisture	3.8	96.2
Wet/Mole Plowing	79.5	20.5
Wet/Bed	84.3	15.7
Dry/Bed	10.2	89.8

Source: Carter, Aust, Burger and Patterson – 1998.

Soil Response to Harvesting in a Wet Pine Flat - SC

Harvest	SD	BD (Mg/m^3)	Ksat (cm/hr)	MI (MPa)
Dry	UND	1.24	10.1	0.54
Dry	COMP	1.38	4.30	1.12
Wet	UND	1.26	8.90	0.63
Wet	COMP	1.44	1.60	0.53
Wet	RUT<8”	1.46	0.60	0.51
Wet	RUT>8”	1.48	0.40	0.51
Wet	PUD	1.46	1.20	0.67

Source: Aust, Burger, Carter, Preston, Patterson – 1998

Soil Disturbance and Silviculture Treatments Upland Hardwood Stand – N. Alabama

	Clear Cut	Deferment	Strip Cut (Whole)	Strip Cut (Strips)
UND	18	62	20	25
TWL	33	18	30	35
TSE	16	6	20	19
RUTS < 6”	16	6	20	12

Source: Carter, Rummer and Stokes – 1997.

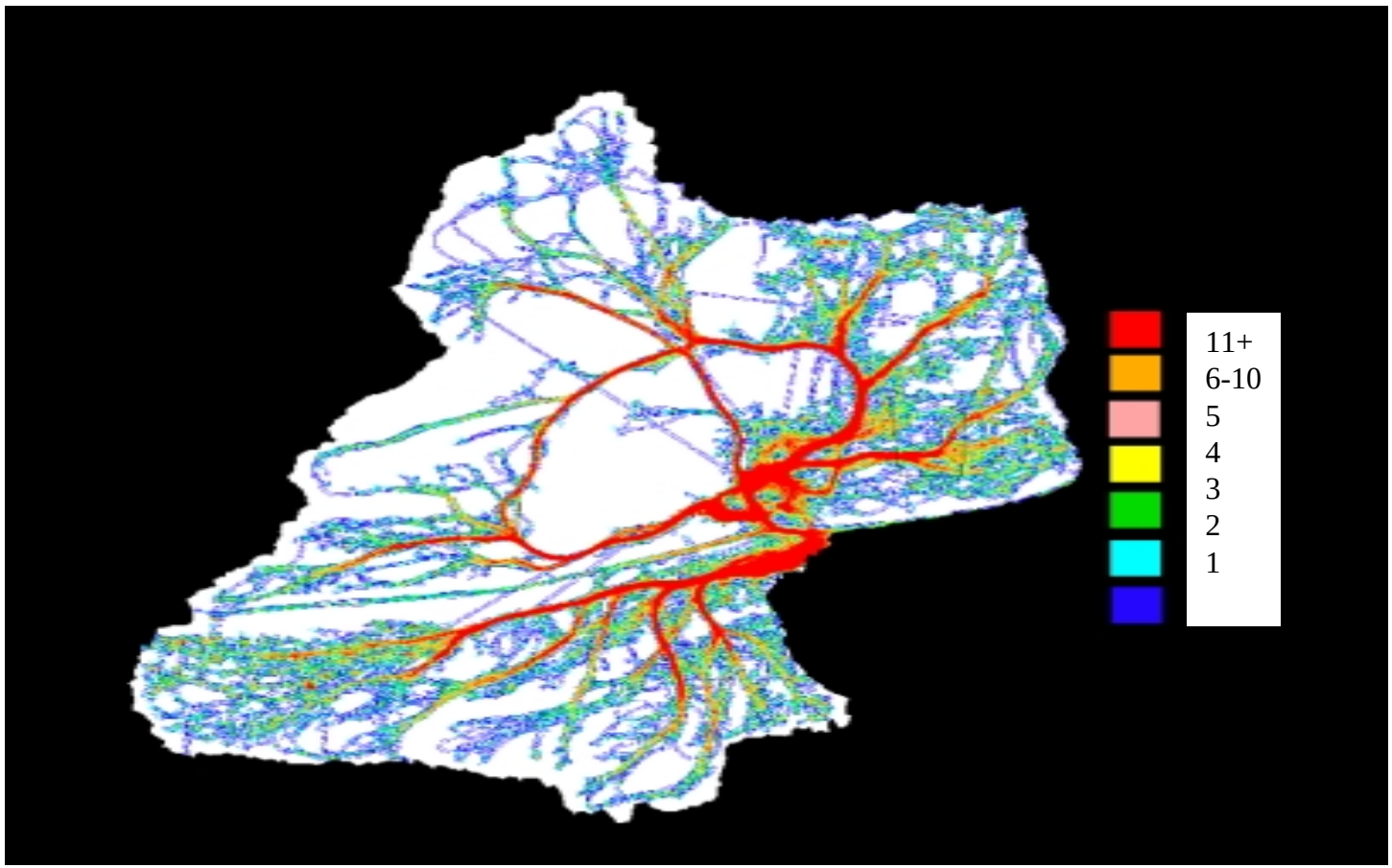
Soil Response to Soil Disturbances – N. Alabama

	CC		DC		SC	
	BD (Mg/m^3)	CI (MPa)	BD (Mg/m^3)	CI (MPa)	BD (Mg/m^3)	CI (MPa)
UND	1.13 - 0.98		1.04 - 1.13		1.10 - 0.87	
TWL	1.04 - 0.94		1.07 - 1.13		1.09 - 0.77	
TSE	1.20 - 1.08		1.14 - 1.35		0.95 - 0.95	
RUTS <6”	1.38 - 1.31		1.10 - 1.45		1.00 - 1.18	

Source: Carter, Rummer, Stokes - 1997

Soil Compaction and GPS

Harvest Trafficking Monitoring – North Auburn

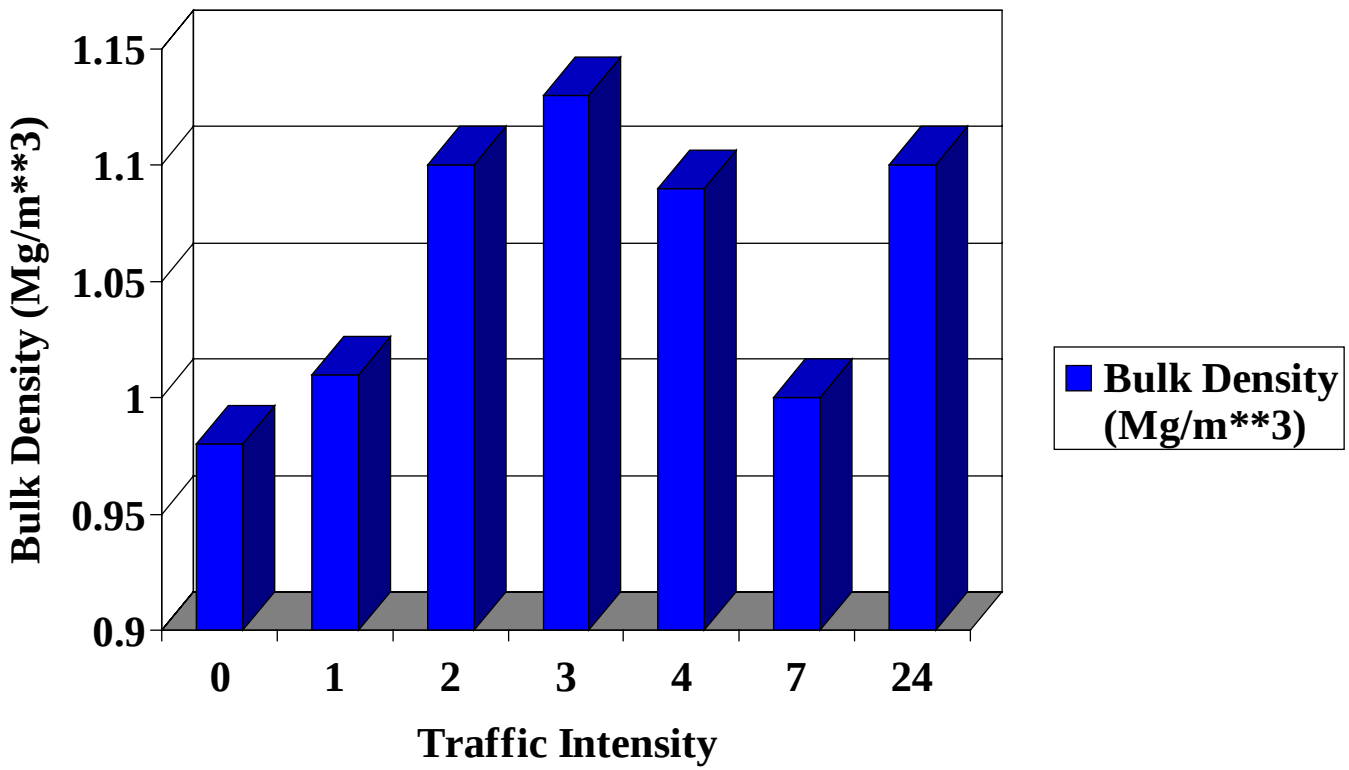


Soil Disturbance by Disturbance Classes and GPS – North Auburn

DC/#Passes	Visual	GPS
UND/0	9.5	27.9
SD/1-3	37.5	37.9
HD/4-20	27	29.2
D&T/21+	18.5	5.0

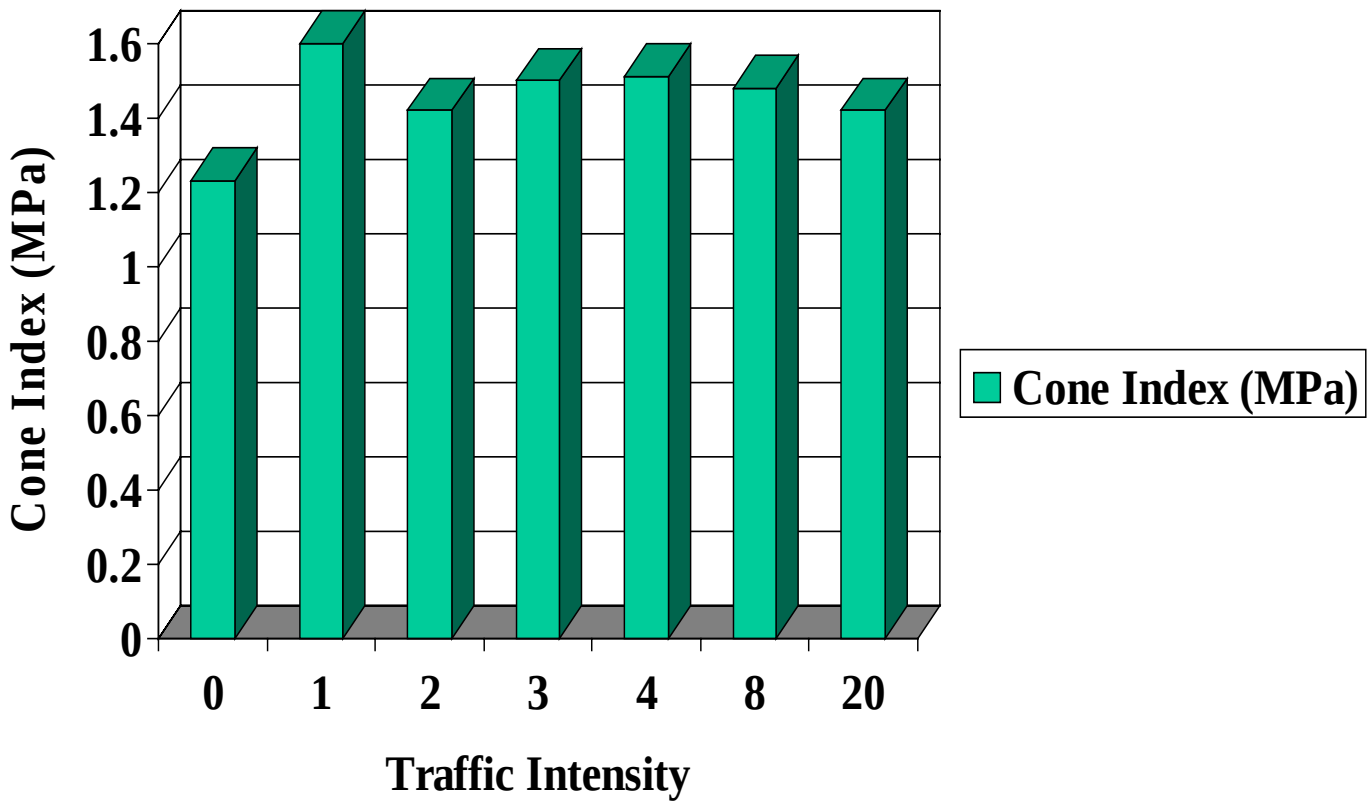
Source: McDonald, Carter, Taylor, Torbert – 1998.

Bulk Density by Traffic Intensity – North Auburn



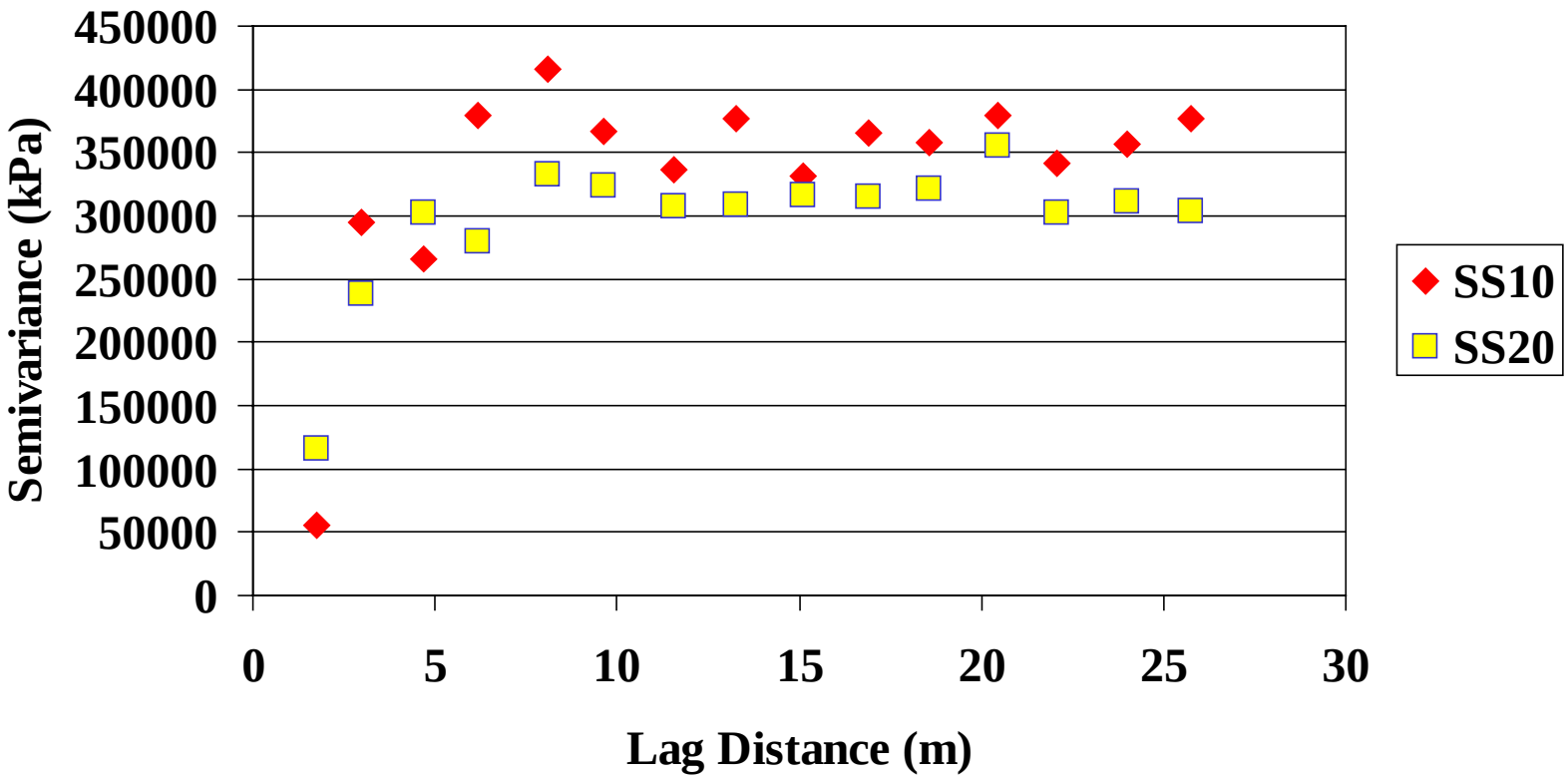
Source: Carter, McDonald, Torbert - 2000

Cone Index by Traffic Intensity – North Auburn

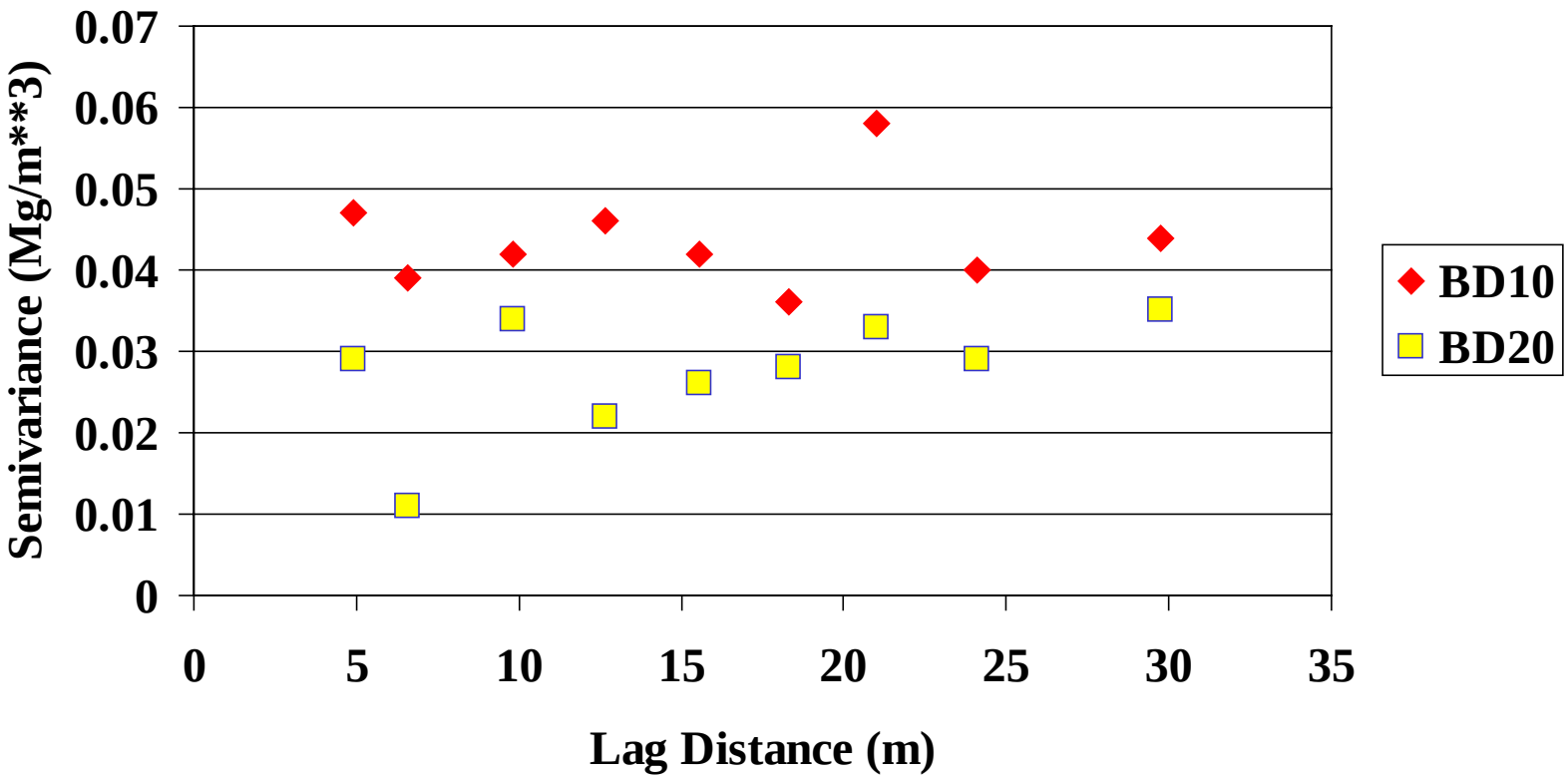


Source: Carter, McDonald and Torbert 2000

Semivariogram of Soil Strength - North Auburn

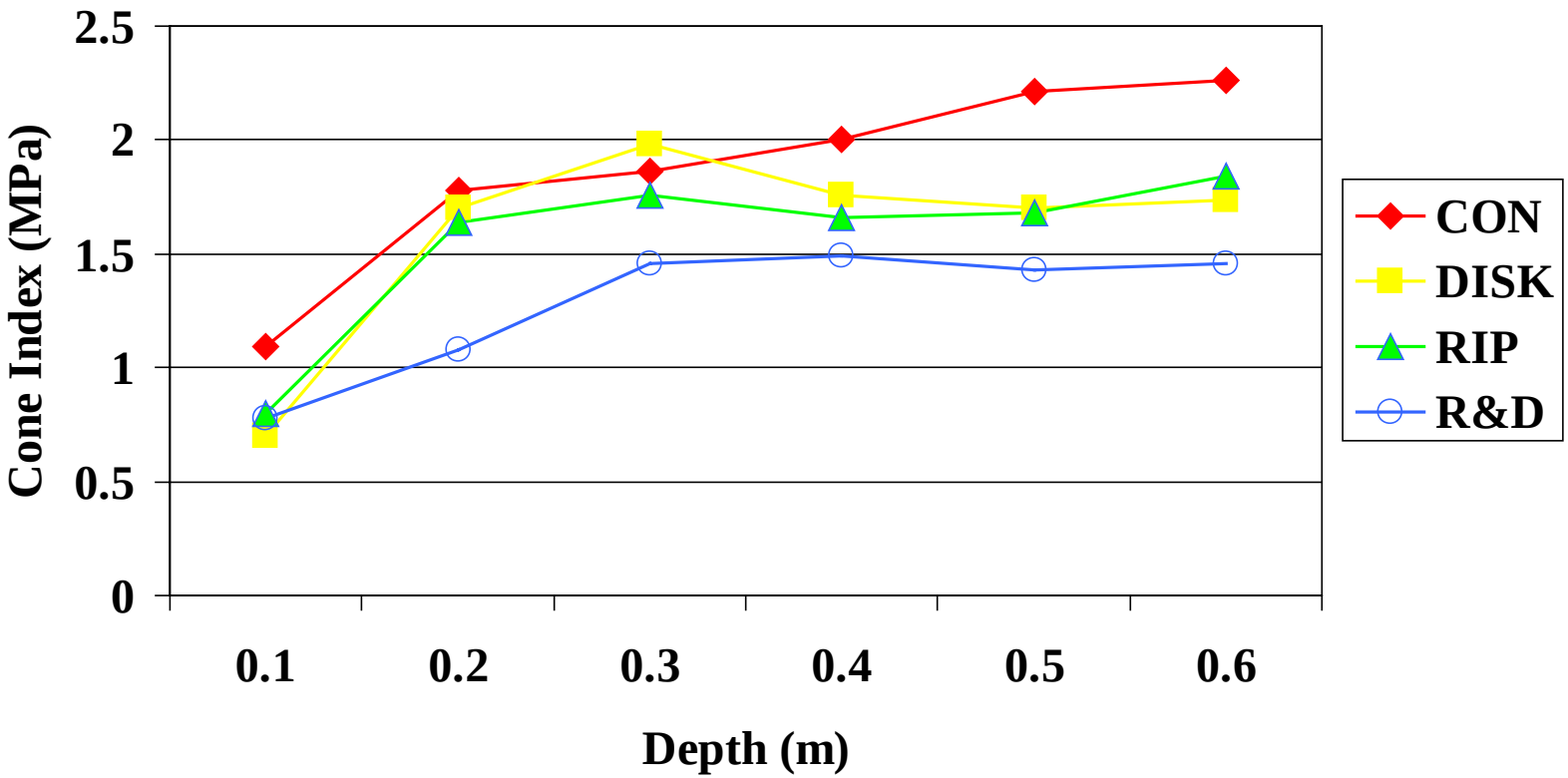


Semivariogram of Bulk Density – North Auburn



Soil Compaction and Site Preparation

Soil Response to In Row Tillage
Camp Hill, AL



Soil Compaction and Slash Levels

Soil Compaction and Machine Factors

Soil Erosion Studies

Runoff and Sediment Production North Auburn

	Harvested	Control
Total Sediment (g)	8.17	1.91
Runoff (l)	68.9	23.6
Sediment Concentration (mg/l)	260.5	200.6

Source: Grace and Carter 2000

Literature Cited

Aust, W. M., J.A. Burger, E.A. Carter, D.P. Preston, and S.C. Patterson. 1998. Visually determined soil disturbance classes used as indices of forest harvesting disturbance. South. Journal of Applied Forestry 22:245-249.

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CLEAN WATER ACTION PLAN:

Extension Perspectives Related

To Animal Waste Disposal

Animal Waste Utilization

NOT

Animal Waste Disposal

ANIMAL WASTE VALUE:

- » + SOIL AMENDMENT
- » + PLANT FOOD
- » - water pollution POTENTIAL
- » - air pollution POTENTIAL

Late 1980's:

- Alabama Cooperative Extension Specialists, AU researchers, NRCS Engineers and Agronomists meet to discuss ways to encourage utilization of broiler litter as plant food

Late 1990's:

- Extension Specialists participate in Concentrated Animal Feeding Operation (CAFO) Work Group to help write AFO/CAFO Rules

EXTENSION MISSION (ANIMAL WASTE):

- RESEARCH-BASED
- PRACTICAL RECOMMENDATIONS TO CLIENTELE
- PROTECTION OF WATER QUALITY
- PROTECTION OF AGRICULTURAL LIVELIHOOD
- HIGH QUALITY OF LIFE

PRESENT -

–WHAT

–WHY

–HOW

CLIENT MAKES DECISION

LOOK AT TOTAL PICTURE

MARKET

FACILITY TYPE

LABOR

LAND

NEIGHBORS

LOCATION! LOCATION! LOCATION!

- MAXIMIZE LONG TERM PROFIT
- MINIMIZE NEGATIVE ENVIRONMENTAL IMPACT (water, air, soil)

CHALLENGES

- ODOR (and perception thereof)

- NUTRIENT OVERLOAD/EXCESS -

  RUNOFF (w, w/o sediment)

  DEEP PERCOLATION

SOLUTIONS

- LOCATION
- STORE/TREATMENT SYSTEMS
- AVAILABLE, USEABLE SOIL
- TRANSPORTATION

NUTRIENT MANAGEMENT TRAINING

- Matching crop Nutrient use to AVAILABLE manure nutrients, NOT matching available manure nutrients to crop needs
- Soil testing for P and K (and using PHOSPHORUS INDEX)

LAND APPLICATION TRAINING

- Buffers
- Property line setbacks
- Method (transportation, calibration)
- Timing to crop needs
- Soil characteristics

CERTIFIED ANIMAL WASTE VENDOR TRAINING (CAWV)

-EXTENSION leads training

-Alabama Department of Agriculture and Industries regulates

Help develop Qualified Credentialed Professionals (QCPs) to assist AFO/CAFO operators in Waste Management System Plan (WMSP) development and implementation

EXTENSION GOALS IN ANIMAL WASTE MANAGEMENT

- Help guide/generate research
- Help select practical research to guide Best Management Practice (BMP) development
- Help animal feeding operations (AFO) operators understand AFO/CAFO RULES
- Help AFO operators make the best choices for their systems, their environment, and their long term sustainability

Soil Scientist Certification in Georgia: History, Status, and Challenges

Larry T. West
Department of Crop & Soil Sciences
University of Georgia, Athens

A Little History

The Beginning

- GA DHR developed interest in use of county soil surveys for site evaluation for on-site systems – early 80’s
- USDA-NRCS Soil Scientist “loaned” to GA DHR
- Interpretations for on-site systems developed for each series mapped in GA

On-Site Interpretations

- Each series
  - Suitable
  - Unsuitable
  - Suitable with system modification
    - Modifications described
- Basis
  - Depth to water table
  - Depth to rock
  - Estimated perc at 30”

Use of Soil Information

- Scale of county soil surveys too broad to be effective
- Site specific evaluations
  - Method decided by County Board of Health
  - Based on series concepts
    - Inertia
    - Easy communication
    - Works well for subdivision plans

The Labor Force

- Initially, retired NRCS Soil Scientists
  - Contacts between Soil Scientist and Environmentalist
  - No question of qualifications
- Greater demand for site evaluations than available soil scientists
- Who was qualified?
  - Professional organizations developed lists of qualified people

Multiple Professional Organization and Agency Lists

- GA Soil Classifiers, ARPACS, GA Chapter NSCSS, GPSS
  - Education and experience w/ or w/o exam
  - Emphasis on NRCS experience
- Health Districts developed lists
- Confusion
- Limited potential for discipline

Inconsistent Product

- Environmentalist needs
  - Critical properties
  - Series range or more specific data
- Map scale
  - What is “high intensity”?
- Mapping techniques
  - NCSS standards
  - More and deeper observations
  - Variants
  - Symbols

The New Era

- Soil map required for on-site permitting
- Development of standards
  - Frequency and depth of observation
  - Location accuracy
  - Information included in report
    - Morphology
    - Suitability
- Uniform practices statewide
- Certification of soil classifiers and others

Soil Classifier Certification

- Certification Board administered by DHR
  - Soil classifiers
  - Environmentalists
  - Academics
- Requirements
  - Education; 5 soil science courses
  - Experience; 4 years “mapping classifying and interpreting soils in the field”
  - Exam
  - Insurance
  - Continuing education

Status

- 42 Certified Soil Classifiers
  - Most have NRCS experience
- 16 Soil Clasifiers in Training
  - Education
  - Exam
  - 6 months experience
- More Soil Scientists in Georgia than ever before

New Challenges

- Continuing education
  - What qualifies?
    - Professional meetings?
    - Formal courses?
    - Workshops?
  - How much is enough?

New Challenges

- Training
  - Not all employers are good trainers
    - Personality
    - Monetary investment
      - “ignorance can be cured; greed cannot”
  - What is needed?
    - Only soil survey?
    - GIS, GPS, database management, business skills?
    - On-site system installation and management?
  - How much OJT can the public stand?

What is the Role of NCSS?

- Training and continuing education
  - Formal short courses
    - “New” soil scientist training
    - Soil Scientist Institute
    - Other
  - Soil survey workshops
  - Field reviews
- If it is required and worthwhile, the private sector will pay

What is the Role of NCSS?

- Information access
  - OSD
  - NASIS
  - New technology
- Data exchange
  - Public data is public data
  - Private data may be available and useful
    - Water movement
- Research

What is the Role of NCSS?

- Program support
  - Standards
  - Refined and more specific interpretations
  - Interpretations for alternate on-site system designs
  - Agency employee training
  - Specific field questions
- MOU's for time commitments
- NCSS cannot be the watchdog

Conclusion

- Private sector soil survey is real and is a growing industry
- NCSS has historically defined and led soil survey efforts in the U.S.
- We have the opportunity to expand and continue this leadership role
- Will we seize the opportunity?

"PEN TECHNOLOGY"
evolving methods of making soil surveys

L. P. Wilding

Soil & Crop Sciences

Texas A&M University

College Station, Texas

M. L. Golden

USDA

Natural Resources Conservation Service

Temple, Texas

Background

- **1993 - National SWCS Meeting Ft. Worth**

- **Vendors demonstrated PEN technology**
  - **Not viewable outdoors**
  - **No color screen**
  - **Hard drive limitations**

Introduction

- **PEN Capabilities**
  - **Creating digital soil database & updating digital databases. Can be used for:**
    - **SSURGO; PEDON; NRI**
    - **Customer Toolkit**
    - **Soil Data Viewer**
    - **Other data collection in field or office setting.**

SSURGO FIELD DATA COLLECTION

- **Paradigm Change - Soil Survey**
- **Utilize digital ortho**

StratMap Layers

Digital Orthophoto Quadrangles (DOQs)

Digital Elevation Models (DEMs)

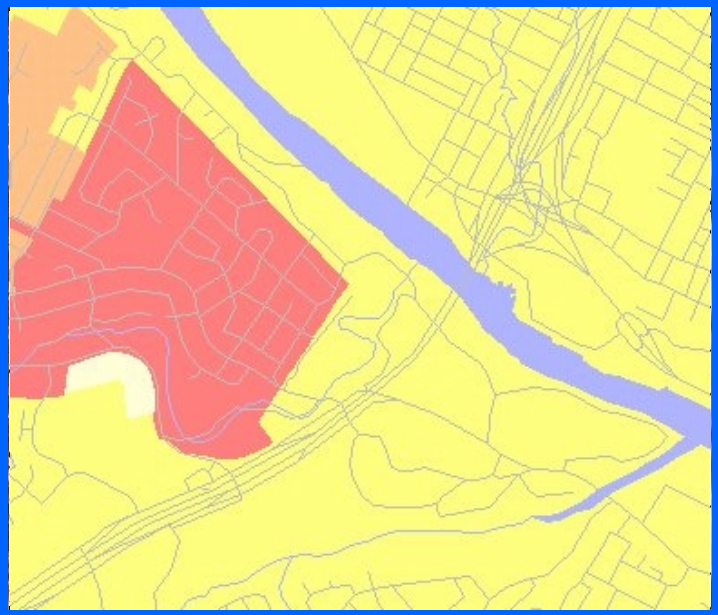
Contours

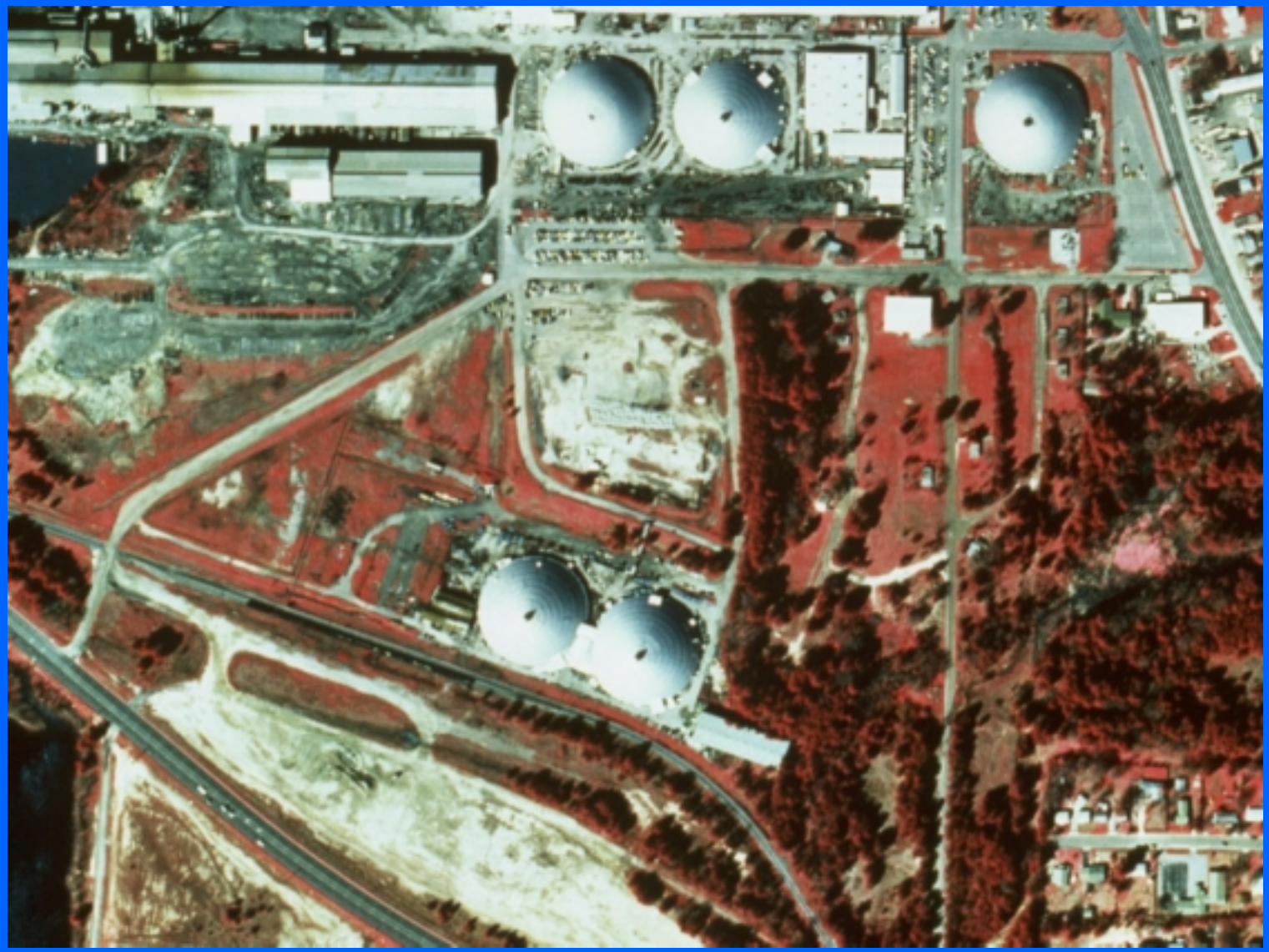
Soil Surveys

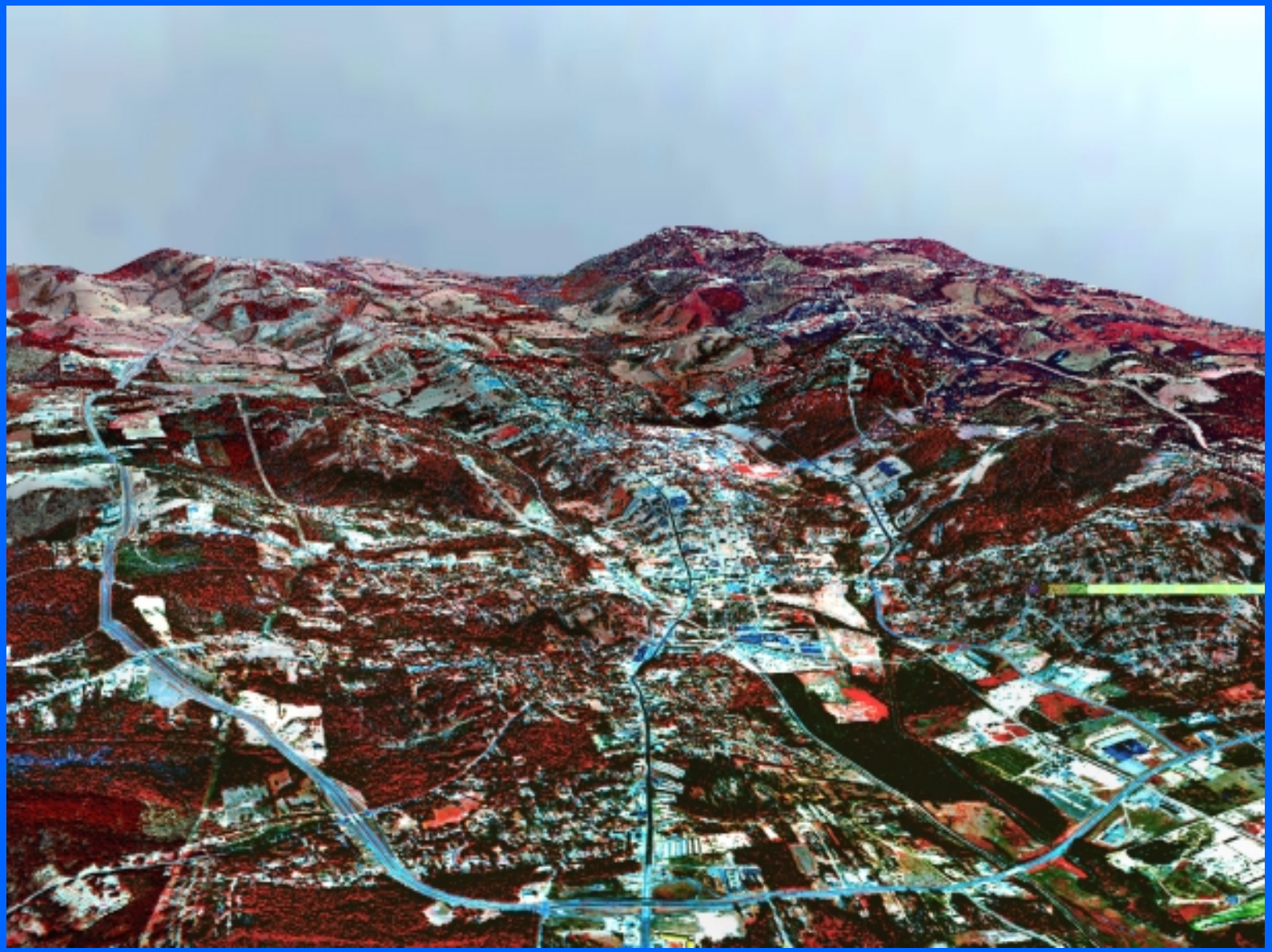
Water Features

Transportation

Political Boundaries







SSURGO

- **Eliminate:**
  - **Drafting of soil lines on imagery**
  - **Compilation from FI to photobase FP**
  - **Compilation from FP to mylar**
  - **Scanning process for data capture**

SSURGO

- **Reduce:**
  - **Time required to edit line work**
  - **Time to attribute soil polygons**

Pen Requirements

- **Sealed unit for use outdoors or indoors**
- **Lightweight**
- **Ruggedized**
- **Resistant to:**
  - **dust**
  - **moisture**
  - **heat**

Pen Requirements

- **Hand-held system**
- **Operated by PEN rather than mouse or keyboard**
- **Mobile system**
  - **Walking**
  - **Motorcycle**
  - **Soil probe truck**

Soil Mapping Demo
Map View Design Edit Calc Options
Gesture Mode
HAMMERHEAD

SSURGO

- **Increase accuracy of soil data**
  - **GPS: Know where you are at**
  - **Slope layer: Developed from DEM**
  - **Elevation: Developed from DEM**
  - **Geology layer:**
  - **Other layers: Moisture, temperature, etc.**

Fort Hood, Texas
Soil survey Field mapping project using pen technology

Goal 1 **Evaluate Digitizing Software**

Goal 2 **Evaluate PEN Computer**

Goal 3 **Evaluate PEN Performance in Field Setting**

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 1 Evaluate digitizing software

- Compatible/Windows 95 or NT
- Displaying multi-layers
- Vector line creation & editing
- Attributing & editing
- Import/Export file formats
- Drag and drop - cultural features
- GPS

Fort Hood, Texas
Soil survey Field mapping project using pen technology

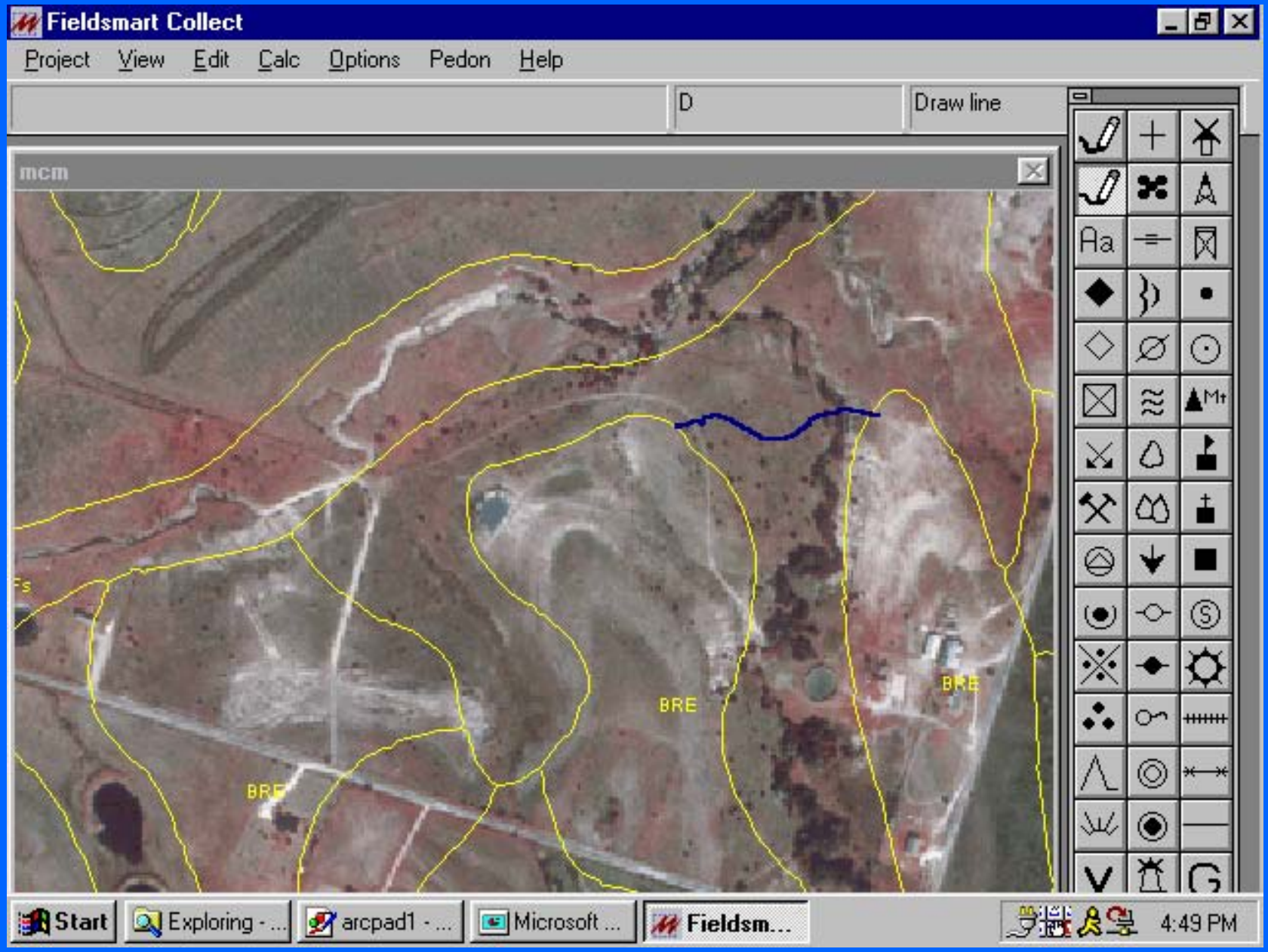
GOAL 1 Evaluate Digitizing Software

- Most packages were compatible with Windows 95, 98, and NT
- Evaluated 6 different packages
- Most packages had the capability to build vector lines and edit polygons but were complex and cumbersome
- User friendly packages are limited in creating topology for polygons

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 1 Evaluate Digitizing Software

- All packages displayed multi-layers
- Drag and drop soil symbols and cultural features (Only one package had this feature while other packages did not offer feature)
- Attributing and editing - only one package was user friendly but most were too complex for use by field soil scientist


Fieldsmart Collect
Project
View
Edit
Calc
Options
Pedon
Help
D
Draw line
mcm
BRE
BRE
BRE
Start
Exploring - ...
arcpad1 - ...
Microsoft ...
Fieldsm...
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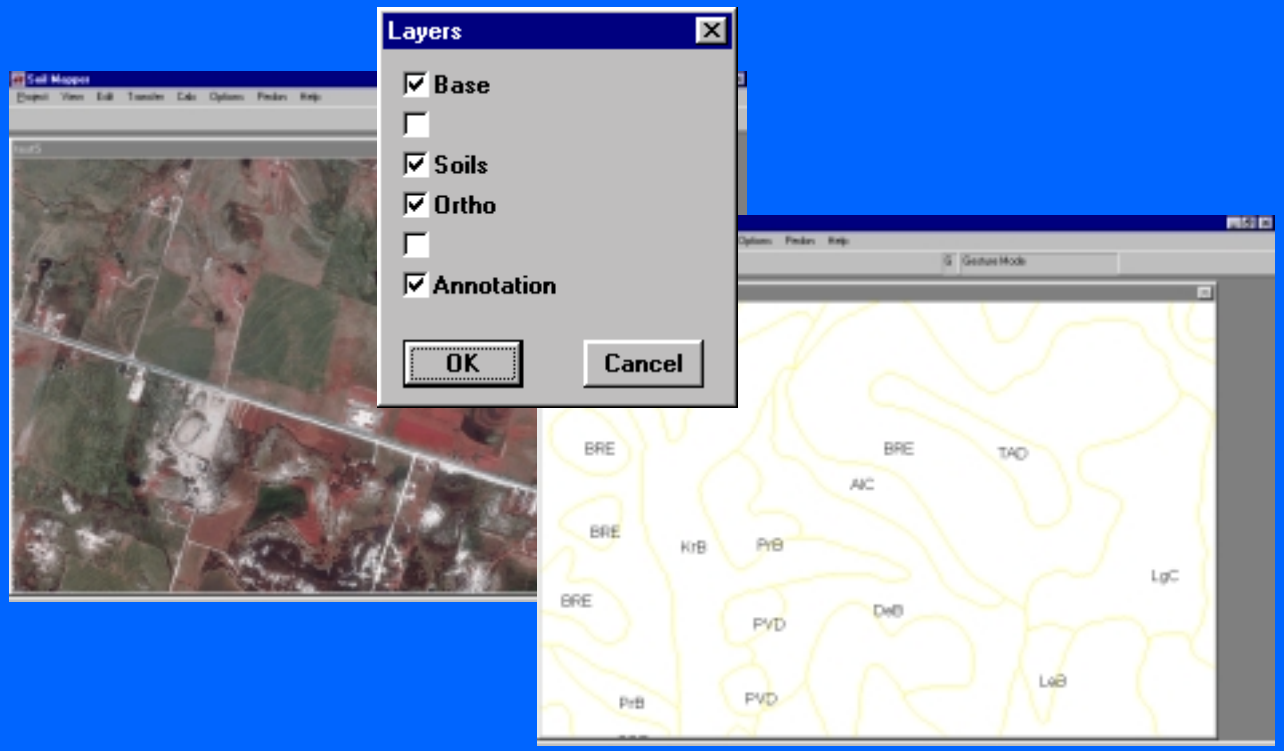
System Capabilities:

Layering

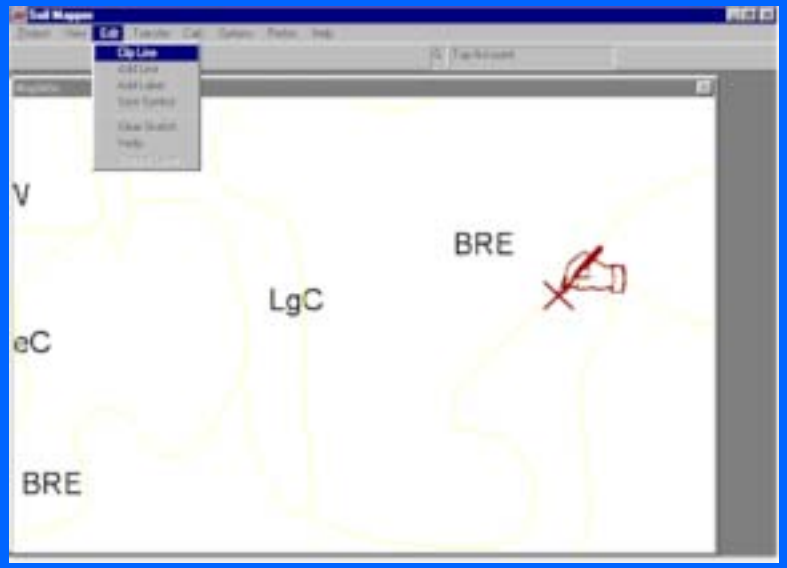
The Map Viewer improves display speed and supports selective download by structuring map data as multiple layers.



System Capabilities:

Modifying the Pedon Boundaries

Modifying the pedon boundaries is easy using the 'Clip Line' and 'Add Line' features.



Select the portion of the boundary you wish to modify or 'clip'.

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 1 Evaluate Digitizing Software

- Most packages imported several different data formats
- Some packages were limited on the export of geo-spatial formats
- Evaluated internal GPS - software did not allow on screen tracking and external GPS was too cumbersome to use

Fort Hood, Texas
Soil survey Field mapping project using pen technology

SUMMARY of GOAL 1

- **Each software had some functions we required; currently no one package contained all functionality to produce a soil survey.**

- **However, by late summer, one company expects a complete package that meets NCSS requirements to digitize.**

"On the fly"

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 2 Evaluate PEN Computers

- **Speed**
- **Storage**
- **Monitor quality**
- **Connectivity to other systems and peripherals**

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 2 Evaluate PEN Computers

- **Monitor Quality**

  - Active Matrix screen works indoors only

  - Active Matrix screen (back-light) works in very low light outdoors or indoors

  - Super reflective screen works well in bright sunlight

Project View Edit Transfer Calc Options Pedon Help
BRE
BRE
BRE
BRE
PrB
DeB
SaB
LeC
Start
Soil Mapper

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 2 Evaluate PEN Computers

- **Speed and Storage**

  - Processor currently limited to 233 mhz

  - Battery life about 2 hours

  - No. 2 button mouse

  - Size of screen limited to 8.5 inch diagonal

  - The 233 mhz too slow to run 3-D imaging using DEMs (5 minutes per quad)

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 2 Evaluate PEN Computers

- **Operating Systems**
  - **PEN works on Windows 95 & 98 but not on NT at present**
  - **PEDON was functional on PEN**
  - **Soil Data Viewer functional on Windows**

Fort Hood, Texas
Soil survey Field mapping project using pen technology

GOAL 2 Evaluate PEN Computers

- **Connectivity**

  - PEN is network compatible

  - Transfer of files on internet successful

  - Files successfully printed

Soil Mapping Demo
HAMMERHEAD

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SUMMARY of GOAL 2

- **No perfect screen for all light conditions**

  - Super Reflective Screen works best on bright sunny days

- **The 223 processor was adequate to display and map soils but inadequate to use DEMs for 3-D mapping**

- **Connectivity to peripherals is adequate when using docking station**

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GOAL 3 Evaluate PEN Performance In Field Setting

- **Update soil mapping on two 7.5’ quads utilizing DOQQs, DEMs, stream layers, etc.**

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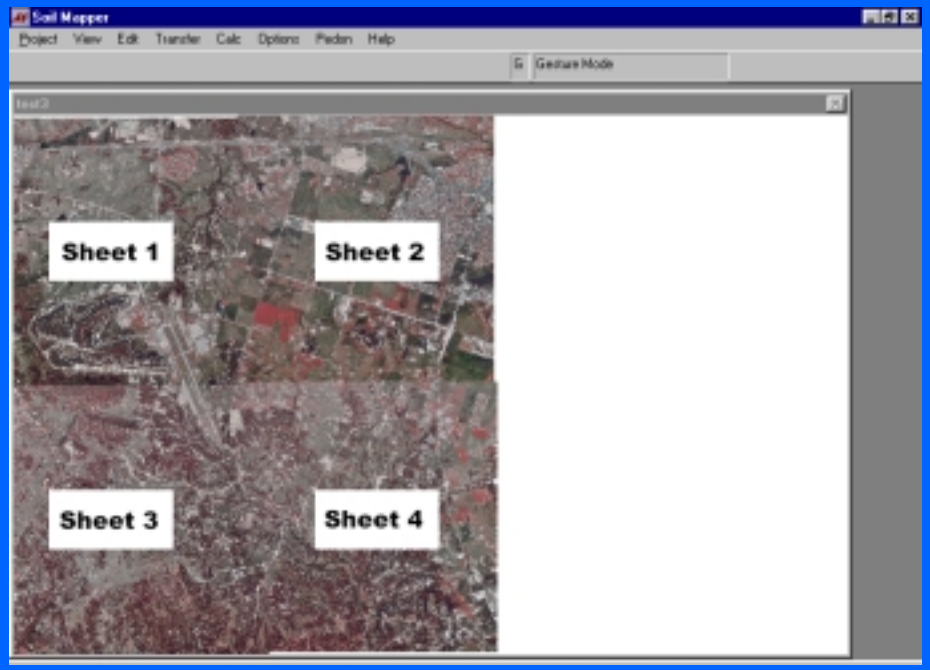
GOAL 3 Evaluate PEN Performance In Field Setting

- **Successfully displayed DOQs**
- **Successfully edited soil lines on 2 quads**
- **Successfully attributed soil polygons and cultural features**
- **Successfully imported drainage layers**
- **Unsuccessful in using DEMs**

System Capabilities:

Map Library

You can navigate around a large area without being limited by map sheet boundaries.



The system handles multiple map tiles through a map library.

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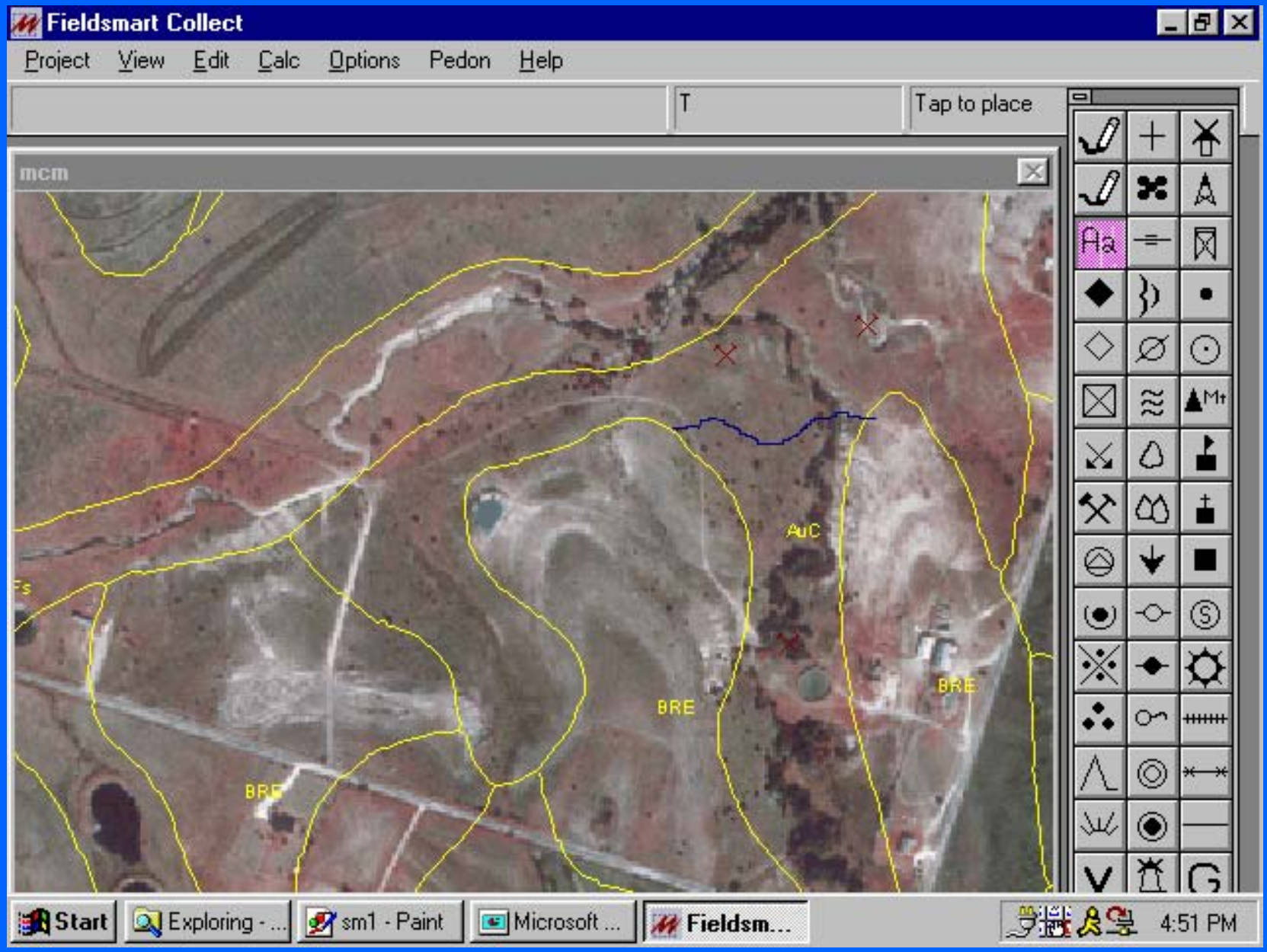
SUMMARY of GOAL 3

- **Technology is advancing for hardware and software for use in GIS. The screen and digitizing software are still the main limitations for use in the field.**

BRE
BRE
PrB
DeB


Fieldsmart Collect
Project
View
Edit
Calc
Options
Pedon
Help
T
Tap to place
mcm
AuC
BRE
BRE
BRE
Start
Exploring - ...
sm1 - Paint
Microsoft ...
Fieldsm...
4:51 PM

FINDINGS

- **To date there is no PEN system that will perform to our full expectation.**
- **The future looks bright for this technology to evolve in the near future to overcome deficiencies so we can produce or update soil surveys in a field setting.**

SUMMARY

- **Challenge present methods and processes**
- **Utilize digital ortho photography**
- **Mobile, lightweight, rugged PEN based unit**
- **Utilize digital ortho photography**
- **Digitizing software developed to map soils "on the fly"**
- **Color reflective screen for use in sunlight**
- **PEN based PC "The Complete Survey"**
- **Paradigm change for making soil surveys**

Image to Image Rectification for Digitizing Soil Survey Maps

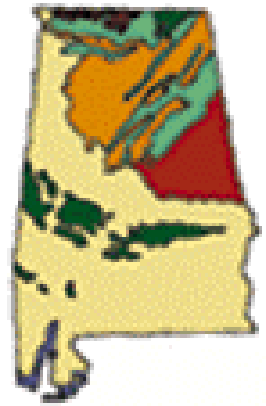
John M. Beck

Research Associate

Auburn University

Alabama Land Resource Information Center

Alabama Land Resource Information Center



Spatial technology lab, provides geo-spatial information to enhance teaching, research, and extension at Auburn

SOIL SURVEY REPORTS

- GIS and the availability of national data sets require a 1:24,000 scale
- Most of Alabama's Soil Surveys were not published at 1:24,000

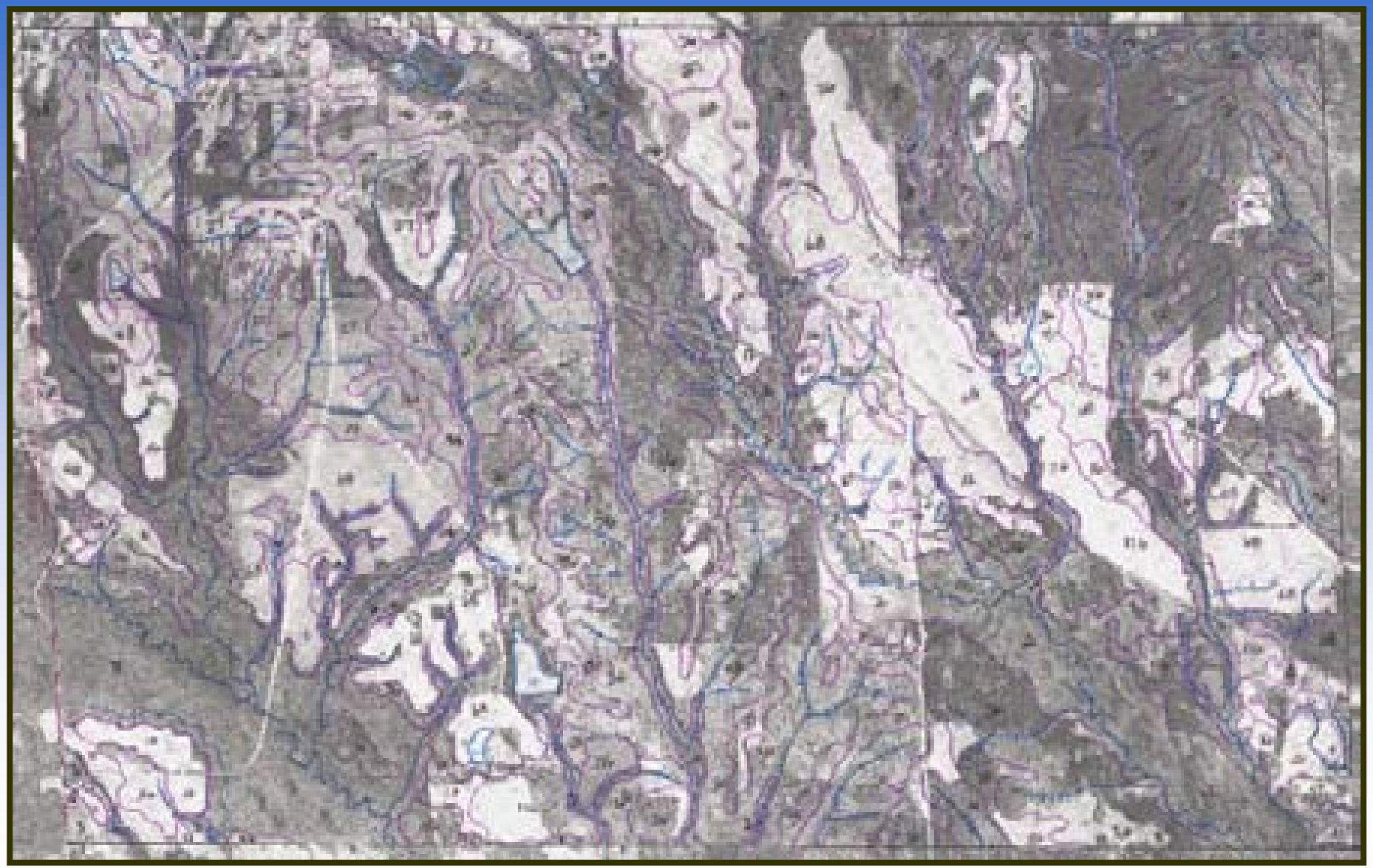
THE MILLION DOLLAR QUESTION?

Can we effectively take a soil survey report published at a scale other than 1:24,00 and create a SSURGO product?

ONE POSSIBLE SOLUTION

- Use Remote Sensing software

ATLAS MYLAR SHEET



DOQ

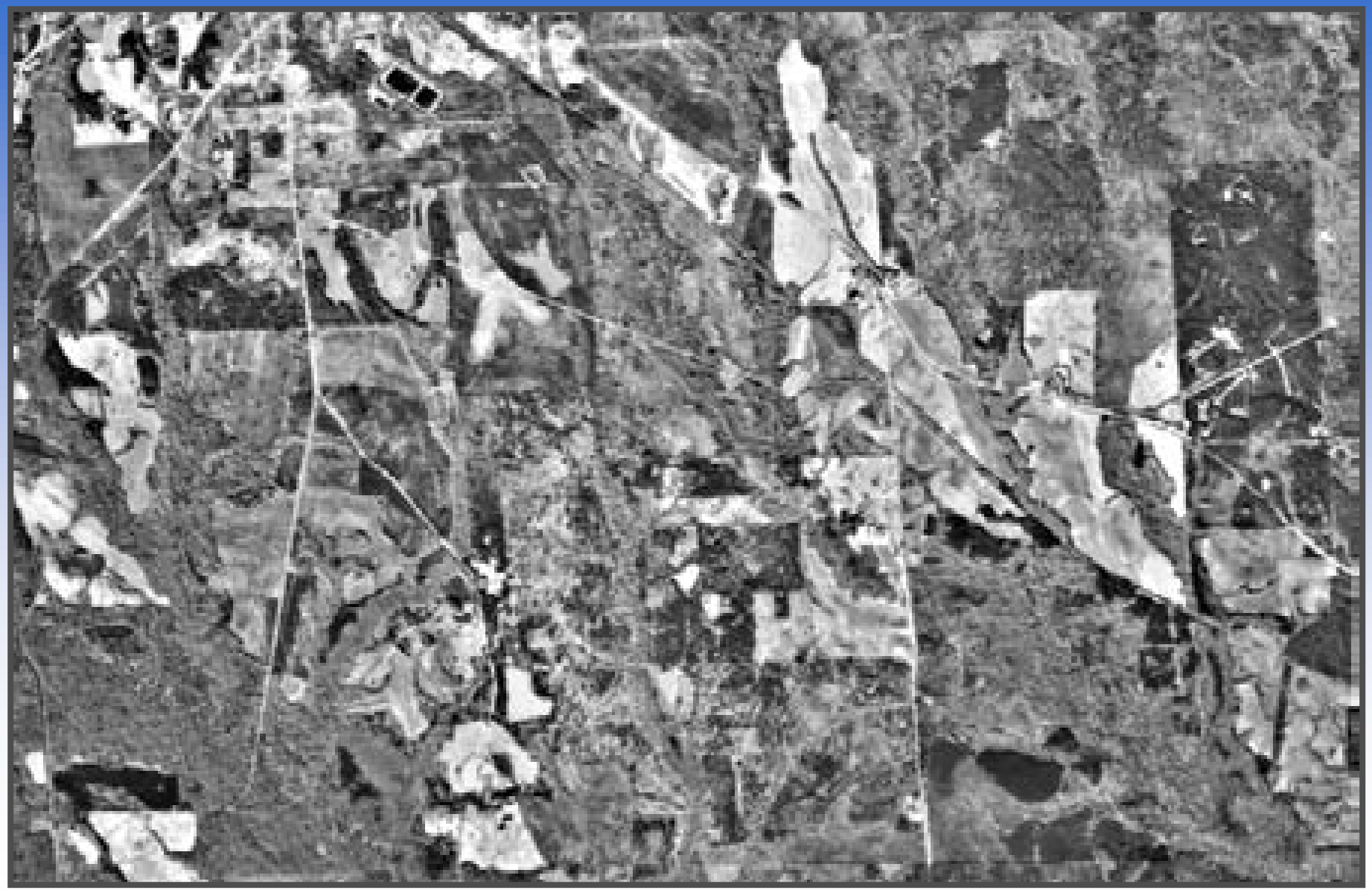
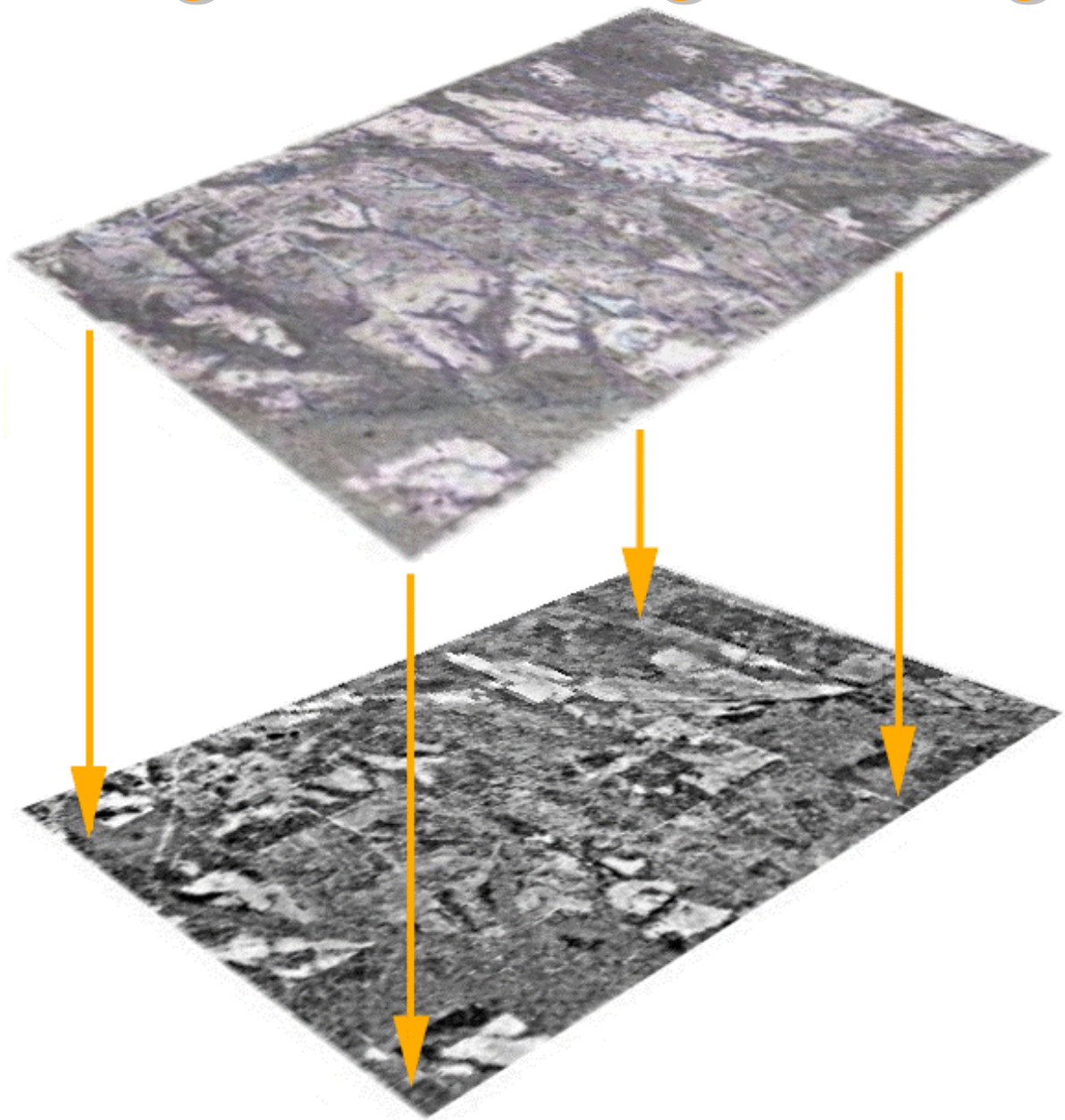
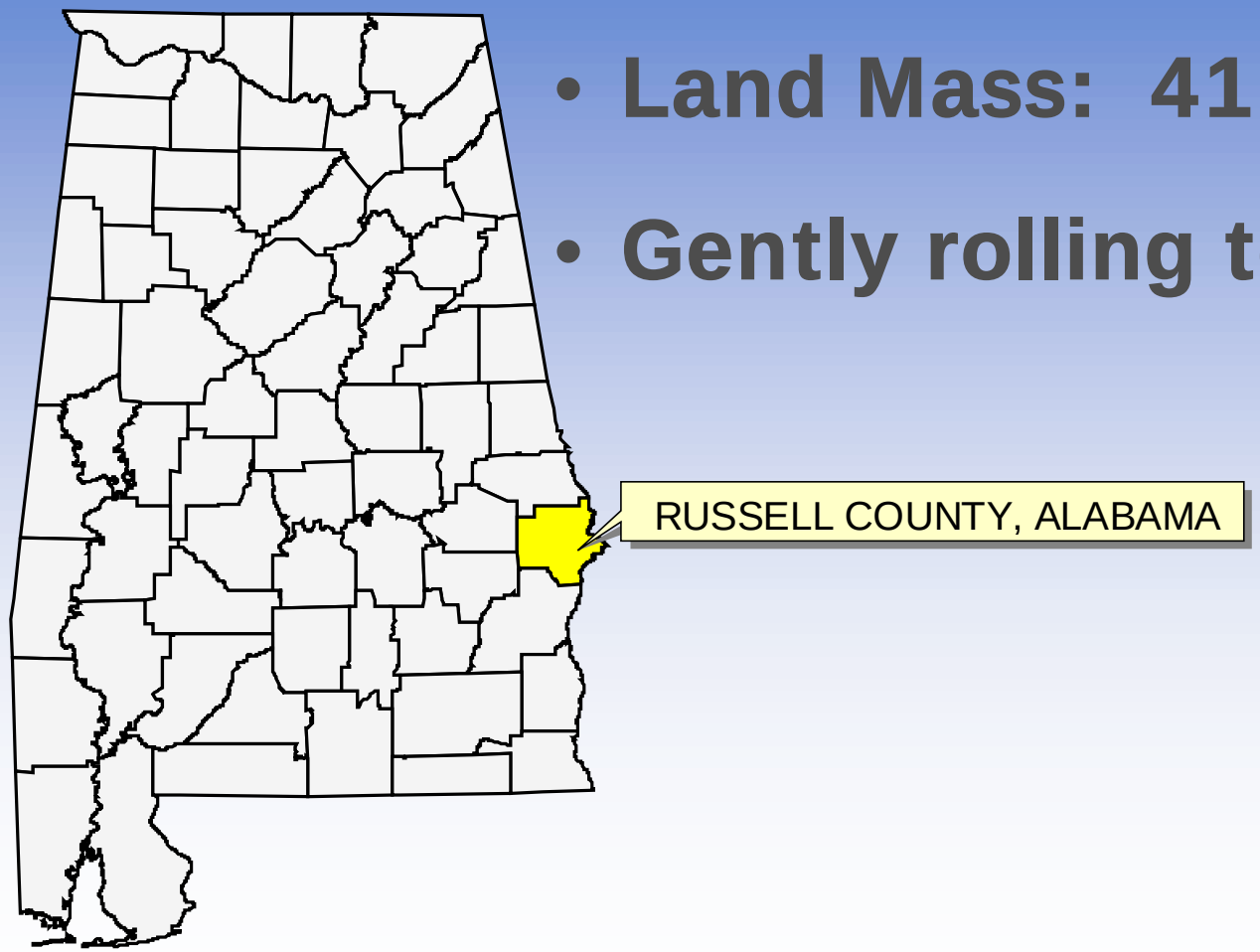


Image to Image Merge

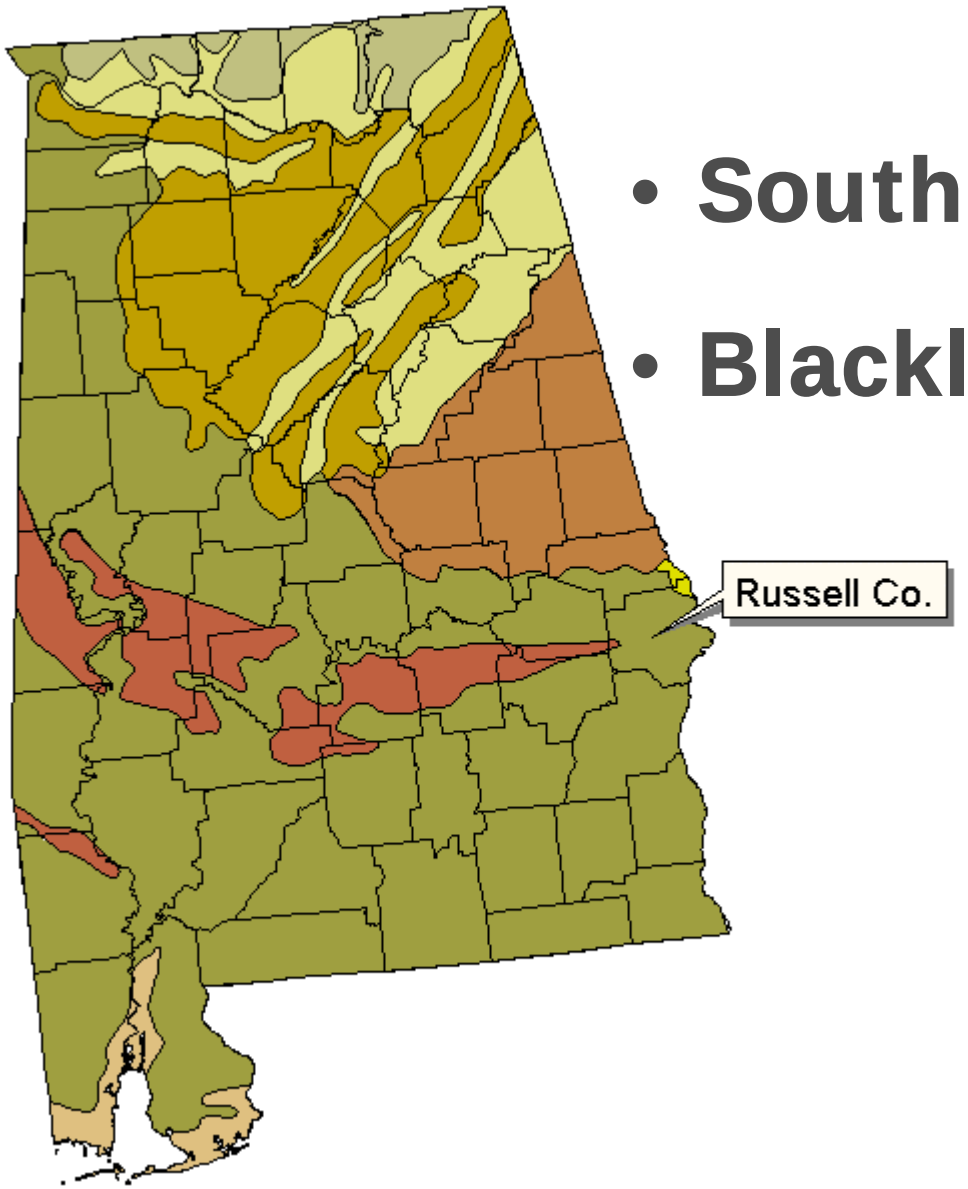


CASE STUDY:
Russell County, Alabama



- **Land Mass: 413,940 Acres**
- **Gently rolling topography**

MAJOR LAND RESOURCE AREAS



- Southern Coastal Plain
- Blackland Prairie

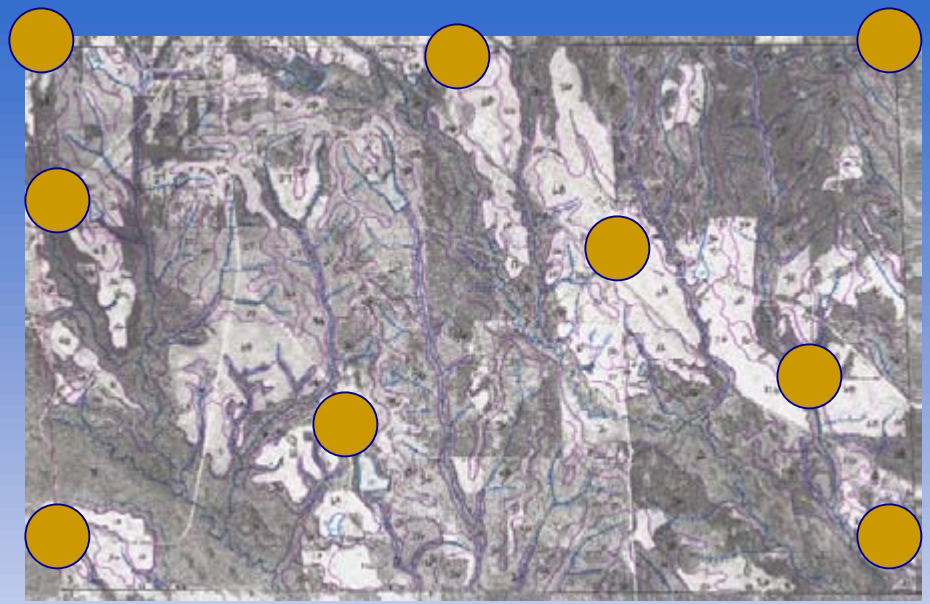
THE PROCESS
Step 1. Scan Atlas Mylar Sheets

- High resolution scan at 800 dpi
- EPSON Expression 836XL Flat Bed scanner (12.5” x 17.5 ”)

Step 2. Ground Control Points

- ERDAS Imagine software
- Located GCPs on both images
- An average of 250 points per sheet

Ground Control Points

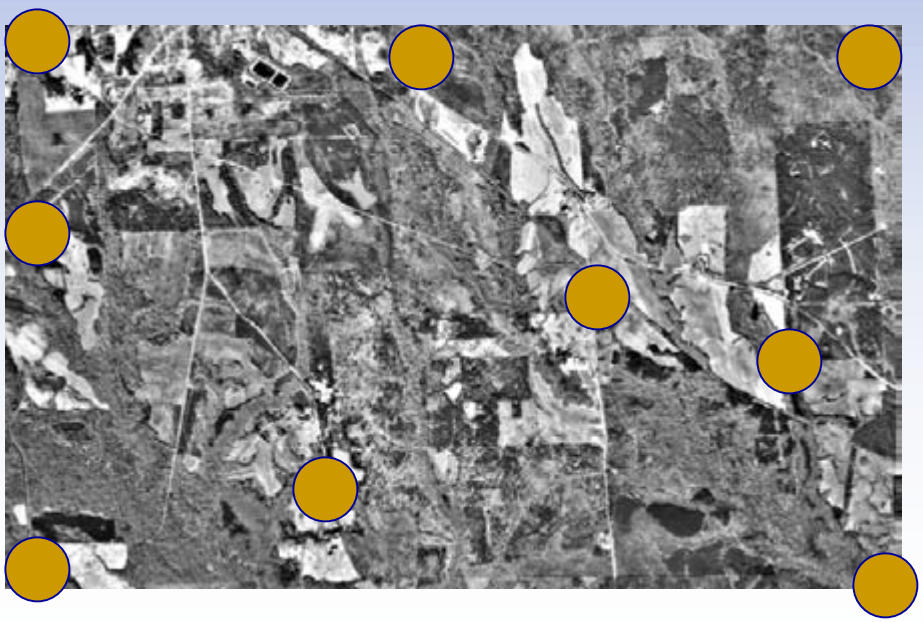


Primary Points

- Road Intersections
- Buildings
- Ponds
- Section/Property Lines

Secondary Points

- Streams
- Tree Lines
- Roads
- Pastures



Step 3. Geo-Rectify the Sheets

- GCP's were used to compute a transformation equation
- 2nd order polynomial - Delaney Triangles
- Resample Method: Bilinear Interpolation

Delaney Triangles

- Splits the image into localized regions
- Computes a transformation equation for each region
- Provided the best method to minimize distortion

Bilinear Interpolation

- Results are smooth and lack a stair stepped effect
- More spatially accurate than using a nearest neighbor resampling method

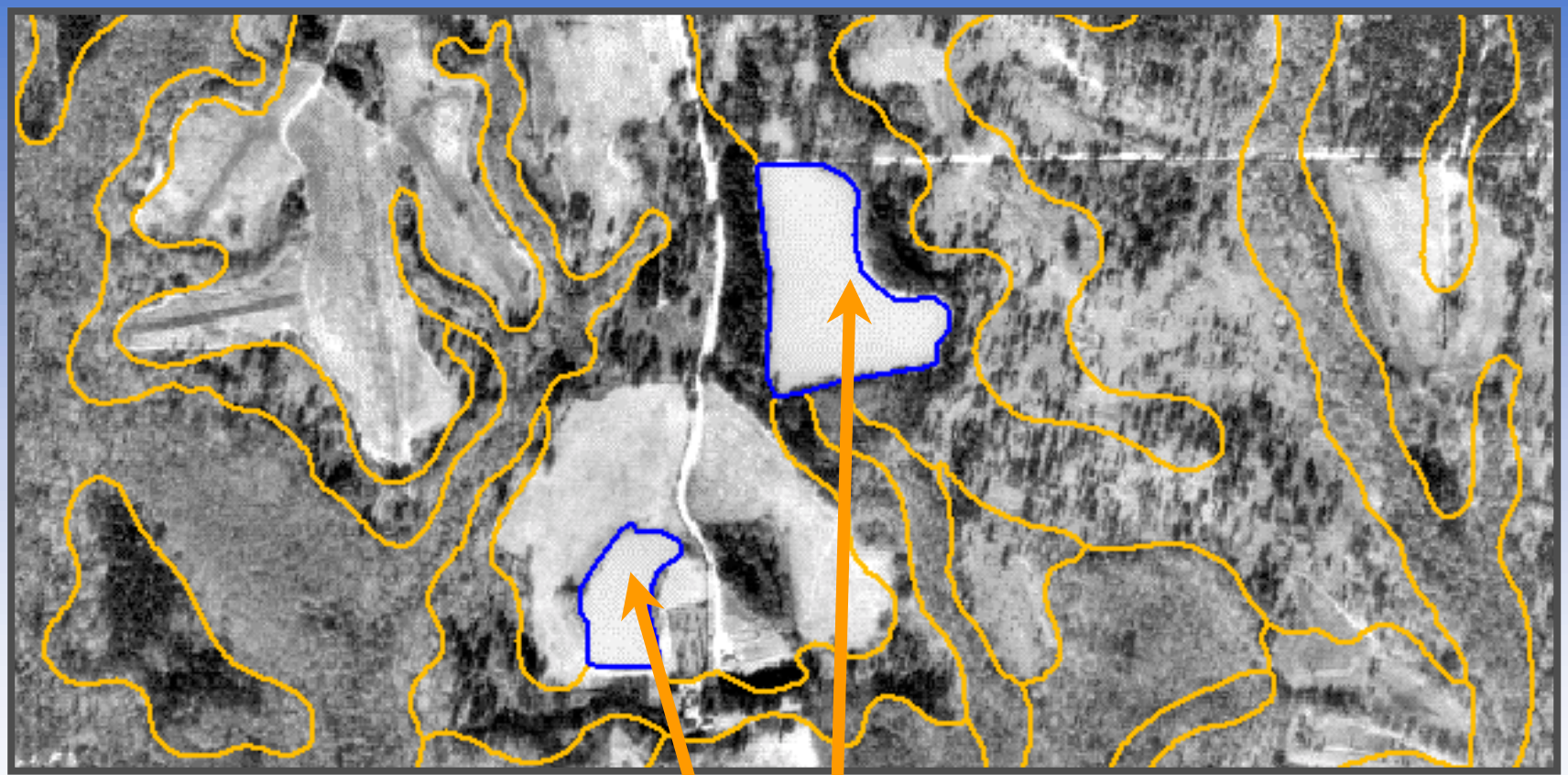
Step 4. Digitize Soil Lines

- Raster to Vector Conversion Routine
- Manual On-Screen Digitizing

Step 5. Recompile

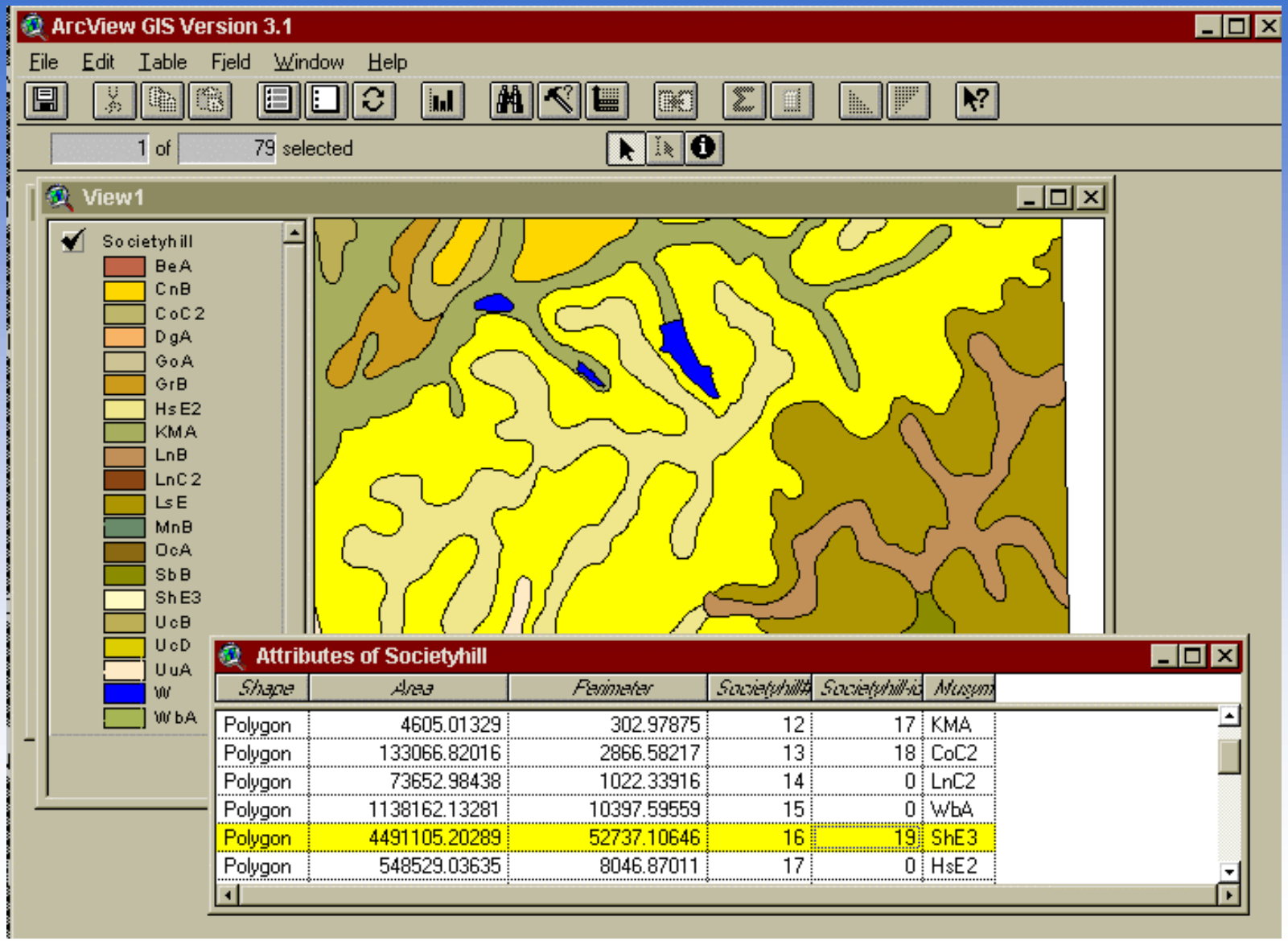
- Soil lines are verified by visual inspection
- New lines are digitized for changes in landscape
- Problem areas fixed

Digitize Changes in Landscape



New Ponds

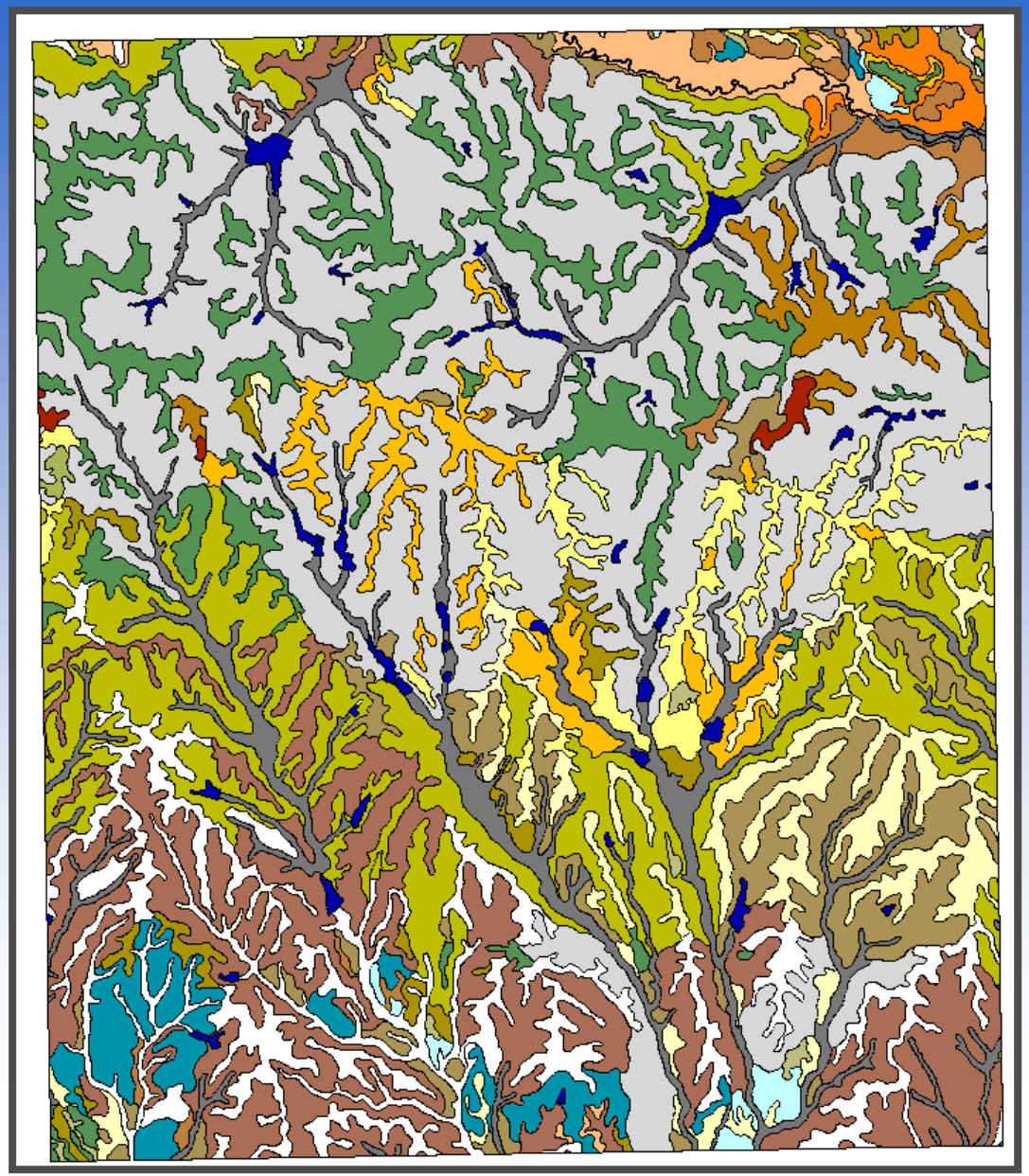
Step 6. Label Polygons



Step 7. Quality Control

- Quad sheets were printed on mylar and inspected by USDA-NRCS Soil Scientist
- USDA-NRCS Arc/Info AMLs were used to check for SSURGO standards

Finished Product



Soil Mapping Using GIS, Expert Knowledge, and Fuzzy Logic

A-Xing Zhu, James E. Burt, Ken Lubich, Dave Roberts

1. Introduction:

Detailed soil spatial and attribute information is required for many environmental modeling and land management applications at the watershed level [Beven and Kirkby, 1979; Burrough, 1996; Corwin et al., 1997; and Jury, 1985]. Currently, soil maps produced through conventional surveys are the major source of soil spatial information for these applications. However, standard soil surveys were not designed to provide the detailed (high-resolution) soil information required by some environmental modeling (Band and Moore, 1995; Zhu, 1999a] and crop management applications (Peterson, 1991). The inadequacy is the incompatibility of soil maps with other landscape data derived from detailed digital terrain analyses and remote sensing techniques [Band and Moore, 1995; Zhu, 1997a; Zhu, 1999a]. This inadequacy is largely due to the limitations of the discrete data model and polygon-based mapping practice employed in conventional soil surveys.

Zhu (1997a), Zhu (1999b), Zhu and Band (1994), Zhu et al. (1996), and Zhu et al. (1997) developed a soil-land inference model (SoLIM) to overcome the limitations in conventional soil surveys by combining the knowledge of local soil scientists with GIS techniques under fuzzy logic to map soils. The approach is based on the soil factor equation by Dokuchaeiv (Glinka, 1927) and Hilgard (Jenny, 1961) or the soil-landscape paradigm concept described by Hudson (1992). This concept contends that there exist relationships between soil and its formative environmental factors. If we know the relationships between soil and its environment for an area, then for a given location in that area we would be able to infer what soil might be at that location from its environmental conditions. The SoLIM approach employs GIS/remote sensing techniques to characterize the soil environmental conditions and uses a set of knowledge acquisition techniques to extract soil-environmental relationships from local soil experts. A set of inference techniques constructed under fuzzy logic links the characterized environmental conditions with the extracted relationships to infer the spatial distribution of soils.

This paper describes and assesses the SoLIM approach from perspectives of improving soil surveys. The next section provides a background on the limitations of conventional soil survey and its soil maps. Section 3 describes how some of the limitations are overcome or reduced in the SoLIM approach, which is followed by the assessment of SoLIM in Section 4. Summaries are presented in Section 5.

2. Limitations of the Model and Process Used in Current Soil Surveys

The ability of soil scientists to conduct soil surveys accurately and efficiently is largely limited by two major factors: the polygon-based mapping practice and the manual map production process. The polygon-based mapping practice is based on the discrete conceptual model (Zhu, 1997a), which limits soil scientists' ability to produce quality soil maps. Under this model, soils in the field are represented through the delineation of soil polygons with each polygon depicting the spatial extent of a particular soil class (single-component unit) or a group of commonly found classes (multiple-component unit). The first problem associated with this polygon-based mapping practice is that it limits the size of the "soil body" which can be delineated as a polygon on a paper map. "Soil bodies" smaller than this size are either ignored or merged into the larger enclosing soil bodies. This limitation forces soil scientists to create multiple-component mapping units to express the inclusion of different soils in the polygon. However, the spatial locations of these components cannot be shown in the map. The filtering of small soil bodies due to the limitation of the polygon-based mapping techniques is called ***generalization of soils in the spatial domain*** (Zhu, 1998). This spatial generalization can be very significant and the soil bodies that are filtered out can range from a few hectares on some large scale (small area) maps to hundreds of hectares or more on some small scale (large area) maps.

The second limitation of the polygon-based mapping practice is that the polygons represent only the distribution of a set of prescribed soil classes (ideal concepts of soils), not individual soils in the field which often differ from the prototypes of these prescribed classes. In order to map soils, field soil scientists have to assign individual soils in the field to one and only one of these classes (referred to as *Boolean Classification*).

Once assigned to a class the local soil is said to be typical of that class; thus the local conditions of that soil are lost. Local soil scientists may know that the local soil differs from the typical type of the assigned class, but this expert knowledge cannot be conveyed using polygon-based soil mapping. This approximation of local soil conditions by the typical type of a prescribed soil class is referred to as ***generalization of soils in the parameter domain*** (Zhu, 1998). This generalization forces soil scientists to map soil spatial variation as a step function, which means that soil variation appears only at the boundaries of soil polygons. Field experience tells us that although abrupt changes of soils over space do exist, changes in soil properties often take a more gradual and continuous form than what the polygon-based mapping practice allows.

The manual soil map production process limits soil scientists' ability to update soil surveys rapidly and accurately. During the manual production process soil scientists first detect different soil formative environments through their visual interpretation of geological, topographic maps and air photos. The spatial extents of these soil formative environments are then used to delineate soil polygons based on soil scientists' understanding on the relationships between these environmental conditions and the soil mapping units. The boundaries of soil polygons may initially be delineated on a set of air photos and then be transcribed onto a base map for map compilation purpose. There are several major limitations associated with this process. First, subtle yet important changes in environmental conditions may not be easily observed visually due to the limitation of visual perception and the limitation of visually processing many variables simultaneously. This can result in small soil bodies not being mapped. Secondly, visual interpretation is not only a time-consuming but also an error-prone process, since it is very likely to make mistakes after staring through a pair of stereoscopes for many hours. As a result, misinterpretations can often occur during the soil boundary delineation process. Thirdly, the process of transcribing soil polygon boundaries from a set of air photos to a base map is not only time-consuming but could also be error-prone, further degrading the quality of soil maps. Fourth, much of soil scientists' time is devoted to this soil polygon delineation process, preventing them from further investigating soils and their environment in the field and from improving their understanding of soils for future updates. Finally, this entire soil map production process must be repeated for each future soil survey update. This makes soil survey updates very inefficient.

As a result of these limitations, current way conducting soil survey is very time-consuming. There are approximately 2.2 billion acres in the United States. The current rate of soil survey updating is about 10 million acres per year. This means that at current rate it will take us 220 years to update all of soil surveys. If the effort is doubled as more staff is shifted from initial soil surveys to updates the survey update will still be at a century cycle (over above three generations of soil scientists). A radical change is needed to move soil survey to a more acceptable update rate and to a product that can be continually updated efficiently and accurately.

3. The SoLIM approach

Zhu (1997a), Zhu (1999b), Zhu and Band (1994), Zhu et al. (1996), and Zhu et al. (1997) developed a soil-land inference model (SoLIM) to overcome the aforementioned limitations in conventional soil surveys by combining the knowledge of local soil scientists with GIS techniques under fuzzy logic for soil mapping. This approach consists of three major components: a similarity model for representing soils as a continuum, a set of automated inference techniques for mapping soils using the similarity model, and a set of procedures for deriving soil information products from the similarity model. This section briefly describes each of these three components.

3.1 Representing soil as continuum: the similarity model:

Zhu (1997a) developed a soil similarity model to overcome the two generalizations in representing soils. The similarity model has two parts: the raster representation of soils in the spatial domain and the similarity representation of soils in the parameter domain. Under raster GIS data modeling, an area can be represented by many small squares (pixels). The pixel size can be very small; it is often 30 meters on each side, although much finer pixel sizes are possible. With raster representation, generalization of soils in the spatial domain can be greatly reduced and spatial details of soil variation can be represented at a very fine spatial resolution.

The similarity representation of soils in the parameter domain is based on fuzzy logic (Zhu, 1997a). Under fuzzy logic, the soil at a given pixel can be assigned to more than one soil class with varying degrees of class assignment (Burrough et al. 1992; Burrough et al., 1997; McBratney and De Gruijter, 1992; McBratney and Odeh, 1997; Odeh et al., 1992). These degrees of class assignment are referred to as ***fuzzy memberships***. This fuzzy representation allows a soil at each pixel to bear a partial membership in each of the prescribed soil classes. Each fuzzy membership is regarded as a ***similarity measure*** between the local soil and the typical case of the given class. All of these fuzzy memberships are retained in this similarity representation, which forms an *n*-element vector (***soil similarity vector***, or ***fuzzy membership vector***), $\boldsymbol{S}_{ij}$ (S_{ij}^{1}, S_{ij}^{2}, …, S_{ij}^{k}, …, S_{ij}^{n}), where *n* is the number of prescribed soil classes and the *k*th element, S_{ij}^{k}, in the vector represents the similarity value between the soil at pixel (*i*,*j*) and soil class *k*. With this similarity representation, the local soil at a given pixel is no longer necessarily approximated by the typical case of a particular class but can be represented as an inter-grade to the set of prescribed classes. This method of representation, which allows the local soil to take property values intermediate to the typical values of the prescribed classes, largely reduces the generalization of soils in the parameter domain.

By coupling this similarity representation with a raster GIS data model, soils in an area is represented as an array of pixels with soil at each pixel being represented as a soil similarity vector (referred to as a ***raster soil database***, Figure 1). In this way, soil spatial variation can be represented as a continuum in both the spatial and parameter domains.

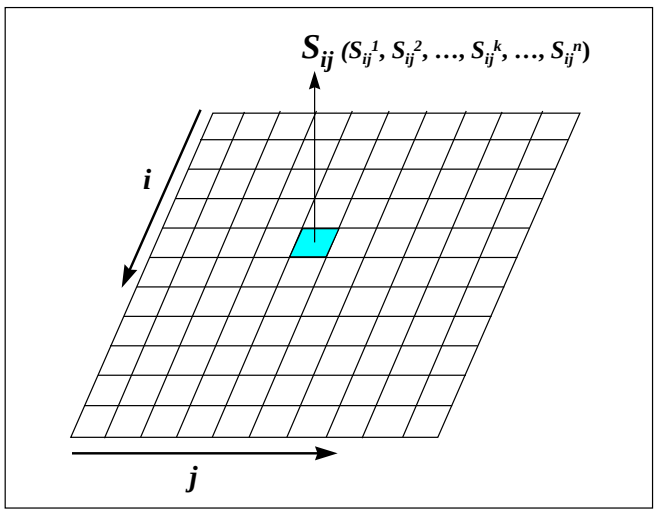


Figure 1: The raster soil database. Soil bodies are presented as pixels in spatial domain and as similarity vectors in parameter domain.

3.2 Populating the similarity model: automated soil inference under fuzzy logic

The similarity model provides only added flexibility for representing soil spatial variation. The degree of success in using this model depends on how the model is populated or how the soil similarity values in the vector at each pixel are determined. The SoLIM approach determines the soil similarity values using the soil factor equation outlined by Dokuchaeiv (Glinka, 1927) and Hilgard (Jenny, 1961) or the soil-landscape paradigm concept described by Hudson (1992). This concept contends that soil is the result of the interaction of its formative environmental factors over time as described in Equation [1].

$$S' = \int f_1(E)dt \qquad [1]$$

where *S'* is soil, *f* is the relationship of soil development to the formative environment, *E*, which generally includes variables describing climate, topography, parent materials, and vegetation factors, and *t* is time. Since it is difficult, if not impossible, to explicitly describe the *t* factor at every location across landscape and information on *t* is sometimes implicitly expressed in other formative environmental factors such as topographic positions and in local soil scientists' knowledge, under the SoLIM implementation Equation [1] is simplified to:

$$S' = f(E) \qquad [2]$$

Data on soil formative environmental conditions (E) can be derived using GIS techniques (Figure 2) (Zhu et al., 1996 and McSweeney et al., 1994). The soil-environmental relationships (f) can be approximated by the expertise of local soil scientists (Zhu and Band, 1994; Zhu, 1999b) or using techniques such as artificial neural networks (ANN) (Zhu, 1998), case-based reasoning (CBR) (Kolodner, 1993; Schank, 1982; Shi and Zhu, 1999), and supervised fuzzy classification (Wang, 1990). The acquired soil-environmental relationships can then be combined with data characterizing the soil formative environment conditions to infer S' under fuzzy logic (Zhu and Band, 1994; Zhu et al., 1996). S' is a measure of similarity between the characterized soil formative environment for the typical case of a given soil class and the characterized soil formative environment at a given local location. Since the similarity measure of a local soil to the central concept of a particular cannot be determined without examining the local soil in details, which is prohibitively expensive, S' is used to approximate S (the soil similarity measure) under the SoLIM approach.

The actual process of inferring S' is automated (Zhu and Band, 1994). The acquired soil-environmental relationships are stored in a database (referred to as a ***knowledgebase***). Data characterizing soil formative environments are stored in a GIS database. A set of inference techniques constructed under fuzzy logic (collectively called the fuzzy inference engine) are used to link the knowledgebase with the GIS database to derive soil similarity vectors (Figure 3). In general, for pixel (i,j), the inference engine takes the data on soil formative environment conditions for that pixel from the GIS database and combines the data with the soil-environment relationships for soil category k from the knowledgebase to calculate the similarity value of the local environment to the typical environment of soil category k, S'^{k}_{ij}, which is then used as a surrogate to S^{k}_{ij}. Once all of the soil categories are exhausted by the inference engine the soil similarity vector ($\mathbf{S}_{ij}$) for this pixel is created. The inference engine then moves onto the next pixel in the GIS database and repeats the process of deriving the soil similarity vector. When all of pixels in the GIS database are exhausted, a similarity representation of soils (a raster soil database) for the entire area then is derived.

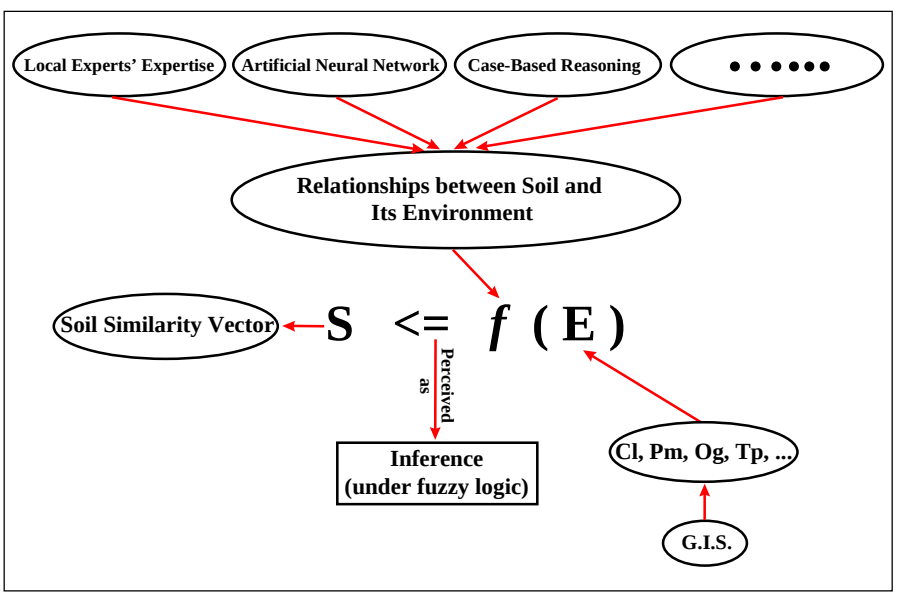


Figure 2: The automated soil inference under fuzzy logic is based on the concept that soil (S) is a function (f) of its formative environment (E).

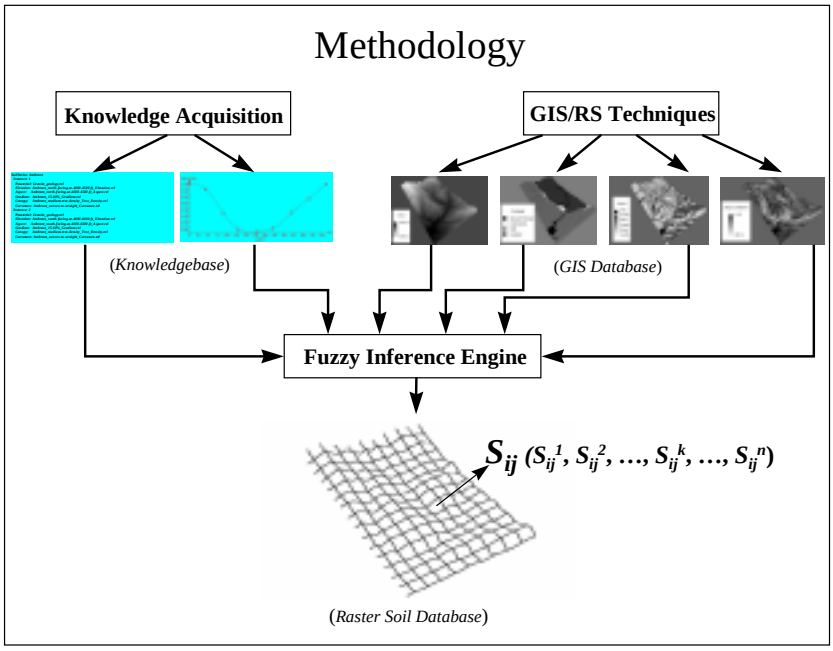


Figure 3: Soil inference process. The knowledge base contains knowledge on soil-environmental relationships. The GIS database contains spatial data on soil formative environmental conditions. The fuzzy inference engine combines the relationships in the knowledge base with the spatial data in the GIS database to produce a raster soil database for the study area.

3.3 Deriving soil information products: uses of the similarity model

The information represented under the similarity model can be interpreted as needed for different uses. Some of the uses are discussed below. The first is the derivation of a spatially detailed soil type map that is created through the hardening of the similarity vector (Zhu, 1997a). The hardening is done by assigning each location the label of the soil class that has the highest membership value in the similarity vector for that point. For example, a similarity vector at a point is (0.2, 0.4, 0.1, 0.3) with values representing membership in Soils A, B, C, and D, respectively. Hardening will result in the soil at the point to be labeled as Soil B since the local soil bears the highest membership in Soil B.

The second use is to assess the quality of the soil type map produced through the hardening of the similarity representation. Zhu (1997b) used two indices computed from the similarity vector to estimate the uncertainty in producing a soil type map through hardening the vectors. The first index, the exaggeration uncertainty, measures the error introduced when assigning a soil type to a local soil that is not the typical case of the soil type. In other words, the exaggeration uncertainty approximates how much the local soil is exaggerated to be the soil type assigned to. The second index, the ignorance uncertainty, measures the error occurred when ignoring the similarity of the local soil to other soil types other than the type being assigned to. This index approximates the loss of information when ignoring the intermediate (between-type) nature of the local soil. Zhu reports (1997b) that these two indices were useful to portray the spatial variation of soil map quality. This quality information is very critical for assessing the usefulness of soil maps and also for effectively allocating future update efforts.

The third use is the derivation of a spatially continuous soil property map for an area (Zhu et al., 1997; Zhu, 1997a). Although other ways of generating soil property maps from the similarity representation are possible, Zhu et al. (1997) used the following linear and additive weighting function to estimate the *A*-horizon depths.

$$V_{ij} = \frac{\sum_{k=1}^{n} S_{ij}^{k} \bullet V^{k}}{\sum_{k=1}^{n} S_{ij}^{k}} \qquad [3]$$

V_{ij} is the estimated soil property value at location (i,j), V^k is the typical value of a given soil property of soil category k, and n is the total number of prescribed soil categories for the area. This function is based on the assumption that the more the local soil formative environment characterized by a GIS resembles the environment of a given soil category, the closer the property values of the local soil to the property values of that candidate soil category. The resemblance between the environment for soil at (i,j) and the environment for soil category k is expressed as S_{ij}^k, which is used as an index to measure the level of resemblance between the soil property values of the local soil and those of soil category k.

4. Assessment of the SoLIM Approach:

4.1 Assessment of the quality of products from SoLIM:

The SoLIM approach was tested in a watershed in western Montana, the Lubrecht Experimental Forest watershed (Zhu et al. 1996). The results from that case study are discussed here to provide an assessment of the effectiveness of the SoLIM approach in deriving detailed and accurate soil spatial information. The assessment will be conducted through the comparison of the products derived from the SoLIM approach with these derived from conventional soil maps. Two soil products (soil type map and soil property map) will be examined in this section.

The soil similarity vectors can be hardened to produce a soil map. The hardening is done by assigning each location the label of the soil class that has the highest membership value in the similarity vector for that point. The SoLIM-derived soil map and the conventional soil map over the Lubrecht study area are shown in Figure 4. It can be observed from the two maps that the SoLIM-derived soil map contains much greater spatial detail than the conventional soil map of the area. In a semi-arid to semi-humid area like western Montana, moisture condition is the dominant factor in the soil forming process. The moisture conditions in the small draws (shallow but very wide gullies, ravines or valleys) are often very different from the respective major slopes on which these small draws are situated. This moisture difference is particularly true for major south-facing slopes and the small draws in them. The evaporation on these major south-facing slopes is strong due to their direct south exposure and moisture conditions on these slopes are often very poor. On the other hand, the small draws face away from direct south and the moisture conditions are better. As a result, soils in these small draws are often better developed and different from those on the major south-facing slopes. These differences in soils between the small draws and the major slopes are depicted on the SoLIM-derived map but not on the conventional soil map.

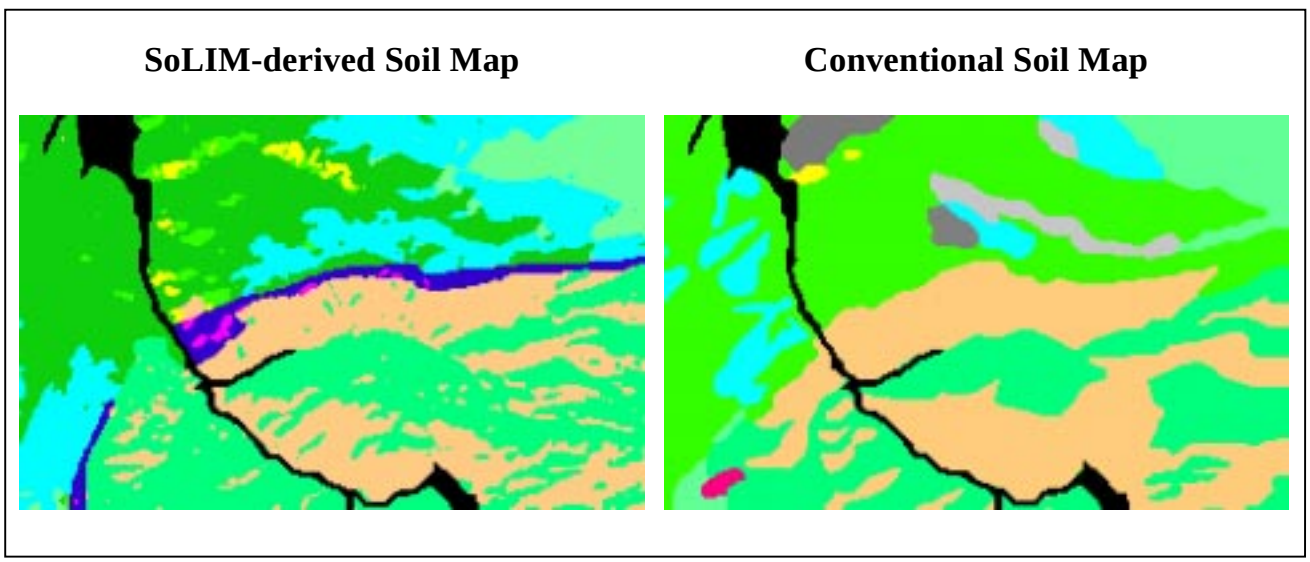


Figure 4: Maps of soil series distribution in Lubrecht, Montana. The SoLIM-derived map depicts soil spatial variation in much greater spatial detail than the conventional soil map.

Field observations further verified that the SoLIM-derived soil series map has a higher quality than the conventional soil map. Table 1 summarizes the results from comparing field observations against the results from SoLIM and the conventional soil map. A total of 64 field sites were investigated and soil series at these sites were determined by a soil scientist. Of the 64 sites, SoLIM inferred the soil series correctly at 52 sites (81% accuracy), while the conventional soil map identified only 39 sites correctly. There were sites at which the soil series from SoLIM differed from those derived from the conventional soil map. For 71% of these mismatches the soil series from SoLIM matched the field observations.

Table 1: Comparison between SoLIM and the Soil Map Against Field Observations at the Series Level

	Overall		
	Correct	**Total Samples**	**Percentage**
SoLIM	**52**	**64**	**81**
Soil Map	**39**	**64**	**61**
	Mismatches		
	Correct	**Total Samples**	**Percentage**
SoLIM	**17**	**24**	**71**
Soil Map	**4**	**24**	**17**

To further assess the SoLIM approach, two soil property maps depicting the spatial variation of *A*-horizon depth were derived: one from the similarity representation of SoLIM using Equation 3 and the other from the conventional soil map. Figure 5 compares the two soil *A*-horizon depth maps. It can be clearly seen that the depth map inferred from SoLIM shows a more continuous spatial variation than the depth map from the conventional soil map, which shows the changes occurring only at the boundaries of the soil polygons. Changes in soil property values occurring only at the boundaries of soil polygons are not realistic in this study area. Field observation of *A*-horizon depths at 33 sites suggests that the inferred depths at these 33 sites matched the observed depths better (with R^2=0.602) than did the depths derived from the conventional soil map (with R^2=0.436).

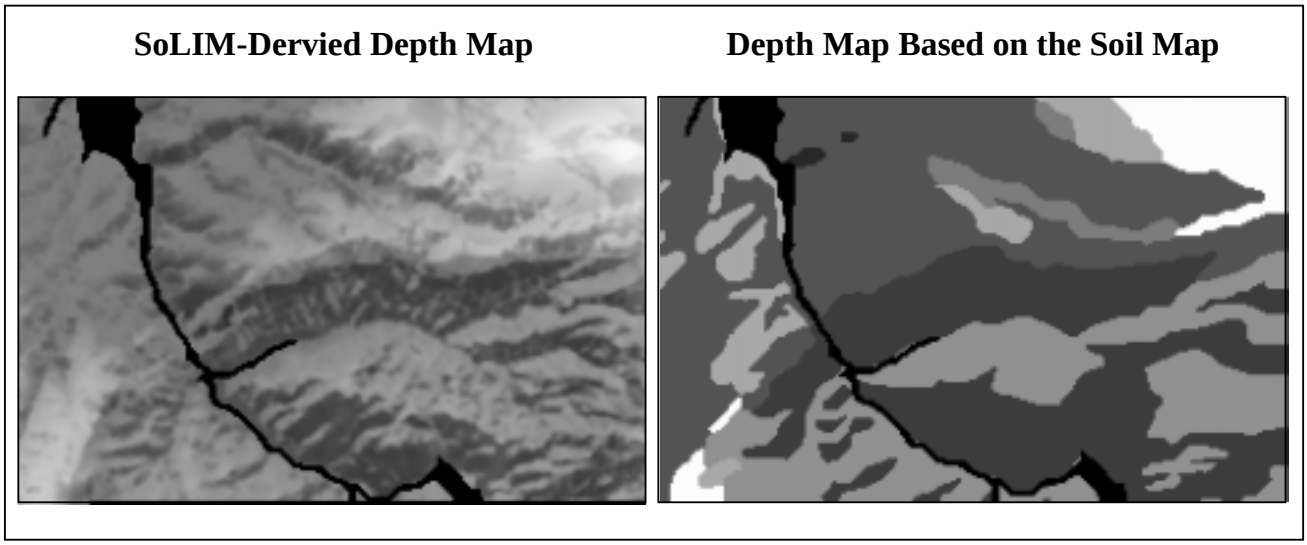


Figure 5: Maps of soil A-horizon depth in Lubrecht, Montana. The SoLIM-derived depth map shows a gradual variation of soil A-horizon depth while the depth map from the conventional soil map shows abrupt changes at the boundaries of soil polygons.

The high quality soil products from SoLIM are related to three aspects of SoLIM. First, environmental variation can be quantified in great detail within GIS due to the capability of digital data processing and the ability for handling many variables simultaneously in a GIS environment. The availability of this detailed data on soil formative environments makes it possible to greatly reduce soil inclusions and misinterpretations. Second, the soil similarity model allows local soil conditions to be expressed at pixel resolution, thus allowing the occurrence of small map unit components in the landscape to be expressed at a level of detail impossible in conventional soil maps. Third, the fuzzy logic used in the soil similarity model allows the soil at a pixel to be expressed as an integrade rather to be approximated by only one typical soil type. Fuzzy logic allows the properties of a local soil to be more accurately estimated.

4.2 Assessment of the process of soil survey using SoLIM:

In addition to the high quality of its products the SoLIM approach has several other advantages over the conventional approach in terms of the process of soil survey.

- ***Rapid soil survey updates***. Since both the GIS database and the knowledgebase for a given area are stored in a digital environment and reusable, the SoLIM approach can produce new versions of the raster soil database for an area very rapidly by taking advantage of high processing speed of computers in its inference. This can be done in a matter of hours or days rather than over months or years as in the current survey process. The ability to quickly update soil spatial databases allows soil surveys to keep up with the rapidly changing spatial data processing technology and the advancement in our understanding of soils. For example, the knowledgebases can be re-applied to produce updated soil surveys when high resolution GIS and remotely sensed data become available. The readily available knowledgebases can also be studied and conveniently updated by soil scientists. The updated knowledgebases can be re-applied to produce soil surveys containing our most recent understanding of soils.
- ***Reduced cost***. Since the GIS databases, the knowledgebases, and the fuzzy inference engine are all reusable, most of the investment during the initial soil surveys or initial updates retains its value. The modular design of SoLIM (compiling the GIS database, acquiring knowledge, and performing inference, see Figure 3) allows each module to be updated independently in subsequent updates. Future soil survey updates will need only to improve the GIS databases, update the knowledgebases, and perfect the inference engine. There is no need to start everything from scratch again. This means not only saving human and material resources, but also improving the efficiency of conducting soil surveys.

- ***More focused soil scientists***. The modular design in SoLIM divides the whole soil survey process into tasks with each task being performed by the most suitable professionals. For example, compiling GIS databases and performing inference are most suitable for professionals in GIS or information sciences. Acquiring knowledge about soil-environmental relationships is best suited to the talent of soil scientists since they are the ones with the trained eyes. De-coupling the study of soil-environmental relationships from soil map-making will liberate soil scientists from time-consuming map-making tasks and allow them to focus on what they do best: studying soils and discovering soil-environmental relationships.
- ***Maintaining knowledge continuity***. A large portion of local expertise is lost each year as experienced local soil scientists retire. It is desirable to document this expertise to maintain continuity of knowledge on soil-environmental relationships between different generations of local soil scientists. The soil-environmental relationships in the knowledgebases used by SoLIM can be a major source of knowledge for new generations of soil scientists.
- ***Digital products***. The output from the fuzzy inference engine is already in digital format. The soil data can be directly used in any GIS applications without going through the tedious digitization process, which not only consumes a lot of labor and adds to costs, but also degrades the quality of the final products due to possible errors in the digitization process.

5. Summaries

The success of the SoLIM methodology is due to the integration of knowledge on soil-environmental relationships with the power of GIS under fuzzy logic. The similarity model overcomes the limitations of the conventional discrete conceptual model and allows the representation of soils as continua in both the spatial and attribute domains. The capability of GIS for processing spatial data enables soil formative environmental conditions to be quantified in great detail. A set of fuzzy inference techniques effectively couples this ability of GIS with the knowledge of soil-environmental relationships to infer soil spatial information under the similarity model. The SoLIM approach to soil survey not only improves the quality of soil information products from the survey, but also makes the survey updates more efficient and less costly. Due to these advantages and with the continuing improvement of information gathering and process technology, we argue that the SoLIM approach has the potential to significantly advance the way soil surveys are conducted in the next century.

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Soil Mapping Using GIS, Expert Knowledge & Fuzzy Logic

A-Xing Zhu*
James Burt*
Ken Lubich+
Dave Roberts+

*University of Wisconsin-Madison
+USDA-NRCS

OUTLINE

The Problems SoLIM Addresses

Overview of SoLIM

Assessment of the SoLIM Approach

Current and Future Efforts

The Problems SoLIM Addresses

The Polygon-based Model

Acquiring Knowledge

Polygon Maps → $S \Leftarrow f(E)$

Manual Delineation

Photo Interpretation

The Manual Mapping Process

Overcoming the Polygon Map Model

The Polygon Map Model

Using polygons to represent the spatial distribution of soil classes

Limitations

Generalization in the parameter domain

Using a class to represent the varying soil objects

Generalization in the spatial domain

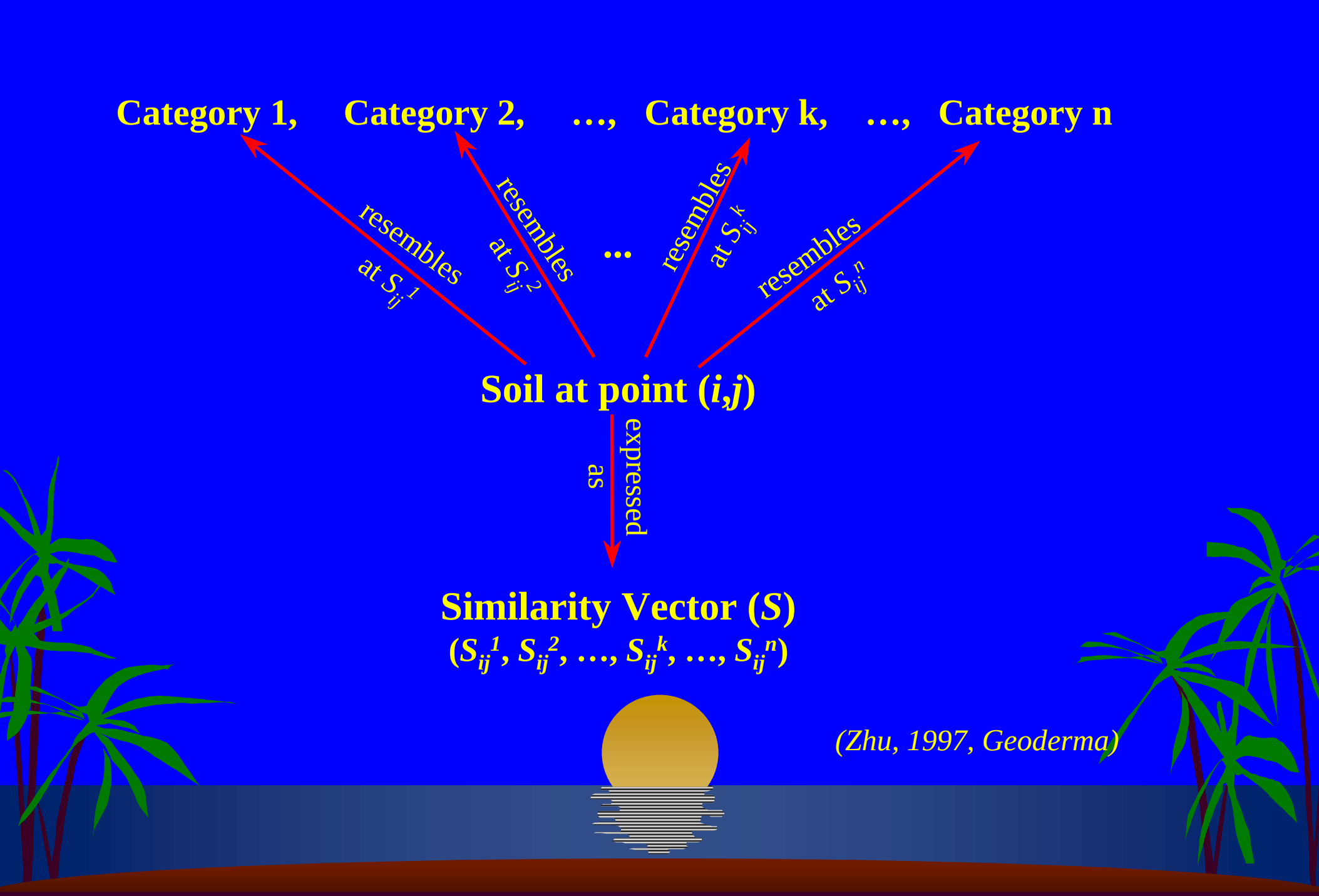
Only soil objects larger than a certain size (scale dependent) can be mapped

Overcoming the Polygon Map Model

The Similarity Model

Similarity representation in parameter space

Objects are represented as a vector of similarity values


Category 1, Category 2, …, Category k, …, Category n
resembles at S_{ij}^{1}
resembles at S_{ij}^{2}
…
resembles at S_{ij}^{k}
resembles at S_{ij}^{n}
Soil at point (*i*,*j*)
expressed as
Similarity Vector (*S*)
$(S_{ij}^{1}, S_{ij}^{2}, \ldots, S_{ij}^{k}, \ldots, S_{ij}^{n})$
(Zhu, 1997, Geoderma)

Overcoming the Polygon Map Model

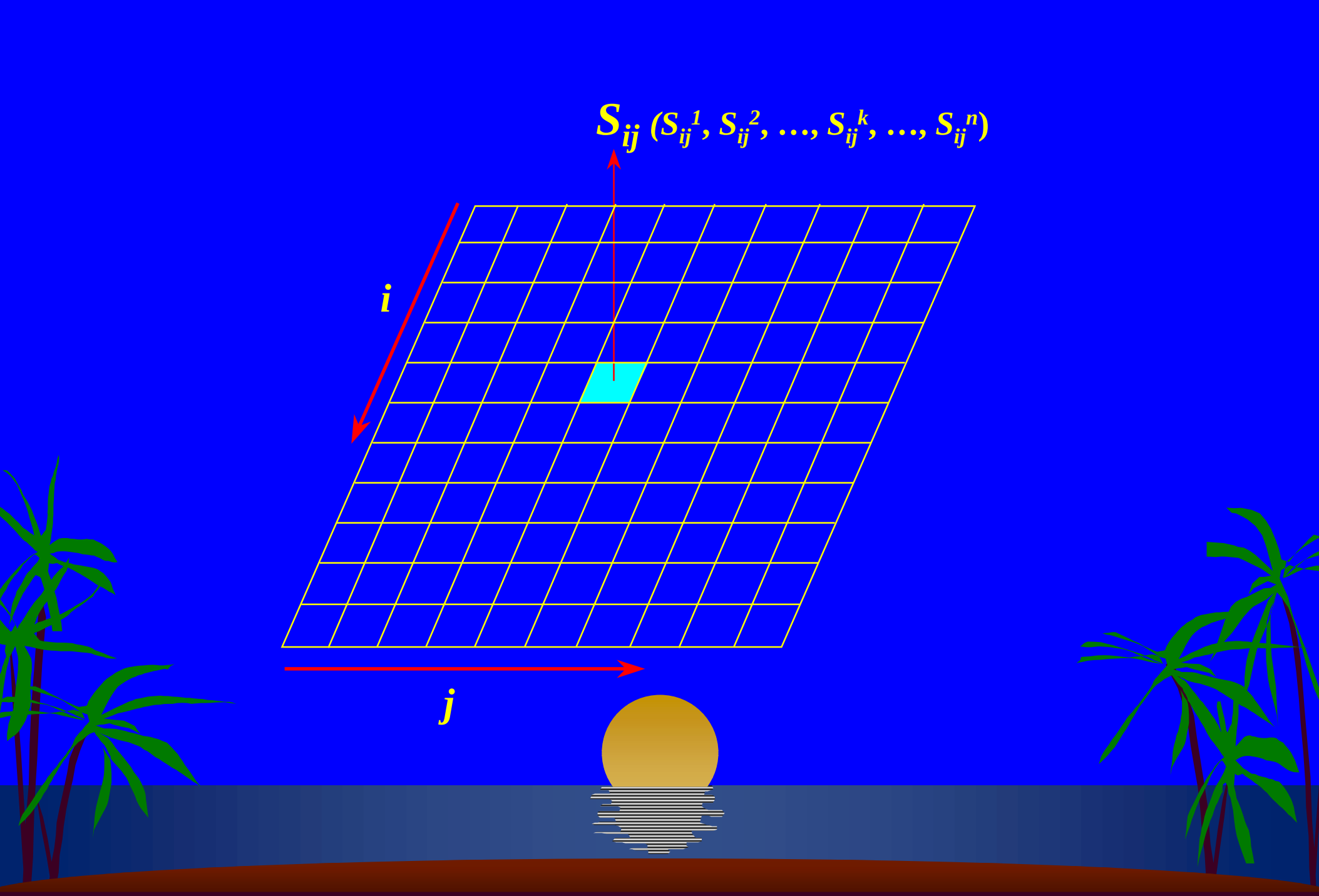
The Similarity Model

Similarity representation in parameter space

Objects are represented as a vector of similarity values

Raster representation in geographic space

Spatial details are represented at the spatial resolution of a raster data model


S_{ij} (S_{ij}^1, S_{ij}^2, …, S_{ij}^k, …, S_{ij}^n)
i
j

Automating the Mapping Process

The Conventional Process

Manual delineation and compilation of soil polygons

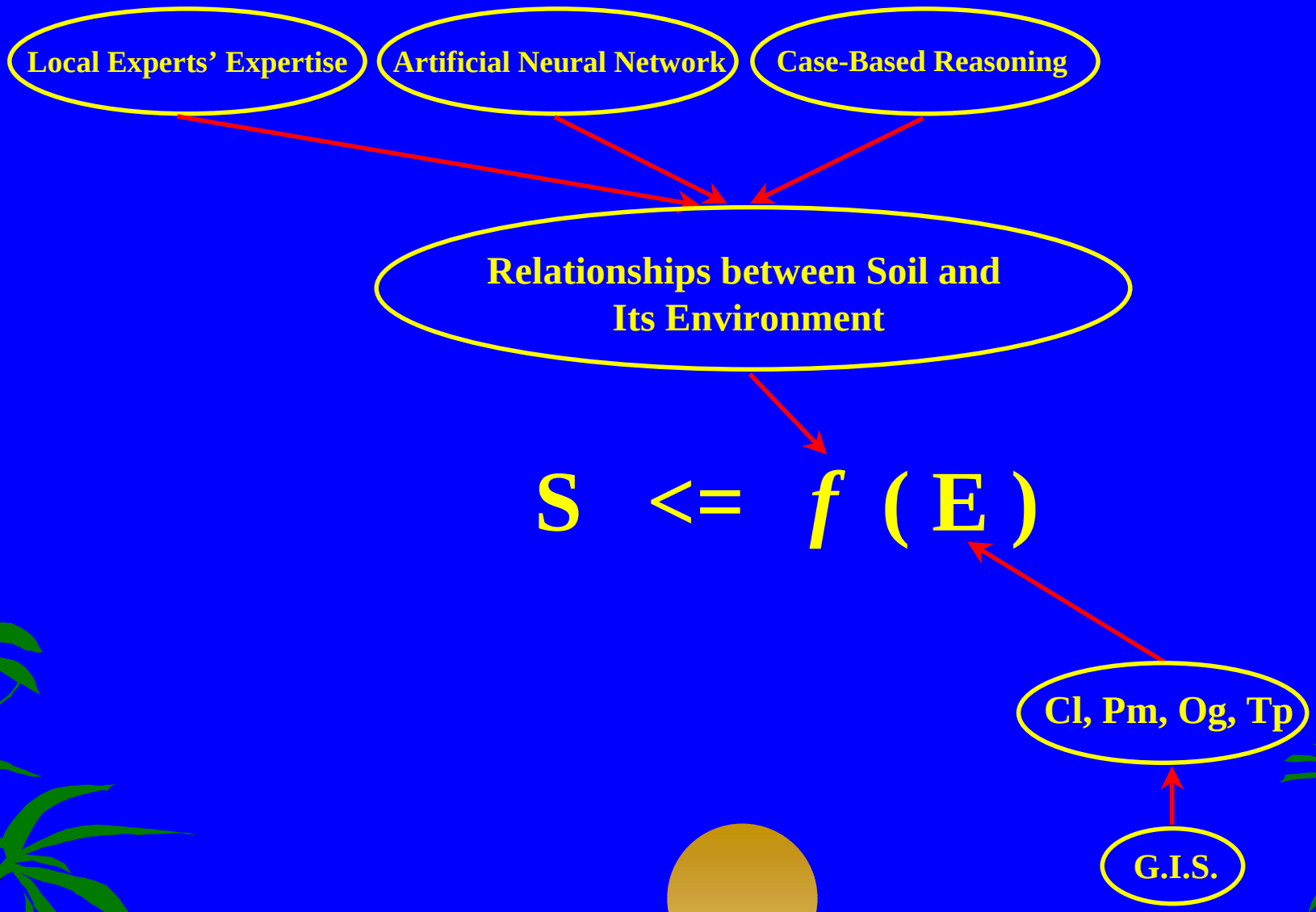
Limitations

- **Labor intensive and time consuming**
- **Inconsistency and susceptible to errors**
- **Not reusable**

Automating the Mapping Process

Methods of Soil Mapping

$$S \Leftarrow f(E)$$



(*Zhu et al., 1997, SSSAJ; Zhu, 2000, Water Resources Research*)

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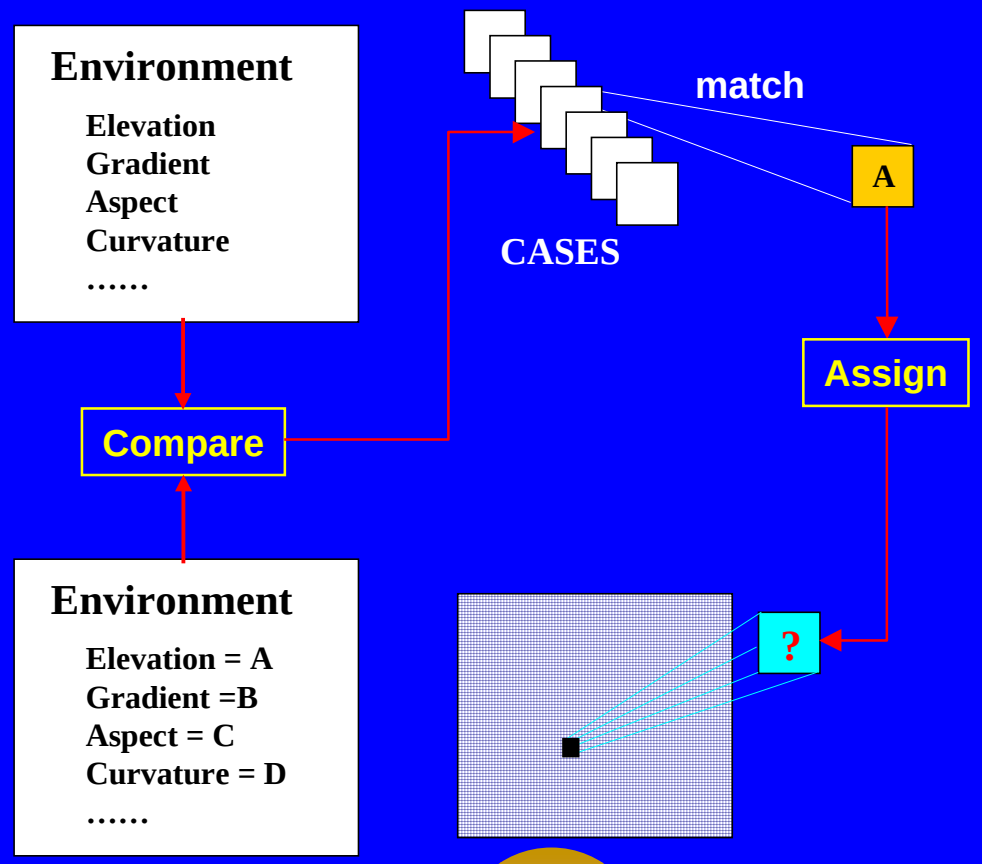
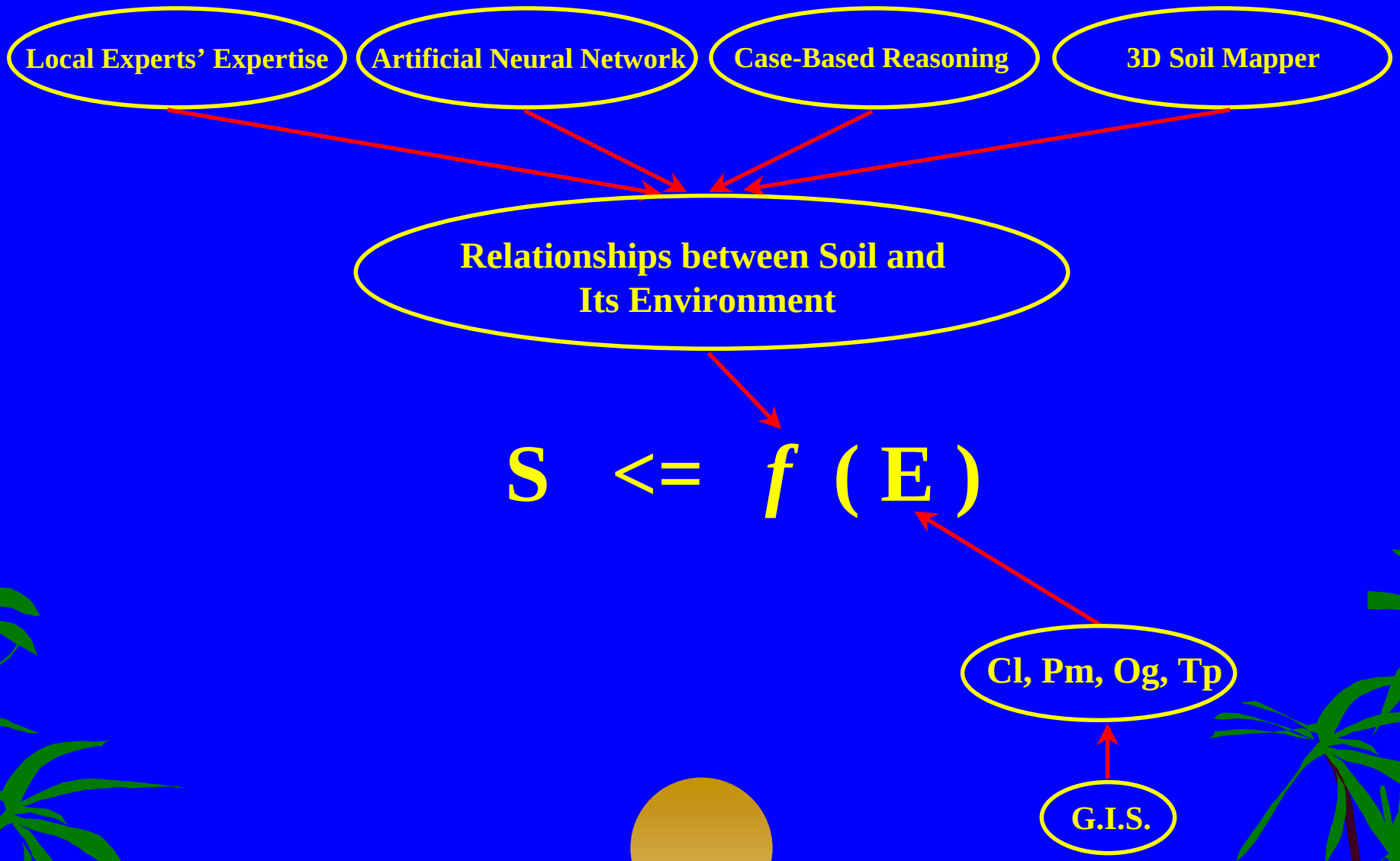
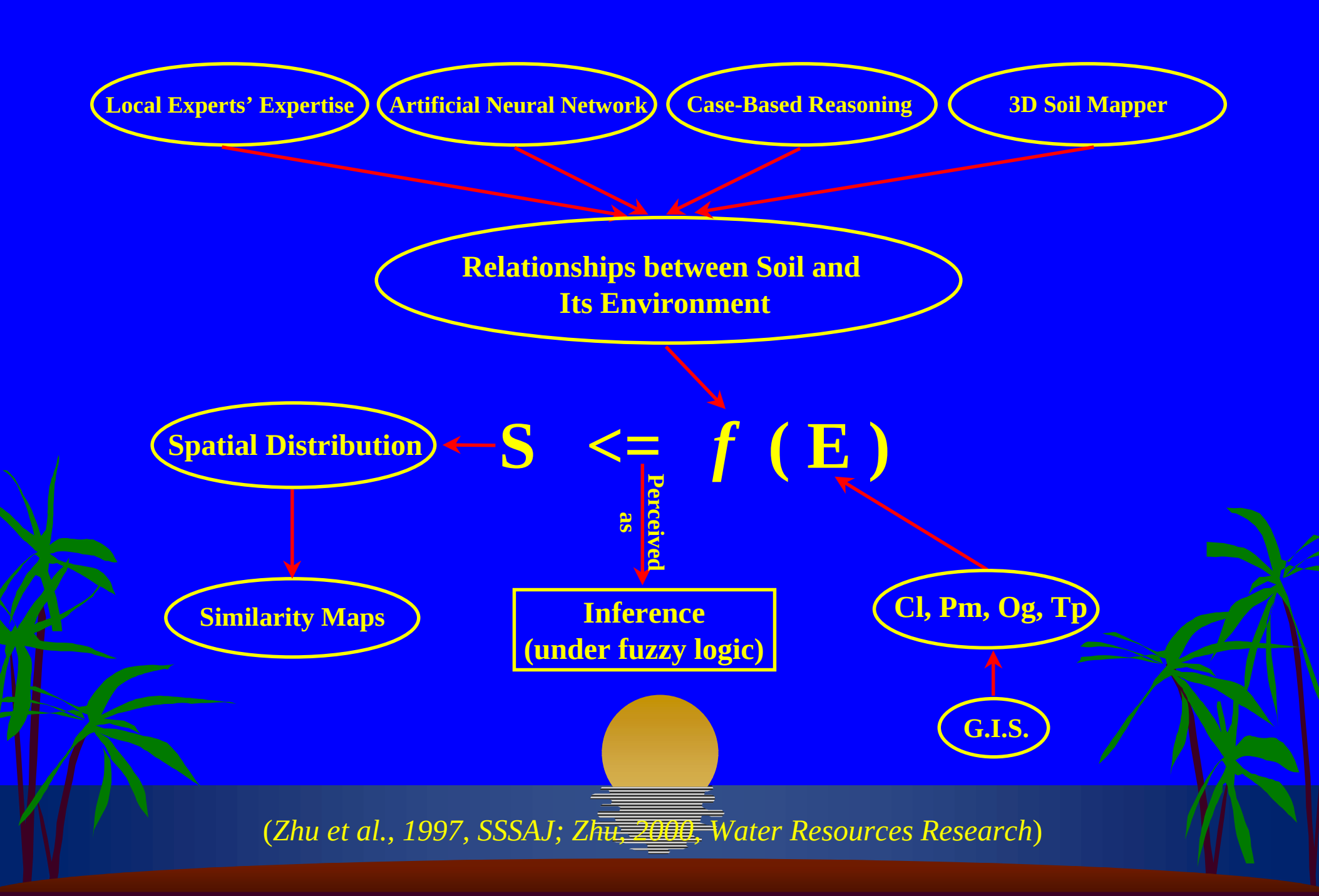




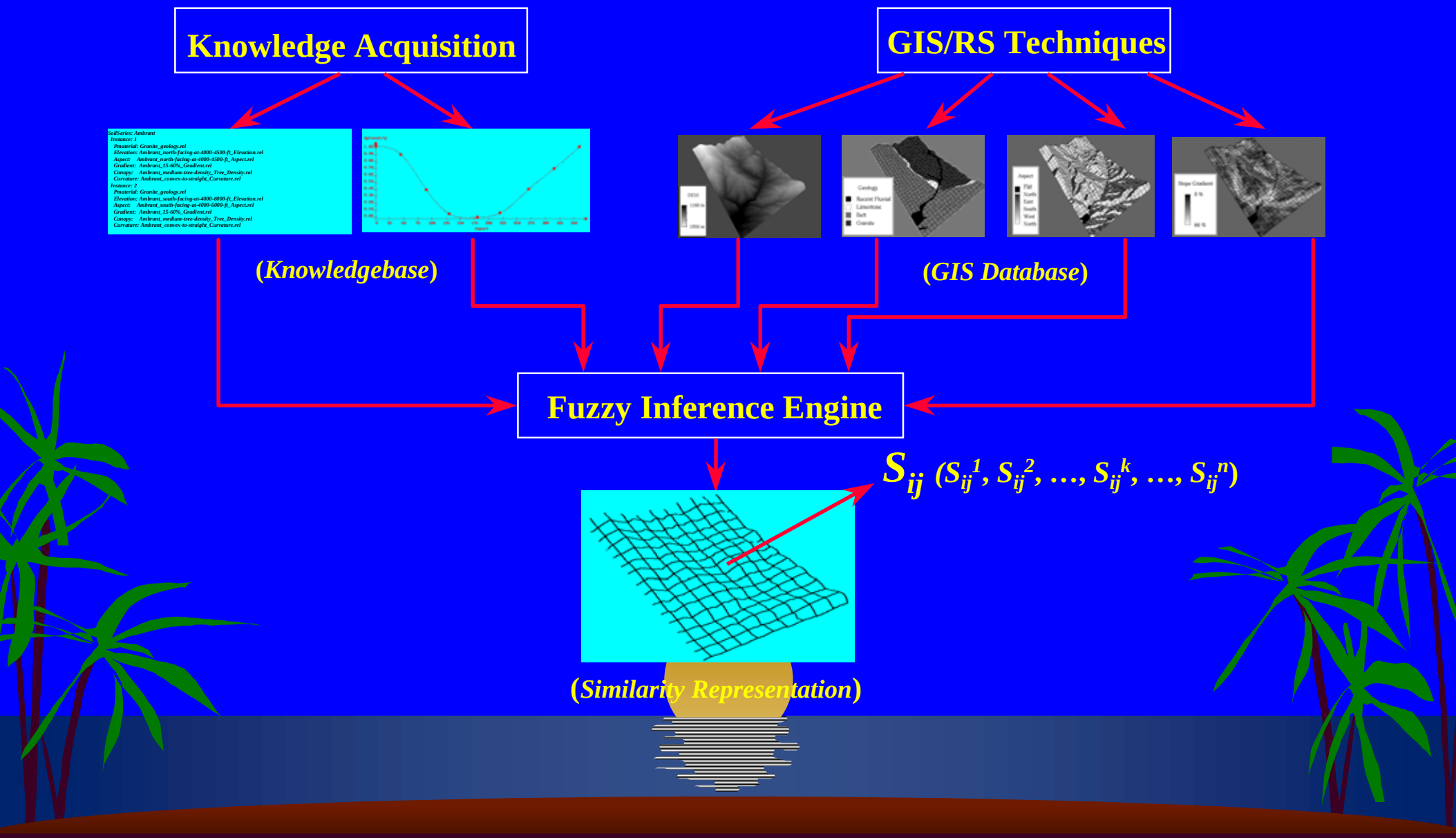
(*Zhu et al., 1997, SSSAJ; Zhu, 2000, Water Resources Research*)

9.4ft cells (609 x 547) x 5.0 (v) Elev: 50.0 Scale: 1:11660
dorer
shoul
Brod
shoul
ng
lamoi
dodgev
shoul
lyc-chur&
Brod
shoul
lador
dorer
Brod
lamoi
ng
dodgev
lamoi
lador
ng
lamoi
lyc-chur&
newh
elevas
elevas
newh
elevas
elevas
newh
elevas
newh
elevas
LeftDrag–View Change RightDrag–V. Exag ShiftLeftDrag–Zoom AltLeftDrag–Pan
3D Mapper 03/00: airdem3.3dm
File Options Help
Cache Graphics
Display Full View
Define Local View
Local View
Adjust View
Plot Transect
Add Points
Add Arcs
Add Streams
Edit
Display Resolution
9.4 feet (3x)
Contour Interval
No Contours
Lighting
Coverages
Phototone
Uniform Gray
Elevation
Slope
Aspect
Profile Curvature
Plan Curvature
droberts (points)
Apply
Local View Cursor:
x: 709744.63ft
y: 489979.40ft
z: 899.26ft
slope: 22.77%



(*Zhu et al., 1997, SSSAJ; Zhu, 2000, Water Resources Research*)

Methodology



Similarity Vectors for A Few Selected Points (Granite)

Point	Ambrant	Rochester	Elkner	Ovando
lub06_02	9.41	0.00	53.79	52.80
lub06_03*	29.37	29.23	16.25	45.81
lub06_04	72.44	50.42	0.00	0.90
lub06_05	20.20	13.14	0.00	2.10
lub07_02	26.62	30.36	0.19	1.85
91_01*	4.66	1.55	8.55	58.00
91_02	8.26	0.00	62.21	66.30
91_03	16.54	14.47	69.23	39.79

Assessment of the SoLIM Approach

The Products

Soil type maps

Soil Series Distribution Based on the SoLIM Approach

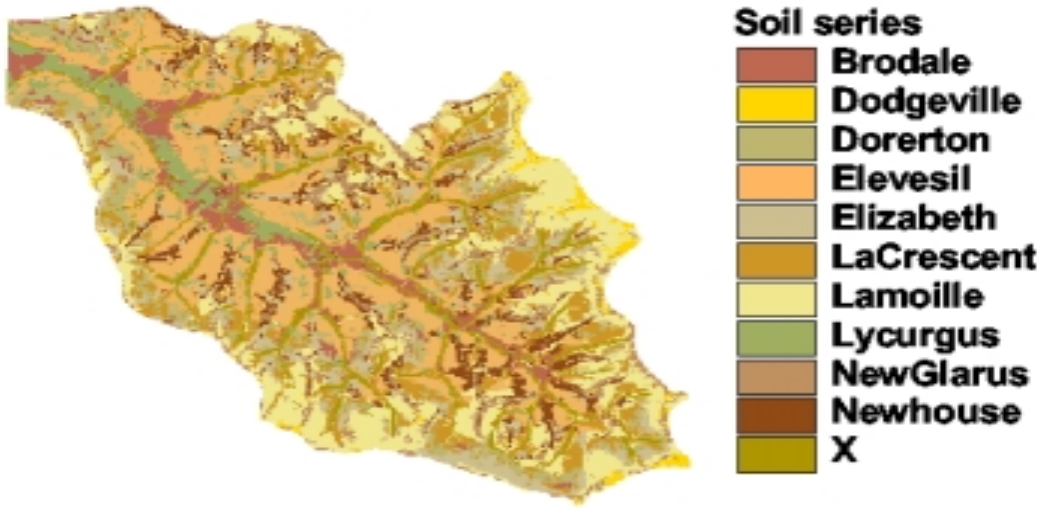
Soil Series Distribution on the Soil Map

Lubrecht, Montana

Comparison between SoLIM and Soil Map against field data for Soil Series

	Overall		
	Correct	Total Samples	Percentage
SoLIM	52	64	81
Soil Map	39	64	61
	Mismatches		
	Correct	Total Samples	Percentage
SoLIM	17	24	71
Soil Map	4	24	17

Hardened Soil Map from CBR Engine



Pleasant Valley, Wisconsin

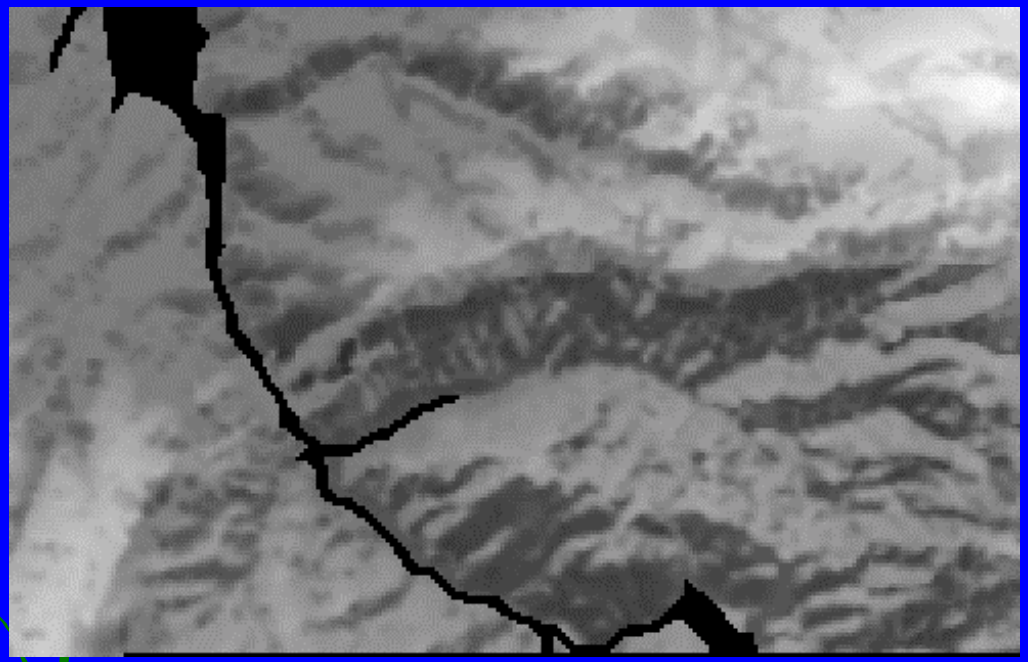
Soil Map Based on Soil Survey

Assessment of the SoLIM Approach

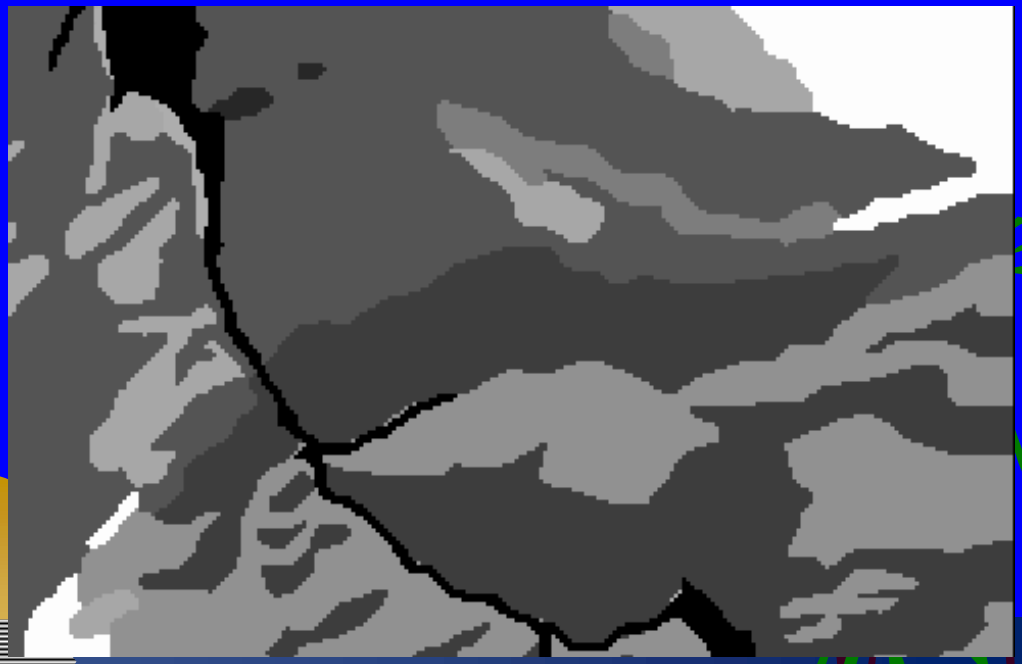
The Products

- Soil type maps
- Soil property maps

A-Horizon Depth Based on the SoLIM Approach

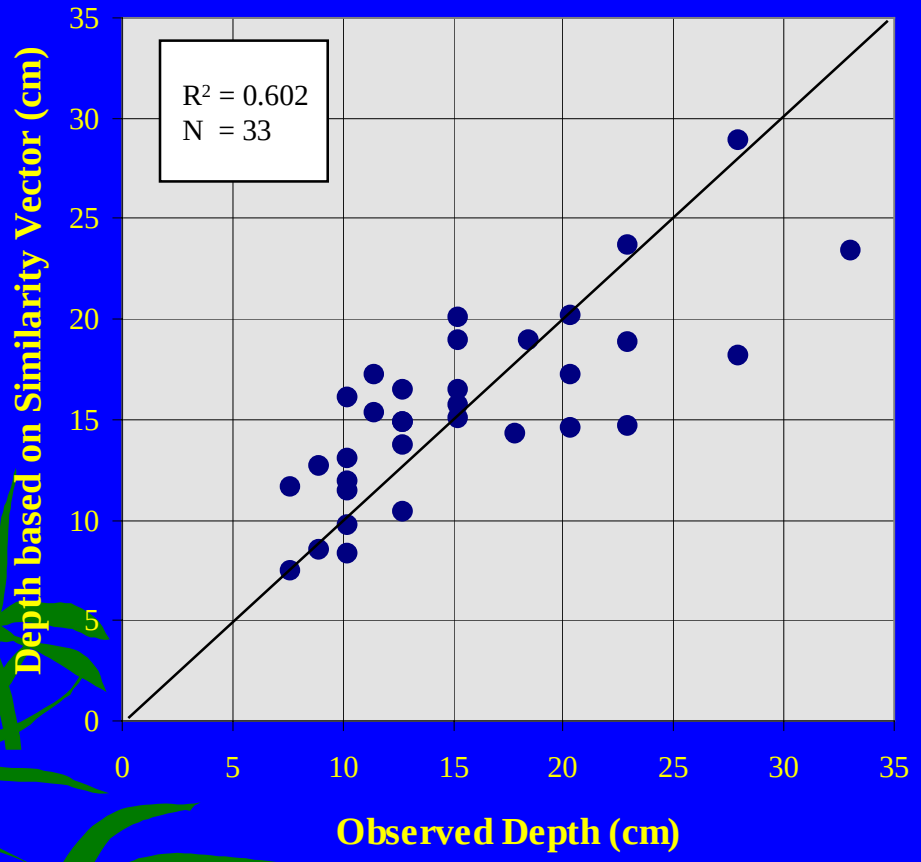


A-Horizon Depth Based on the Soil Map

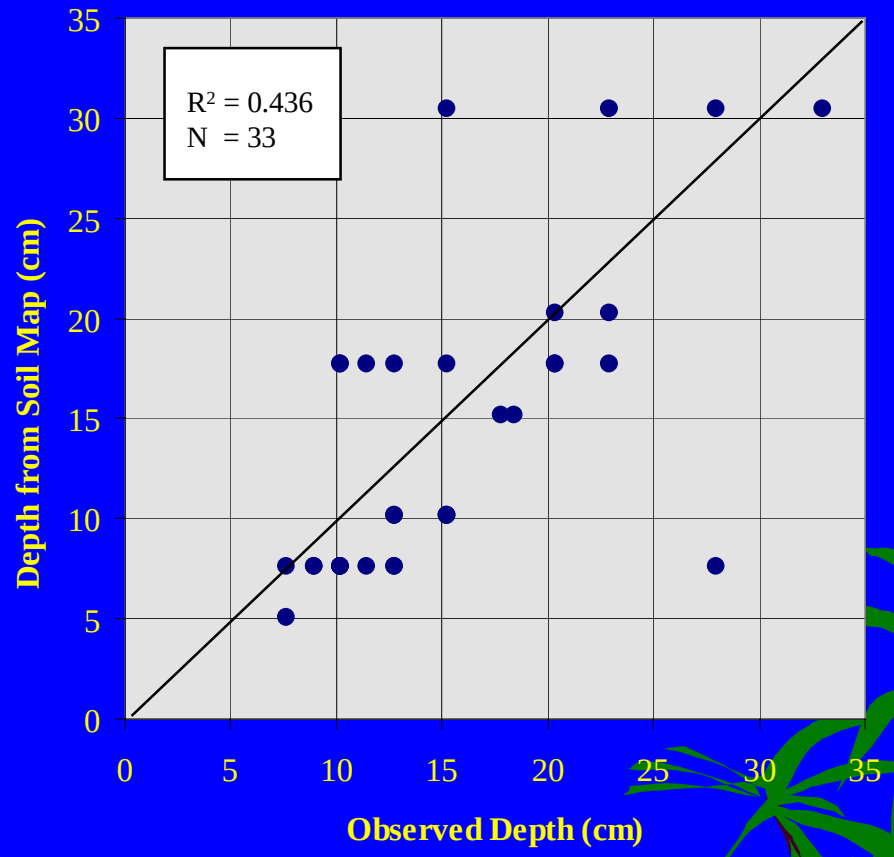


Lubrecht, Montana

Depth Based on SoLIM vs. Depth from the Field



Depth From the Soil Map vs. Depth from the Field



RMS Error of Particle Distribution (28 field samples, top soil)

	Soil survey	*CBR*
Sand	**5.37**	**3.85**
Silt	**6.97**	**4.45**
clay	**4.12**	**3.60**

Pleasant Valley, Wisconsin

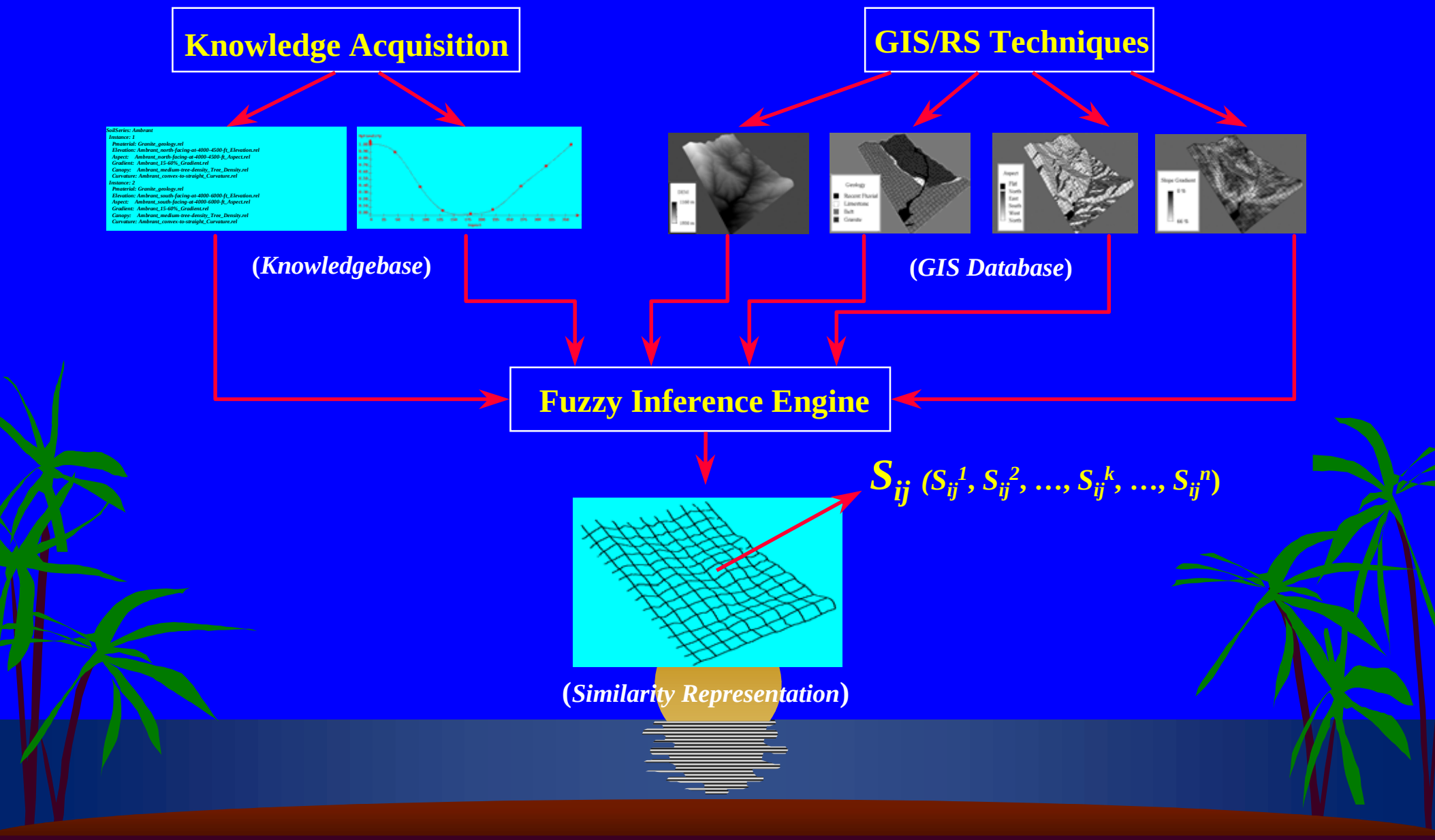
Assessment of the SoLIM Approach

The Products

The SoLIM approach can produce detailed soil spatial information -- quality soil data

The Process

Methodology



Assessment of the SoLIM Approach

The Products

The SoLIM approach can produce detailed soil spatial information -- quality soil data

The Process

Soil spatial information can be easily produced and updated -- short production cycle and reusable

Products are already in a digital format or in a GIS database -- no need for conversion

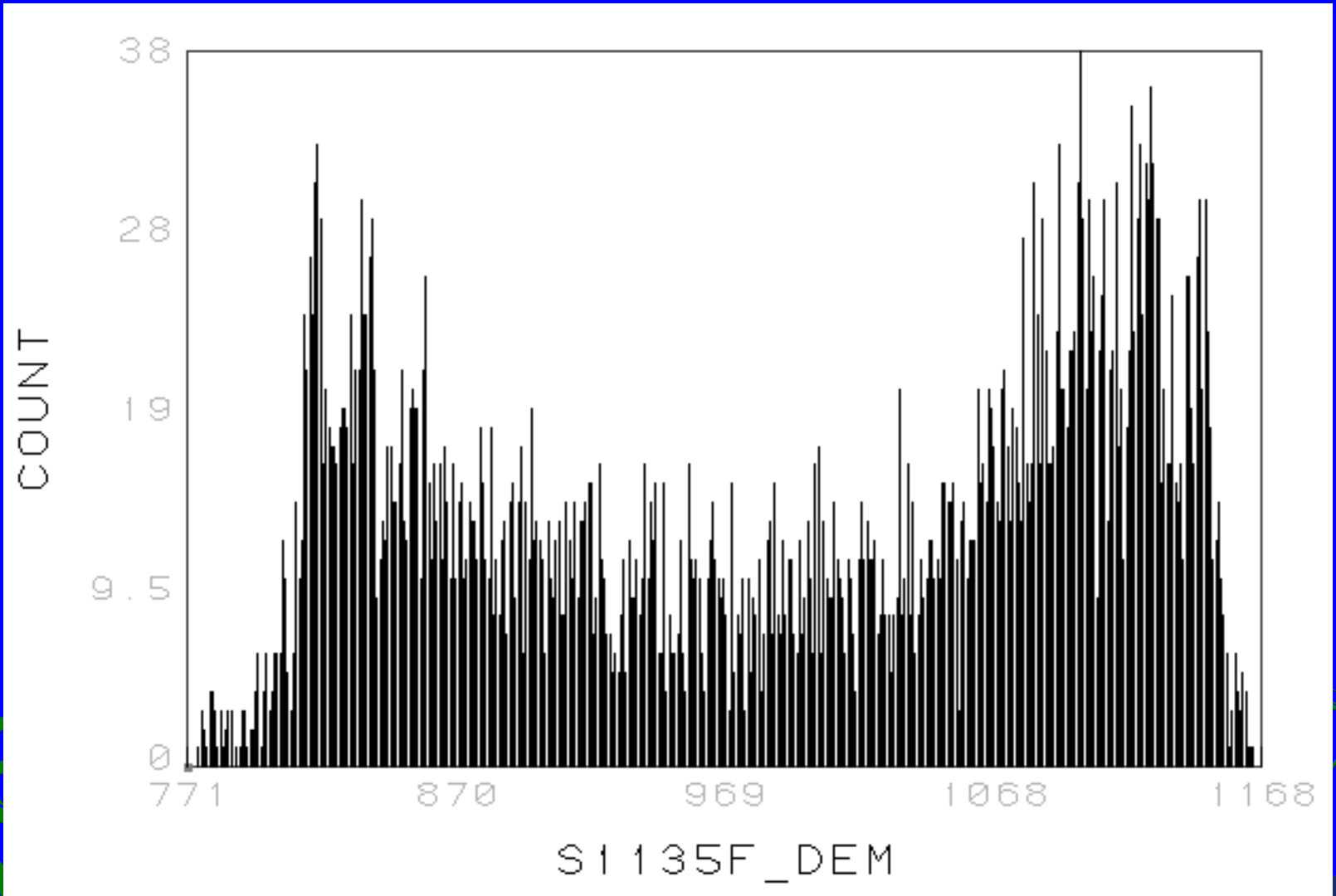
Field soil scientists can easily test hypothesis about soil-environment relationships -- a learning tool

Current and Future Efforts

Basic Research:

Knowledge acquisition – data mining

Data mining approach to knowledge extraction:



Current and Future Efforts

Basic Research:

Knowledge acquisition – data mining

Other methods of computing similarity

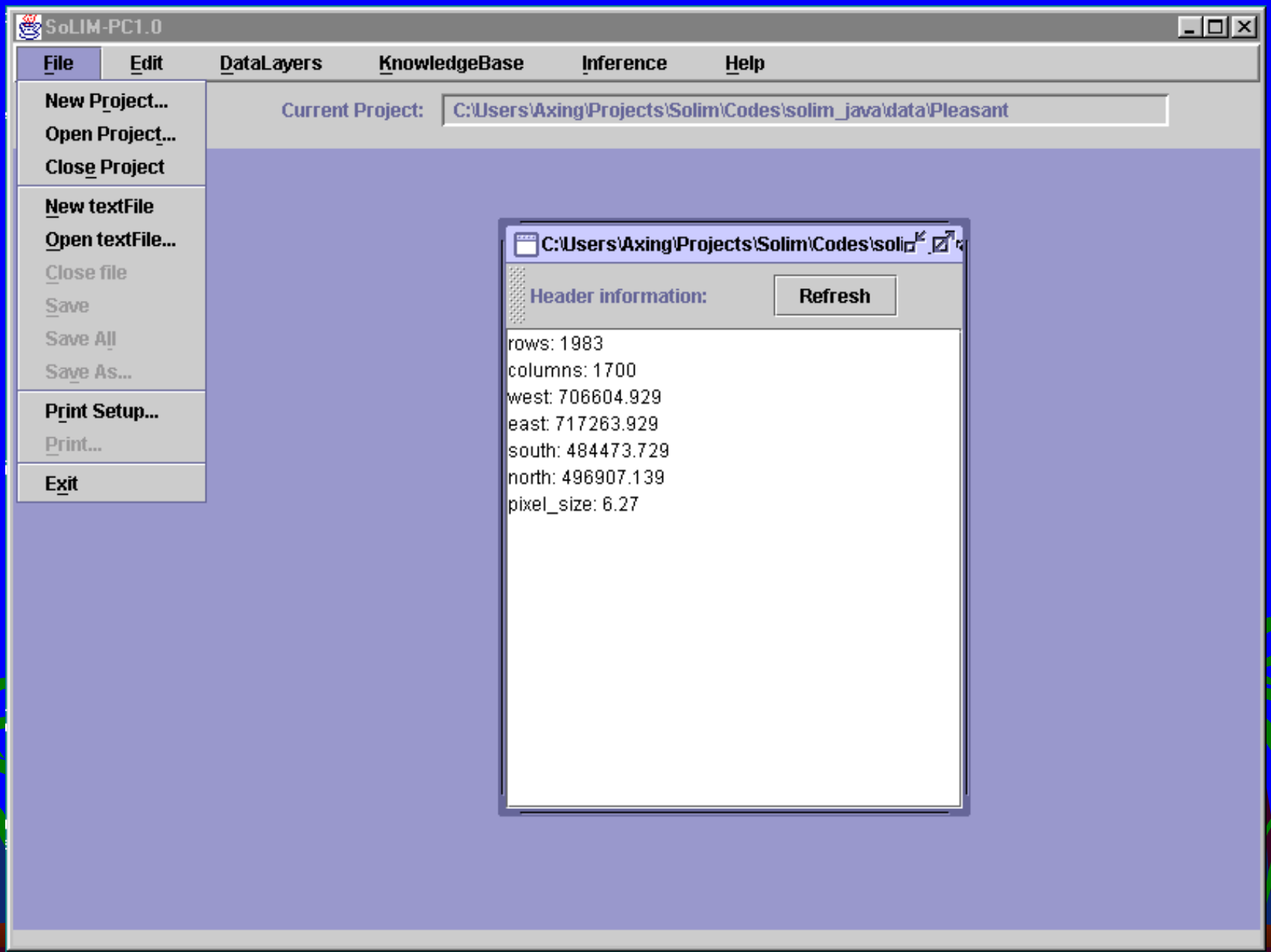
Effective methods for defining soil forming environment

Applied Research:

How to incorporate the approach into current soil survey efforts?

-- to develop a turnkey system for soil scientists

The Turnkey SoLIM:



Current and Future Efforts

Basic Research:

Knowledge acquisition – data mining

Other methods of computing similarity

Effective methods for defining soil forming environment

Applied Research:

How to incorporate the approach into current soil survey efforts?

-- to develop a turnkey system for soil scientists

-- to develop a set of survey procedures utilizing the approach

Thank You !

Soil Survey Activities in the National Park Service

Pete Biggam
Soil Scientist
Natural Resources Information Division
Inventory and Monitoring Program
Denver, Colorado

Mission Statement

The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The National Park Service cooperates with various partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

Introduction

From the spectacular mountain ranges and glacier fields of Alaska to the Sonoran deserts of the American Southwest, from the volcanic landscapes of Hawaii to the magnificent barrier islands of the northeastern United States, the National Park Service acts as steward for natural resources that have inspired, awed, and brought enjoyment for more than a century. Responsible for nearly 80 million acres of public land, the National Park Service preserves and protects some of the world's most scenic and important natural resources.

Unfortunately, many National Park Service units are being subjected to a wide variety of impacts. Air pollution degrades the magnificent views of Grand Canyon, while water quality and quantity problems threaten the delicate aquatic ecosystems in Everglades. Many parks today face urban encroachment; many more suffer from the impacts of excessive visitation. Left unchecked, these factors of change could threaten the very existence of many biotic communities within the parks.

In 1991, the National Park Service published its Vail Agenda, a comprehensive strategy for serving America's noble trust into the 21st century. To meet our resource stewardship

responsibilities, the Vail Agenda action plan calls for park managers and superintendents to have solid natural resource information at their disposal.

- Park managers must have comprehensive information about the nature and condition of major biotic and abiotic natural resources placed under their stewardship.
- Park managers need to know how resource conditions change over time.

Only by having reliable scientific information can park managers take corrective actions before those impacts severely degrade ecosystem integrity or become irreversible.

Natural Resource Inventory and Monitoring Program

The Natural Resource Inventory and Monitoring (I&M) Program was established to help prevent the loss or impairment of significant natural resources in more than 265 of the 368 units of the National Park System. Many natural resources in the system are subjected to unfavorable influences from a variety of sources, for example, air and water pollution, urban encroachment, and excessive visitation. Left unchecked, such effects can threaten the very existence of many natural communities in the units.

The principal functions of the I&M Program are the gathering of information about the resources and the development of techniques for monitoring the ecological communities in the National Park System. Ultimately, the inventory and monitoring of natural resources will be integrated with park planning, operation and maintenance, visitor protection, and interpretation to establish the preservation and protection of natural resources as an integral part of park management and improve the stewardship of natural resources by the National Park Service.

The detection of changes and the quantification of trends in the conditions of natural resources are imperative for the identification of links between changes in resource conditions and the causes of changes and for the elimination or mitigation of such causes. Inventory and monitoring provides important feedback between natural resource conditions and management and trigger specific management and evaluation of managerial effectiveness.

Guidelines for the acquisition of natural resource inventories on NPS units are as follows:

- Data collected for each park unit will contain a “core” set of data for universal park planning and management purposes
- All data will be collected and maintained in accordance with clearly defined protocols and quality-assurance standards.
- Data will be compatible for use at ecosystem and other broad levels

Recommended minimal dataset for all natural resource parks:

- Natural Resource Bibliographic Database
- Base Cartography
- Soils

Recommended minimal dataset for all natural resource parks (continued):

- Geology
- Vegetation
- Species Survey and Distribution
- Water Resources/Water Quality
- Air Quality
- Climate

Soil Management Policies

Management Policies and Guidelines for soil resource management are contained in **NPS-77 "Natural Resources Management".** The NPS Management Policies states:

The NPS will actively seek to understand and preserve the soil resources of parks and to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its contamination of other resources.

Resource managers, with the assistance of the Inventory and Monitoring Division, will acquire appropriate, detailed soil maps, define the distribution of soil series, determine their physical and chemical characteristics, and provide interpretations needed to promote soil conservation and to guide resource management and development decisions.

Potential impacts on soil resources will be routinely monitored. Management action will be taken to prevent, or if that is impossible, to mitigate adverse, potentially irreversible impact on soils. Conservation and soil amendment practices may be implemented to reduce impacts. Importation of off-site soil or soil amendments may be used to restore damaged sites. Off-site soil will normally be salvaged, but it will not be removed from pristine sites if such actions would impair the ecosystem overall. If off-site materials are used, a soil management specialist will develop a prescription and select materials needed to restore the original native soil physical and chemical characteristics. Caution will be exercised to avoid introduction of nonnative species.

Soil Management Objectives

Soil management objectives follow from the overall resource management objectives in NPS management policies. The objectives are not mutually exclusive, and, typically, more than one objective applies in a given situation. Soil management objectives are as follows:

1. Preserve intact, functioning, natural systems by preserving native soils and the processes of soil genesis in a condition undisturbed by humans.
2. Maintain significant cultural objects and scenes by conserving soils consistent with maintenance of the associated historic practices, and by minimizing soil erosion to the extent possible.
3. Protect property and provide safety by ensuring that developments and their management take into account soil limitations, behavior, and hazards.
4. Minimize soil loss and disturbance caused by special use activities and ensure that soils retain their productivity and potential for reclamation.

Soils Inventory and Mapping Status

In 1997, I&M Program staff assisted parks with identifying soil mapping needs and priorities so that park objectives could be met through appropriate data collection. National Park Service is currently working with the Natural Resource Conservation Service (NRCS) and private contractors to complete Order 3 soil surveys in all parks, except where more detailed surveys are required for park management. All surveys will follow National Cooperative Soil Survey (NCSS) standards, and will be digitized following SSURGO standards.

The Natural Resources Conservation Service has completed soils mapping on survey areas which cover 141 NPS units, and is currently conducting soil surveys that cover 37 NPS units and will continue to support soil mapping until the project is completed.

Soil map digitization has been completed through SSURGO certification and archival on 29 soil survey areas which cover NPS units, with 10 currently in process of being digitized, and an additional 53 surveys planned to be digitized over the next few years.

Future Directions

The National Park Service is committed to continue its relationship with the National Cooperative Soil Survey and its cooperators at all levels.

National Park Service is also involved in evaluating new soil mapping technologies such as "fuzzy logic" and "predictive soil mapping" on park units in Alaska, California, and Tenneesee, where the sheer size of these units lend themselves to utilizing labor saving approaches, while maintaining high quality results.

National Park Service also wants to keep current on the direction the National Soil Information System (NASIS) is heading to ensure it can provide input on development of soil interpretations to meet agency needs.

DIGITAL MAP FINISHING KEY TASKS

Darwin Newton

Modified from material prepared by Michael Schramm and Tommie Parham

DMFS Locations

- Portland, Oregon
- Reno, Nevada
- Columbia, Missouri
- Indianapolis, Indiana
- Fort Worth, Texas
- Bozeman, Montana
- Nashville, Tennessee

Tennessee DMF Personnel

- GS-11 Cartographer
- GS-9 Cartographer
- GS-6 Cartographic Technician
- GS-6 Cartographic Technician
- GS-6 Cartographic Aid (Part Time)

DMF SITES KEY TASKS

Receive all publication data layers in DLG-3 format from the S.O.

↓

Download SSURGO data from an NCGC *ftp* site and process ALPs once all DLGs are in place

↓

Perform Digital Map Finishing on all quads in a SSA

↓

Edit all quads in SSA, including labels, moving text, etc.

Create set of final checkplots on all quads and perform final edit of map interior and marginalia

Submit final checkplots to SO for review and signing or co-signing of map finishing quality assurance letter

Create postscript files for all quads. Copy workspaces, Metadata and DLGs to tape. Submit to NCGC for review (with a copy of final checkplots). (FTP process is in work)

NCGC KEY TASKS

Develop DMF Process Procedures, and Training
&
Support DMF Sites

Receive all postscript files/workspaces and metadata written to tape from DMFS

Review final checkplots (10% edit review)

IF problems arise

Submit materials to DMFS for correction

IF okay

Generate final publication negatives and register to image

Forward maps to contract printer through GPO

Additional NCGC Tasks

Coordination with National Production Support Service Staff on readiness of manuscript

Coordination with MLRA, DMFS, and S.O. on maps and manuscripts, and photobases

Coordinate edits

STATE OFFICE KEY TASKS

Acquire field imagery and submit to Soil Survey Office for progressive soil survey

⇓

Determine publication format of SSA, as well as ortho publication base

⇓

State request via Carto-19...change from 1/3 quad to full quad format *IF NEEDED*

⇓

Determine layers to be represented in final publication. Ensure features to be shown are noted on the latest version of 37A.

⇓

Assess availability of existing digital data for use in map finishing and determine map compilation needs

If not suitable, compile all needed layer(s) from ortho publication base onto separates

SSURGO process

Scan and/or manually digitize all publication layers,

Process and place in DLG-3 format,

Review final checkplots from DMFS, and

Sign or co-sign map finishing quality assurance letter

Prepare metadata

DMF Options to Generate DLG-3 Files

- DMFS will set the standards for delivery of data to their location
- This will involve a combination of state-created DLGs, compiled ancillary data for scanning and editing (Reference H. Smith letter; September 7, 1999)
- Culture data should be *digitized* not compiled!!

DMF Options to Generate DLG-3 Files

ADDITIONAL OPTIONS MAY INCLUDE:

- Train SO staffs to edit scan files and correctly provide DLG-3 format for ancillary layers. New tools available 10/2000.
- Partner with Digitizing Centers to generate DLG-3 ancillary layers

If suitable, generate checkplots, edit where needed and register to ortho base

Prepare data in DLG-3 format

Prepare metadata and send all publication data layers in DLG-3 format to selected DMFS

MLRA OFFICE KEY TASKS

Coordinate the development of soil survey manuscripts and publication maps to ensure proper scheduling

Coordinate with state and DMF site on data layers and publication base to be represented in final publication

Perform 10% Q.A. review of state check plots and sign or co-sign map finishing quality assurance letter *and* return

Thank you…

The German Federal Soil Protection Act

Heinrich Höper

Geological Survey of Lower Saxony, Department of Soil Survey and Soil Research, Institute of Soil Technology, Friedrich-Missler-Strasse 46-50, D-28211 Bremen. e-mail: heinrich.hoeper@nlfb.de

Introduction

The 1st of March 1999 the German Federal Soil Protection Act (BBodSchG, 1998) entered into force. The purpose of the act is to protect or restore the functions of the soil. Due to the high population density of Germany and it's high industrialisation level there has been a special threat to soils by land development for urban use and by contamination. Already since the 70s different laws and ordinances have dealt with soil protection issues. In the Federal Nature Protection Act from 1976, with some modifications in 1987 and 1998 (BNatSchG, 1998)., a general need for nature protection is defined. Natural resources, especially water, air, vegetation and wild animals, are to be used or spoiled as little as possible, soil is in general to be protected and a loss of its natural fertility has to be prevented. In the ordinace on sewage sludge disposal, last modified in 1992 (AbfKlärV, 1992), maximum quantities of annual application rates and threshold values in soils and sewage sludge for disposal are defined. This applies to heavy metals (Pb, Hg, Cu, Zn, Ni, Cd, Cr) and several persistent organic contaminants (polychlorated biphenyls and polychlorated dioxines/furanes).

In 1985 the German government issued a concept for a soil conservation policy (BMI, 1985), of which different aspects were integrated into updated environment, construction and land planification related laws in the following years. Nevertheless there was in increasing need for a soil protection law. The reasons for this can be summarized as following:

1. Different laws regulated some aspects of soil contamination such as the input of pollutants by application of sewage sludge (AbfKlärV, 1992) and composts (BioAbfV, 1998) or the emission of pollutants by industrial plants by the German Immission Reduction Act (BImSchG, 1990). But there was no law considering the total input of pollutants in soils.
2. Special emphasis was given to water and air pollution as well as to nature protection, but no law existed for protection of the soil and its functions.
3. In Germany, there exist about 300 000 potentially contaminated sites (UBA, 2000). There was a need for regulations concerning investigations and remediation measures for these sites.

The Federal German Soil Protection Act

Heinrich Hoeper

Geological and Soil Survey of Lower Saxony, Germany

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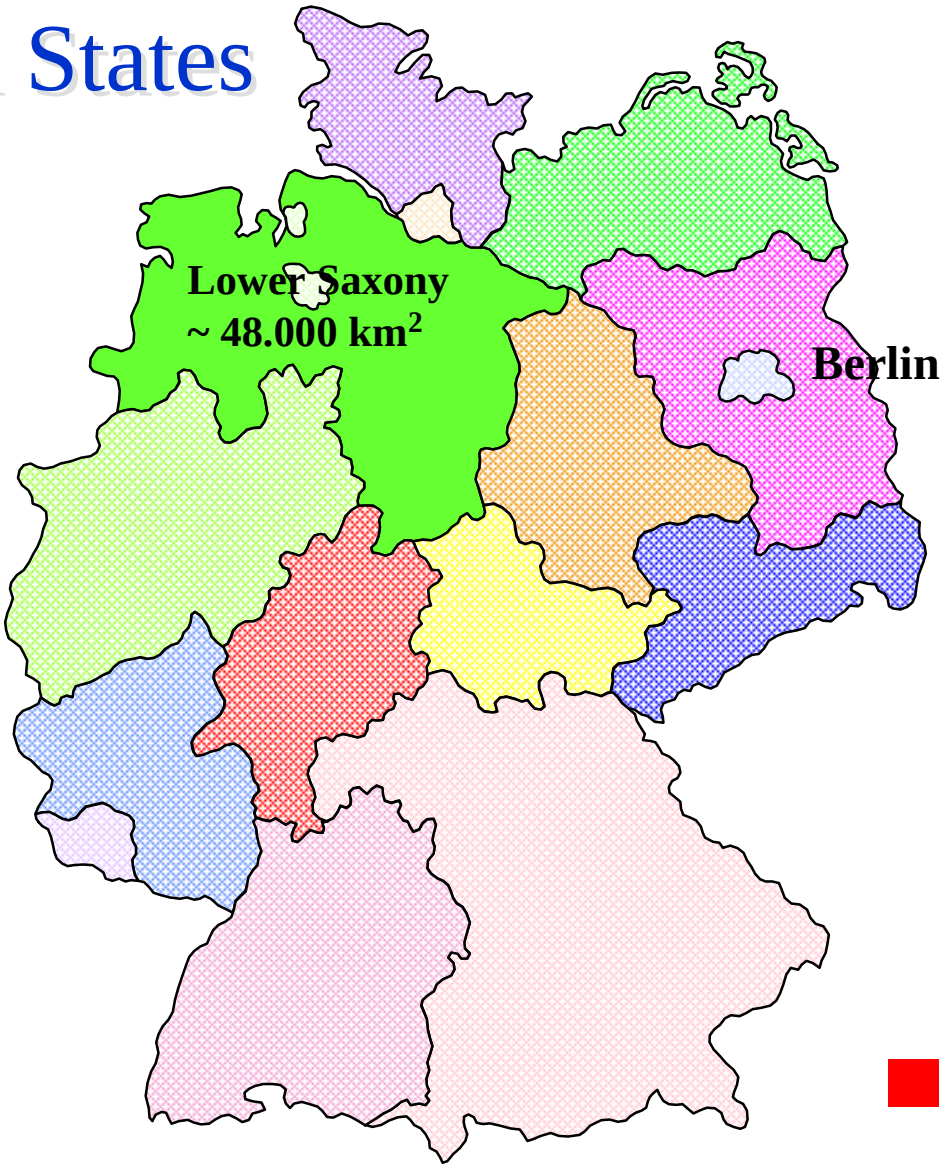
16 Federal German States

Soil survey and soil conservation is a task of the states

Federal law is a frame law



Federal German Soil Protection Act

Act on Protection against Harmful Changes to Soil and on Rehabilitation of Contamitated Sites

Entry into force: 1st of March, 1999

Purpose of the Act

to protect or restore the functions of the soil

this includes

- precautions against negative impacts on soils
- prevention of harmful changes to soils
- rehabilitation of the soil, of contaminated sites and of waters contaminated by such sites

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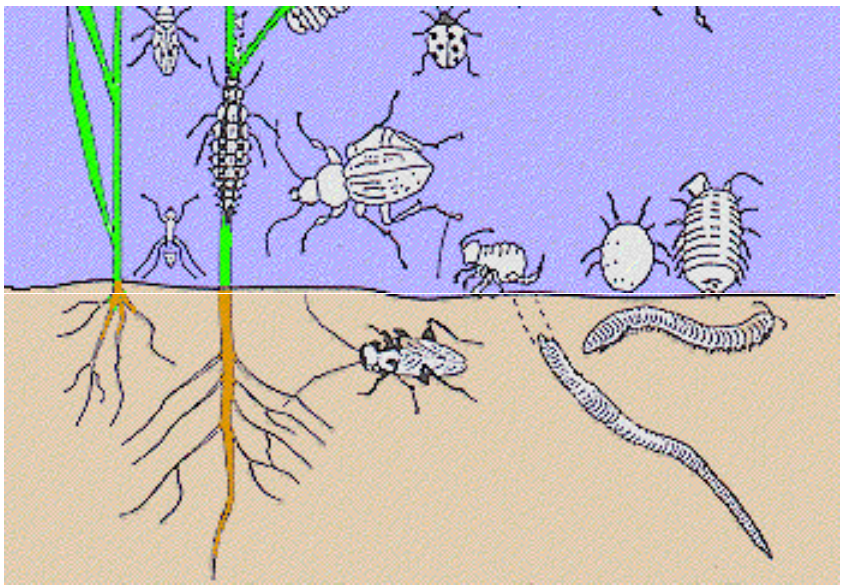
Natural soil functions (1)

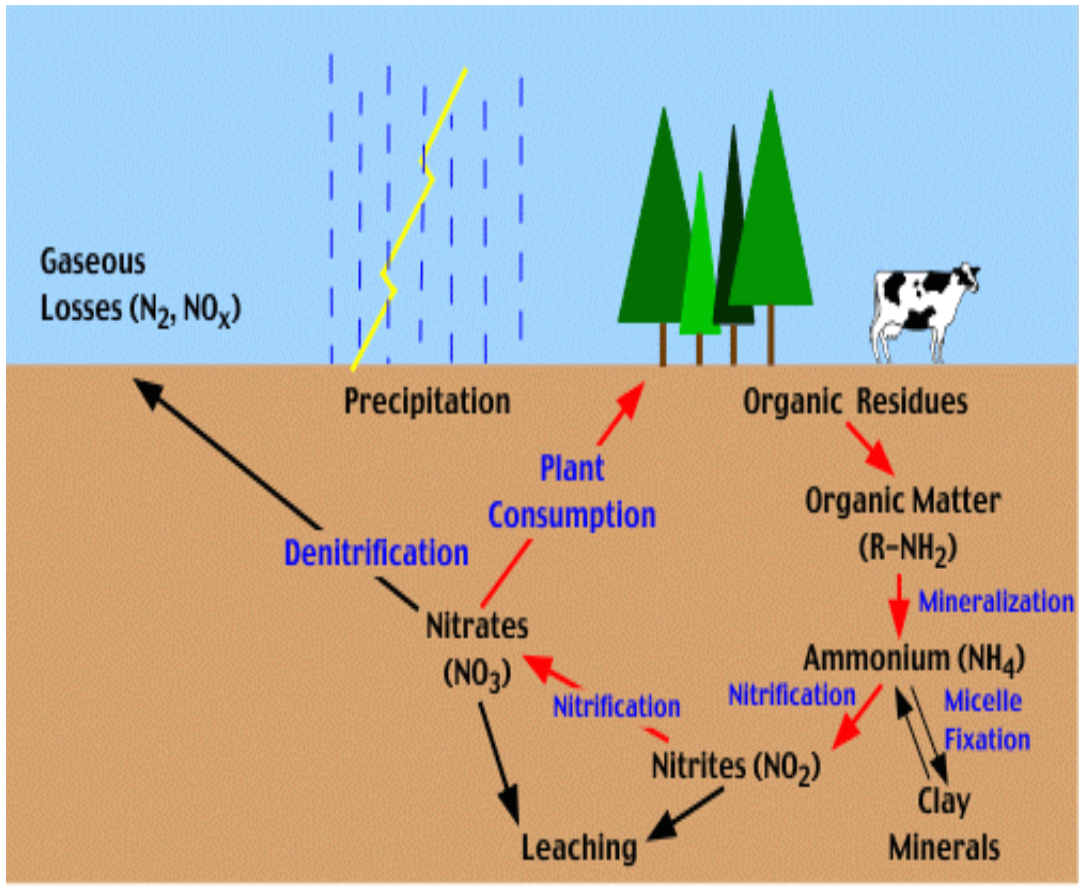
soil as a basis for life and a habitat for people, animals, plants and soil organisms



Natural soil functions (2)

soil as a part of natural systems, especially water and nutrient cycles

soil as a filter and buffer, especially for water protection



Other soil functions

Soil as an archive of natural and cultural history

Soil useful to man

for agriculture and sylviculture

for extraction of primary matters

for settlement and recreation

for other economic and public uses

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Principles and obligations

for property owners and occupants

Obligation to prevent hazard to soils

Obligation for unsealing of unused sealed ground

Restrictions for application of materials to soils

Regulations concerning risk assessment on potentially harmful changes to soils or on contaminated sites

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General indications for harmful changes to soils

Input of pollutants over an extended period of time or in a considerable amount

Increased pollutant contents in food or fodder plants

Considerable loads of pollutants in water coming from the soil

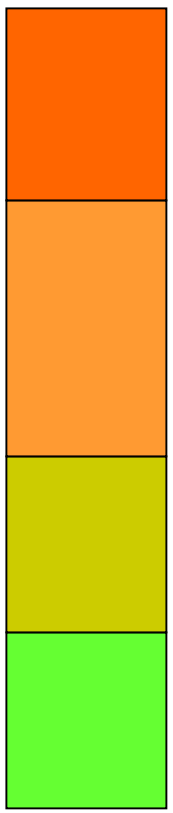
Considerable erosion and deposition by wind and water

Threshold values for pollutants to prevent harmful changes to soils

Action values
(land use dependent)

Trigger values
(use dependent)

Precautionary values
(use independent)



Presence of a harmful change to a soil: Measures are required

Investigations required to determine whether a harmful soil change or a contamination exists

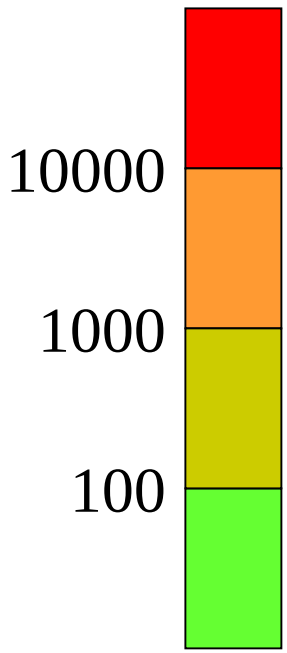
Concern about harmful changes to soil: Precaution measures are required

Threshold values - The pathway concept

Pathway soil - human being (direct contact)

Action values for dioxines and furanes (PCDD/F)

ng I-Teq kg^{-1} dry soil



Industrial and commercial areas

Residential areas, parks

Playgrounds for children

Pathway soil - human being (continued)

Trigger values for heavy metals

[total contents in mg kg^{-1} dry soil]

Substance	play-grounds	residential areas	parks and re-creational areas	industrial and commercial areas
arsenic	25	50	125	140
lead	200	400	1.000	2.000
cadmium	10	20	50	60
chromium	200	400	1.000	1.000
nickel	70	140	350	900
mercury	10	20	50	80

Further pathways

Pathway soil - crop

Action and trigger values for heavy metal and PCB contents on agricultural land, vegetable garden and grassland

Pathway soil - groundwater

Trigger values for inorganic and organic pollutant concentrations in leaching water

Precaution values

Independent of land use

Dependent of soil (texture, humus content)

Precaution values for heavy metals

[total contents in mg kg^{-1} dry soil]

Soil texture	Cd	Pb	Cr	Cu	Hg	Ni	Zn
clay	1,5	100	100	60	1,0	70	200
loam/silt	1,0	70	60	40	0,5	50	150
sand	0,4	40	30	20	0,1	15	60

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Principles of Good Agricultural Practice (1)

to take precautions against harmful changes to soils

Tillage: appropriate to site and weather conditions

Soil structure: Conservation or improvement

Soil compaction: Avoiding by choose of appropriate time and equipment for tillage

Soil erosion: Reduction by means of site-adapted use

Principles of Good Agricultural Practice (2)

to take precautions against harmful changes to soils

Natural structural elements: Preservation of hedges, field shrubbery, trees and terracing needed for soil conservation

Biological activity: Conservation or improvement by appropriate crop rotation

Organic matter: Conservation by means of adequate input of organic material and reduced tillage intensity

Conclusions:

The Federal German Soil Protection Act

defines soil functions to be protected or restored

obliges land owners to use soils precautiously and to prevent harmful changes to soils and water

defines threshold values for pollutants indicating when harmful changes to soils have to be expected and measures to be taken

defines how to proceed with potentially and actually contaminated sites

Thank you for your attention!

SOIL TAXONOMY

Bob Engel
[Comments in bold type added by Warren Lynn, 15 June 2000.1

The Keys to Soil Taxonomy were published in 1998 and the Second edition of Soil Taxonomy was published in 1999. Since then we have made no revisions to these documents. We have had, in effect, an unofficial moratorium for the past two years. We have, however corrected some errors. The corrected documents along with a listing of the errata are posted on the NSSC web site.

During the last two years we concentrated on updating the soil classification database. Classifications of many of the pedons with laboratory data (SOI-8 forms) and of the official series descriptions (OSD's) have been updated. Many of the MO areas have most or all of the classifications updated. This project is continuing, but has slowed this year because of limited travel funds.

In the same period many requests for improvements to Soil Taxonomy have been received. We are planning to start sending these requests out for review. The staff dedicated to working on taxonomy at the National Soil Survey Center is now down to one person. Until the staff is increased the preparation and distribution of amendments for review and finalization of amendments will be slower than in the past.

A number of Soil Taxonomy updates await action:

The Bismarck North Dakota MO staff requests these additions.

> A proposal to add several subgroups that were used in the great group of Borolls prior to the great group being deleted. Some of these subgroups were added to Udolls, but not Ustolls.
>
> The great group Dystrustepts is of larger extent than expected. The great group needs several new subgroups for use in the Bismarck North Dakota MO.
>
> A proposal to add udic subgroups to several frigid Ustolls, mostly in South Dakota, that were Udic Borrolls.
>
> A proposal to change the color criteria of aquic Hapludolls.

A proposal from the Northeast and MO 14 to add subaquic subgroups to several great groups of Entisols, mostly in Maryland, that are permanently under water. Similar taxa also are being considered in Texas. **[Is depth of water limited to where rooted plants can grow?]**

A proposal from St. Paul MN on changing the keying order of the aquic, oxyaquic, and

pachic subgroups. The keying order of these subgroups is inconsistent among the great groups of Mollisols. The order in the more recently added great groups is aquic, oxyaquic, and pachic in that order. Originally pachic was keyed first. When the oxyaquic subgroups were added the hope was that they would identify all soils with a water table within a meter of the surface that failed other aquic criteria. **[Seems more logical that Oxyaquic would compete with Cumulic than with Pachic.]**

The following proposals are from the MO office in Indianapolis IN.

> Travis Neely provided documentation showing that several soil series that were classified as spodic subgroups failed to meet the new criteria. They recommend the spodic subgroup criteria be changed
>
> The addition of an Arenic Oxyaquic subgroups to Hapludalfs. **[In my experience, Bt horizons under arenic and grossarenic surfaces have reductimorphic features. The change could make a Hapludalf with <50cm of sandy epipedon aquic, and a Hapludalf with >50 cm oxyaquic.]**
>
> From Don Franzmeier, Purdue University
>
> In Indiana and other states dense glacial till, usually designated as Cd horizons, qualifies as a fragipan according to the current definition. The two kinds of horizons differ significantly, however. To separate the two kinds of horizons, Don proposes that the definition of a fragipan include the clause, "It has a neutral or acid reaction (pH <7.3)" [Don has agreed to change the proposal to "It is not effervescent".]

Stephen Gourley sent a detailed report of a Northeast Fragipan Study. His proposal concludes that the definition of evidence of pedogenesis in the fragipan definition is too broad. He asks that structure and redox features be removed from the evidence of pedogenesis.

Tom Hahn MO 6, Lakewood CO, called our attention to the fact that Cryepts could be less than 25 cm deep. Thus we propose to add the underlined text to the definition of Eutrocryepts.

KCA. Cryepts that have one or both of the following:

1. Free carbonates within the soil; or

2. A base saturation (by NH40Ac) of 60 percent or more in one or more horizons between 25 and 75 cm from the mineral soil surface or <u>immediately above a root limiting Igyer if at a shallower depth.</u> Eutrocryepts, p.

Del Fanning, Maryland and MO 14 Raleigh, NC proposed revisions to the glauconitic

mineralogy family.

MO 9, Temple TX proposed adding a Crd horizon designation for bedrock that slakes in water (densic material).

Joe Chiaretti MO 3, Reno, NV proposes adding an oxyaquic subgroup to Torripsamments.

A proposal from MO 13 Morgantown ~W to change the name of the andic subgroups in the Appalachian Mountains to amorphic subgroups.

The following class was requested by Hari Eswaren for use in Thailand. No supporting information was provided.

FAA. Aquerts that have within 100 cm of the mineral soil surface: either

A sulfuric horizon; or Sulfidic materials.
Sulfaquerts, p. 245

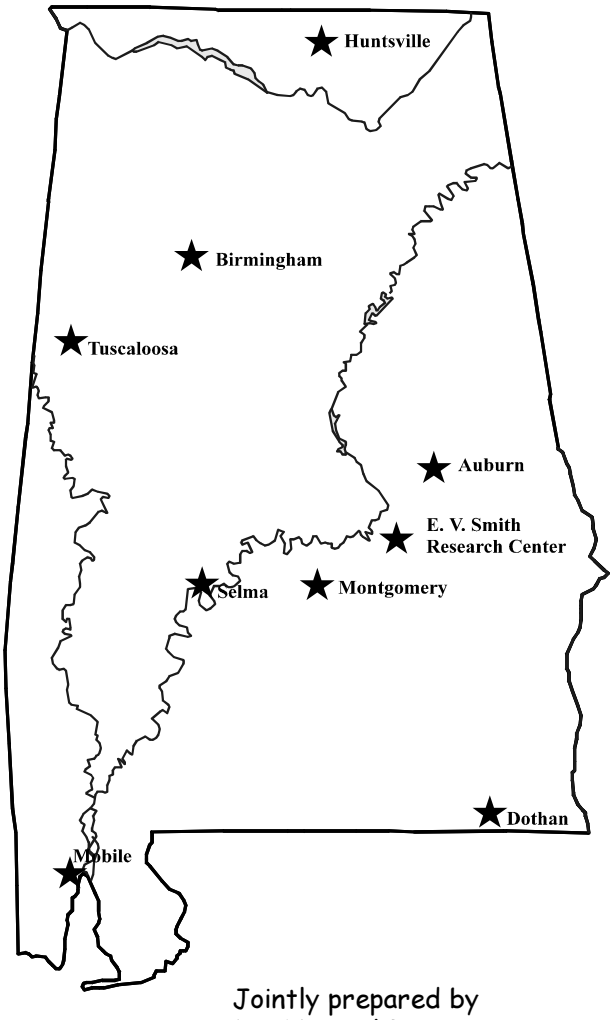
Sulfaquerts

These are the acid sulfate Aquerts (cat clays). They are extremely acid and toxic to most plants if have been drained and oxidized. They are mostly dark gray and have strawcolored mottles of iron sulfate Oarosite) within 100 cm of the soil surface. They are mainly in coastal marshes near the mouths of rivers that carry sediments that are free of carbonates or have low carbonate content. They generally contain an appreciable amount of organic carbon. They are only known to occur in Thailand. Most of these soils support a sparse stand of acid and water tolerant plants. A few areas are used for rice production. [Use **a subgroup to separate sulfidic and sulfuric. Don't put both in one great group. Are drained, acid examples still Aquerts?]**

Southern Regional Cooperative Soil Survey Conference
Auburn, Alabama

June 18-22, 2000

Fieldtrip



Jointly prepared by
USDA-Natural Resources
Conservation Service
and
Auburn University
June 2000

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INTRODUCTION

The conference tourbook was developed to provide participants attending the 2000 Southern Regional Cooperative Soil Survey Conference with applied experiences relative to the soils of Alabama. It was developed by the Natural Resources Conservation Service in cooperation with Auburn University.

General Overview of the State

Spanish explorers arrived in Alabama in 1519 at Mobile Bay and the territory was explored by Hernando de Soto in 1540. Native inhabitants had been settled in Alabama for nearly 10,000 years before European contact. The word Alabama is believed to be Choctaw in origin, meaning "thicket-clearers" or "vegetation-gatherers."

Alabama is bordered on the north by Tennessee and on the west by Mississippi. From the south, a 53-mile panhandle extends along the Gulf of Mexico. Alabama's southern bounder is shared with Florida. The state of Georgia is on the east, where the Chattahoochee River separates the two states.

Major agricultural crops are those typical of other southern states—cotton, soybeans, corn, and peanuts. Poultry, catfish and cattle are the dominant livestock in Alabama. Two-thirds of Alabama's land is in private forest. Timber production is a major contributor to Alabama's economy.

Alabama hosts mild climates, where short, mild to moderate winters and long, warm to hot summers occur (Table 1). Rainfall averages 55 inches in the north to more than 65 inches in the extreme south-west part of the state.

Physiography Of Alabama

Alabama comprises an area of 50,750 square miles or about 32,480,000 acres. Elevations range from sea level in the southwestern part of the State to 2,407 feet at Mt. Cheaha in east central Alabama.

Alabama lies in parts of five physiographic provinces (Figure 1). The five provinces are the Interior Low Plateaus, the Appalachian Plateaus, the Valley and Ridge, the Piedmont, and the Coastal Plain. Each province is subdivided and will be explained in more detail below.

Descriptive information concerning the various physiographic divisions is from Adams (1926), Johnson (1933), Fenneman (1938), Monroe (1941), and Pierce (1966).

Interior Low Plateaus Province

Highland Rim Section

The Highland Rim Section in Alabama is divided into the Tennessee Valley, Little Mountain, and Moulton Valley (Figure 1).

The Tennessee Valley has a rolling surface with a maximum relief of about 400 feet, and lies about 600 feet above sea level. It is underlain chiefly by carbonate rocks ranging in age from Late Ordovician to Early Mississippian (Table 2 and Figure 3). Little Mountain is a range of hills rising about 200 feet above the Tennessee Valley that is capped by the resistant southward dipping Hartselle Sandstone. It is bounded on the south by Moulton Valley, an undulating open lowland ranging in altitude from 575 to 650 feet, and underlain exclusively by the Bangor Limestone of Late Mississippian age.

Appalachian Plateaus Province

Cumberland Plateau Section

The Cumberland Plateau Section in Alabama is a submaturely to maturely dissected upland, underlain largely by rocks of Pennsylvanian age (Table 2 and Figure 3). The upland lies at altitudes ranging from 1,500 to 2,000 feet in the north to about 500 feet in the south, where it passes beneath the Coastal Plain. It is divided from east to west into the following units: Lookout Mountain, Wills Valley, Sand Mountain, Sequatchie Valley, Jackson County Mountains, and Warrior Basin (Figure 1).

Lookout Mountain and Sand Mountain are two synclinal flat-topped remnants of the Cumberland Plateau, underlain by clastic rocks of the Pottsville Formation, rising some 500 to 700 feet above the

surrounding valleys. The intervening Wills and Sequatchie Valleys are narrow, faulted anticlinal valleys underlain predominantly by carbonate rocks ranging in age from Late Cambrian to Late Mississippian . The clastic material of the Red Mountain Formation and the chert of the Fort Payne Chert produce resistant hogbacks in both valleys. The Warrior Basin, a broad synclinal submaturely dissected plateau ranging in altitude from 1,100 feet in the north to 500 feet in the south, is underlain by the clastics of the Pottsville Formation. The Jackson County Mountains are submaturely dissected uplands capped by gently dipping rocks of the Pottsville, with carbonate rocks of Late Mississippian age underlying the intervening wide deep valleys. Relief in this area is as much as 1,000 feet.

Valley And Ridge Province

The Valley and Ridge province consists of a series of parallel ridges and valleys underlain by highly faulted and folded rocks of Cambrian to Pennsylvanian age (Table 2 and Figure 3). Local subdivisions from east to west include the Weisner Ridges, Coosa Valley, Coosa Ridges, Cahaba Valley, Cahaba Ridges, and the Birmingham-Big Canoe Valley (Figure 1).

The Weisner Ridges are a series of mountains as much as 2,130 feet high that are underlain by complexly faulted and folded quartzites and carbonates of predominantly Cambrian age. Immediately west of this area is the Coosa Valley, a broad valley of low relief lying 500 to 650 feet above mean sea level and underlain by complexly faulted and folded Paleozoic sedimentary rocks. The generally low relief of the valley is interrupted locally by low hills and ridges formed by rocks of resistant formations such as the Weisner Quartzite, the Frog Mountain Sandstone, and the Red Mountain Formation. The Coosa and Cahaba Ridges are characterized by a series of parallel, northeast-trending ridges formed by the massive sandstone and conglomerate beds in the Pottsville and Parkwood Formations. The intervening valleys are underlain by shale of the Parkwood and Floyd Formations. The ridges rise 200 to 500 feet above the surrounding valleys. The Cahaba Valley lies between the Coosa Ridges and the Cahaba Ridges, and is a faulted monoclinal valley underlain predominantly by the limestone and dolomite of Early Paleozoic age. Locally, chert-bearing Cambrian and Ordovician dolomites as well as the Fort Payne Chert form resistant ridges. The Birmingham-Big Canoe Valley, which lies west of the Cahaba Ridges, is a broad anticlinal valley underlain by faulted, asymmetrically folded rocks of Cambrian to Mississippian age. One of the most prominent ridges is Red Mountain, a long continuous ridge rising about 400 feet above the valley floor and formed by the southeastward dipping Red Mountain Formation and Fort Payne Chert.

Piedmont Province

Piedmont Upland Section

The Piedmont Upland Section is a submaturely dissected surface developed upon igneous and metamorphic rocks (Table 3 and Figure 3). It consists of the Ashland Plateau to the northwest and the Opelika

Plateau to the southeast (Figure 1). The Ashland Plateau is a mountainous region characterized by narrow steep valleys, with a rolling upland surface lying 1,000 to 1,100 feet above mean sea level. The Opelika Plateau lies at altitudes ranging from 500 to 800 feet and is generally of much lower relief than the Ashland Plateau.

Coastal Plain Province

East Gulf Coastal Plain Section

The East Gulf Coastal Plain Section is underlain by Mesozoic and Cenozoic (Table 2 and Figure 3) sedimentary rocks, which gently dip southward at 20 to 40 feet per mile. The resistant beds form cuestas that gently slope southward forming a series of arcuate, southeasterly to easterly, trending hilly belts across the State. In Alabama, the section is divided into the Fall Line Hills, Black Prairie Belt, Chunnennuggee Hills, Southern Red Hills, Lime Hills and Southern Pine Hills (Figure 1).

Fall Line Hills

The Fall Line Hills is a dissected upland with a few broad, flat ridges separated by valleys ranging from 100 to 200 feet deep. The Fall Line Hills occupy a zone where streams descend from resistant Paleozoic sedimentary and Piedmont crystalline rocks to the less resistant sand and clay of pre-Selma age in the Coastal Plain. It has a maximum width in western Alabama of about 50 miles, and altitudes range from more than 700 feet in northwestern Alabama to about 250 feet along the northern edge of the Black Prairie Belt.

Black Prairie Belt

The Black Prairie Belt lies to the south of the Fall Line Hills and occupies a narrow crescent-shaped area encompassing approximately 8,000 square miles, extending from western Tennessee and northern Mississippi into central Alabama. The area is characterized by an undulating deeply weathered plain of low relief, developed mainly on chalk and marl of the Selma Group. Because of the impurity of the chalk and marl and other factors, typical karst features generally formed in carbonate-rock terranes are missing. In western and central Alabama the interfluves lie at elevations of about 250 feet. The belt is not present in eastern Alabama because of facies changes, with the dominant chalk lithologies of western Alabama being replaced by clastic sedimentary units to the east.

The Arcola Cuesta, supported by the resistant Arcola Limestone Member of the Mooreville Chalk, occurs near the middle of the belt and trends southeastward and eastward from the Alabama-Mississippi boundary to southeast of Montgomery. The Arcola Cuesta is characterized by a line of hills rising 50 to 75 feet above the surrounding prairie floor.

Chunnennuggee Hills

The Chunnennuggee Hills is a pine forested series of sand hills and cuestas developed on the Ripley Formation and Prairie Bluff Chalk in western Alabama and the Blufftown Formation, Ripley Formation, and Providence Sand in eastern Alabama. The hilly belt extends eastward from Sumter County across most of the State. It widens in eastern Alabama as the chalk of the Black Prairie Belt intertongues with the more resistant clay, siltstone and sandstone of the Blufftown and Ripley Formations and Providence Sand. In western Alabama the Chunnennuggee Hills are bounded on the north by the Black Prairie Belt and in easternmost Alabama by the Fall Line Hills.

In western Alabama the more indurated beds of the Ripley Formation support the prominent northward-facing cuesta termed the High Ridge Cuesta by Monroe (1941) and the Ripley Cuesta by Fenneman (1938). It is more generally known as the Ripley Cuesta, and that is the terminology used in this report. The cuesta rises 100 to 200 feet above the prairie floor to the north and is nearly continuous from Sumter County to Georgia.

In eastern Alabama four linear, roughly parallel, northward-facing cuestas are present (Monroe, 1941). The basal sand of the Blufftown Formation forms the Sand Fort Cuesta, separating the Chunnennuggee Hills from the Fall Line Hills. The scarp of the Sand Fort Cuesta is most prominent in Russell County, where it is about 200 feet high. The Blufftown Formation intertongues with the Mooreville Chalk in central Macon County and the cuesta is not present to the west of this area. The back slope of the cuesta is cut into low rounded sandy hills composed of the upper part of the Blufftown Formation.

The Enon Cuesta occurs near the southeastern boundary of the Black Prairie Belt and is supported by the basal Cusseta Sand Member of the Ripley Formation. The Enon Cuesta is 200 feet high in central Bullock County and is traceable eastward to the flood plain of the Chattahoochee River. It does not extend westward from Bullock County as a prominent feature, because of intertonguing of the Cusseta with the Demopolis Chalk.

The Ripley Cuesta south of the Enon Cuesta is by far the most continuous and distinctive topographic feature in the Chunnennuggee Hills. In southern Bullock County the cuesta rises from 120 to 150 feet above the area to the north.

The Lapine Cuesta, southernmost cuesta in the area, was formed on the resistant beds of sand and gravel in the Providence Sand. The cuesta is from 150 to 200 feet high in Barbour County; it is less prominent to the west but is traceable to western Lowndes County. The Providence Sand “pinches out” in Lowndes County in sediments that are probably correlative with the Prairie Bluff Chalk.

Southern Red Hills

The Southern Red Hills includes the Flatwoods, a lowland generally about 5 to 8 miles wide that extends from Sumter County to just east of the Alabama River along the north edge of the area. The flat-lying, relatively smooth surface of the Flatwoods is at an altitude of about 200 feet and is developed on the dark clay of the Porters Creek Formation. The Flatwoods are bordered to the south by a range of hills that rise 200 to 400 feet. In this area, the hills are underlain by formations of the Wilcox Group, but, farther east, the Clayton Formation forms the boundary ridge south of the Chunnennuggee Hills. The northern edge of the Southern Red Hills lies at a nearly accordant altitude of 600 feet and local relief of several hundred feet is common. Considerably large areas of "red levels," or undissected uplands, remain, especially at the outer edge of the belt. Along the southern edge of the Southern Red Hills, a cuesta, known as the Buhrstone Hills, rises 300 to 400 feet above the nearby streams and is considered to be the most rugged topographic region in the Alabama Coastal Plain. This hilly belt is 10 or more miles wide, extends from the Pearl River in Mississippi across Alabama to about the middle of the State and is developed on the indurated resistant siliceous claystone and sandstone of the Tallahatta Formation.

Lime Hills

The Lime Hills from near the Alabama-Mississippi boundary extend eastward in a belt 5 to 8 miles wide across southwestern Choctaw County into Conecuh County. The rugged topography approaches that of the Buhrstone Hills in places, and it is caused partly by the reappearance of the highly resistant Tallahatta Formation in the Hatchetigbee anticline and partly by facies changes from soft clay, sand, and marl to resistant limestones in the upper Eocene and Oligocene deposits.

The Hatchetigbee anticline affects an area at least 50 miles long and 20 miles wide and stratigraphic displacement at the land surface is at least 600 to 700 feet. The southern flank of the anticline lies in the Lime Hills and the northern flank in the Southern Red Hills. The topography in the western part of the Lime Hills is attributed to the resistant beds in the Tallahatta Formation and resistant limestones of the upper Eocene and Oligocene deposits. Relief of 200 to 250 feet from valley floors to ridge crests is common.

The eastern part of the belt in Monroe and Conecuh Counties is less rugged and the hills are approximately 100 to 150 feet above the valley floors. The sand, clay, and marl of the upper Eocene and Oligocene deposits have been almost entirely replaced by more resistant limestones.

Southern Pine Hills

The Southern Pine Hills, a cuesta-like elevated southward sloping dissected plain is developed on Miocene estuarine deposits to the north and on sand and gravel of the Pliocene Citronelle Formation to the south. The plain ranges in altitude from 400 feet in the north to about 100 feet a few miles inland from the Gulf of Mexico. Relief is greatest in the northern part where streams draining eastward to the Tombigbee River and westward to the Alabama River drop to base level in relatively short distances. The relief is as much as 250 feet in this area. To the south the topography is more subdued, being characterized by low rounded hills.

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SOILS OF ALABAMA

Alabama has several major soil areas (Figure 4 and Figure 5). Most of the soils within each area were formed from materials with similar characteristics. Detailed soil surveys, available for most counties, show that each area has several major soil series. A soil series is a part of the landscape with similarities among its properties such as color, texture, arrangement of soil horizons, and depth to bedrock.

Limestone Valleys And Uplands

Soils in this area were formed mainly in residuum weathered from limestones. Soils of the Tennessee and Coosa River valleys were weathered from pure limestones and are mainly red clayey soils with silt loam surface textures. Decatur and Dewey soils are extensive throughout the valleys. Topography is generally level to undulating. Elevation is about 600 feet. Most of the land is open and cropped to cotton or soybeans.

Most of the soils of the uplands are derived from cherty limestones. Bodine and Fullerton soils are extensive in many of these landscapes. They typically have gravelly loam and gravelly clay subsoils and gravelly silt loam surface layers. Elevation is about 700 feet, and topography ranges from level to very steep. Cotton and soybeans are major row crops. Much of the area is used for pasture or forest.

Appalachian Plateau

The Appalachian Plateau comprises Cumberland, Sand, Lookout, Gunter, Brindlee, Chandler and other smaller mountains. Most of the soils are derived from sandstone or shale.

The more level areas are dominated by Nauvoo, Hartsells and Wynnville soils which were formed in residuum from sandstone. They have loamy subsoils and fine sandy loam surface layers. Most slopes are less than 10 percent. Elevation is about 1,300 feet. Corn, soybeans, potatoes and tomatoes are major crops. Poultry is very important in this area.

The more rugged portions of the Appalachian Plateau are dominated by soils such as Montevallo and Townley, which were formed in residuum from shale. These soils have either a very channery loam, or a clayey subsoil and silt loam surface layers. Most areas are too steeply sloping for agriculture. Elevations range from 300 to 700 feet.

Piedmont Plateau

Most of the soils in this area are derived from granite, homblende, and mica schists. Madison, Pacolet and Cecil soils, which have red clayey subsoils and sandy loam or clay loam surface layers, are very extensive. Elevations in most areas range from 700 to 1,000 feet, although in the Talladega Hills, elevations range from 900 to 2,407 feet (highest point in Alabama). Topography is rolling to steep. Most rolling areas were once cultivated but are now in pasture or forest.

Coastal Plain

Most of the soils in this area derived from marine and fluvial sediments eroded from the Appalachian and Piedmont plateaus. The area consists of Upper and Lower Coastal Plains.

Smithdale, Luverne and Savannah soils are extensive in the Upper Coastal Plains. They have either loamy or clayey subsoils and sandy loam or loam surface layers. Savannah soils have a fragipan. Topography is level to very steep. Narrow ridgetops and broad terraces are cultivated, but most of the area is in forest. Elevations range from 200 to 1,000 feet.

Dothan and Orangeburg soils are very extensive in the eastern part of the Lower Coastal Plains. They have loamy subsoils and sandy loam or loamy sand surface layers. Smithdale and Bama soils are very extensive in the western part. These soils have loamy subsoils and sandy loam surface layers. Most slopes are less than 15 percent. Major crops are corn, peanuts, cotton, soybeans and horticulture crops. Timber products and hogs are very important. Elevations range from sea level to 500 feet.

Blackland Prairie

The area of central and western Alabama is known as the "Black Belt" because of the dark surface colors of many of the soils. These soils were derived from alkaline, Selma chalk or acid marine clays. Acid and alkaline soils are intermingled throughout the area. Sumter soils, which are typical of the alkaline soils, are clayey throughout and have a dark-colored surface layer and a yellowish brown subsoil. Oktibbeha soils are acid and clayey throughout. They have red subsoil layers overlying chalk. The clayey Wilcox, Mayhew, and Vaiden soils are the dominant soils of the rolling pine woodlands along the southern edge of the "Prairie." They are acid and are somewhat poorly drained or poorly drained. They are locally known as "flatwoods" or "post oak clays." These clayey soils contain a high percentage of smectitic clays and they shrink and crack when dry and swell when wet. The area is level to undulating. Elevation is about 200 feet. Soybeans is the main crop. Most of these soils are used for timber production and pasture.

Major Flood Plains And Terraces

The soils are not extensive but important where they are found along streams and rivers. They are derived from alluvium deposited by the streams. The Cahaba, Annemaine, and Urbo series represent major soils of this area. A typical area consists of cultivated crops on the nearly level terraces and bottomland hardwood forests on the floodplain of streams.

Coastal Marshes And Beaches

The soils are not extensive. They are on nearly level and level bottomlands along the Mobile River, and tidal flats and beaches on Mobile Bay, and the Gulf of Mexico. Most of the soils are deep and very poorly drained. Dorovan and Lafifte series have very dark grayish brown, muck surfaces over a thick, blackish muck which is over brownish sand. Axis soils have a very dark grayish brown mucky sandy loam surface over a very dark gray sandy loam subsoil. Levy soils have a gray silty clay loam surface over gray clay. Fripp and Duckston soils have a grayish sand surface over white, grayish or pale brown layers of sand. Elevation is from sea level to a few feet above sea level.

Historical Perspective of the Tallapoosa River

HISTORICAL PERSPECTIVE OF THE TALLAPOOSA RIVER

(Jackson, 1995; and Partin, 1968, used for references for this section)

J. N. Shaw, W.E. Puckett, and P.G. Martin

The Tallapoosa River originates in Georgia as the Tallapoosa and Little Tallapoosa Rivers, which flow southwestward into Alabama. These streams join in Randolph County, and from there the Tallapoosa River winds through the rural Piedmont of central Alabama. Near Wetumpka in Elmore County (west of the E.V. Smith Experimental Station), the Tallapoosa joins with the Coosa River to form the Alabama River. The Tallapoosa is one of several major rivers in Alabama, and like all of them, has played a large role in southeastern U.S. history.

The name Tallapoosa is believed to be Choctaw for pulverized rock (Partin, 1968). Unlike it's sister stream the Coosa, the Tallapoosa possesses tight bends and falls, and did not see the large-scale navigation it's sister stream saw (Jackson, 1995). However, it's importance from a strategic standpoint was paramount throughout Alabama's evolution. Much of the river's history revolves around Native Americans and their encounters with European and American settlers. Alabama saw some of the largest and most significant conflicts between these groups.

Evidence suggests Native Americans inhabited this region beginning in approximately 7500 BC. In 1540, de Soto's army clashed with Chief Tascaluza's tribe in the battle of Mabila, which most historians believe took place adjacent to the Alabama River in Clarke County in southwestern, AL. The exact location of this battle has been the subject of much debate (Jackson, 1995). It is believed that over 5000 Native Americans died in this conflict, which would rank it at least as deadly as the major battles in the war between the states (Jackson, 1995).

A major struggle existed for the fertile lands and key access to the Alabama River offered by the Tallapoosa and Coosa Rivers during the 1700 and 1800's. In the early 1700's, the French, British, and Upper Creek Nation all claimed the land adjacent to these rivers. Both the French and British realized control of the lower Tallapoosa and Coosa Rivers meant control of a major portion of the Alabama River, and would provide inland access to the major port on the Gulf Coast at Mobile (Jackson, 1995). For this reason, the French constructed Fort Toulese at the junction of the Coosa and Tallapoosa to safeguard this region (Jackson, 1995). After a struggle, the British won their conflict with the French in 1763, and officially took control of the Tallapoosa, Coosa, and Alabama river system (Jackson, 1995). Although Native American support was largely non-committal during this struggle, their neutrality would turn out to be problematic for their future. As Jackson (1995) states, two major wars were fought during this period; the British won the first (against the French), the American settlers won the second (American revolution), and the Native Americans lost both.

Although the British hoped the Native American nations (mainly Choctaw, and Upper and Lower Creeks) in this region would rise up against the invading American settlers during the American Revolution, little resistance initially materialized (Jackson, 1995). After the colonies won the revolution, the American settlers, Spaniards, and Creeks all laid claim to this river region. The Spaniards relinquished all claim to everything north of Mobile in the late 1700's, and then surprisingly peacefully relinquished Mobile in 1813 (Jackson, 1995). Although the Creek Nation was promised much of the land adjacent to the Alabama rivers by the evolving American government, the increasing settler presence in the region suggested this issue was yet to be settled.

During this period, the tribes of the Creek Nation had established large settlements on the terraces surrounding the Tallapoosa river. A traveler through the region in the late 1700's noted the "very rich soil

on the narrow flats adjacent to the rivers", and the "poor and broken" soils on the uplands (Jackson, 1995). The natural beauty of Alabama did not escape early explorers. Naturalist William Bartram made some of his historic treks through the Alabama River country (Jackson, 1995). Early settlers documented the abundant wildlife and fish populations of the Tallapoosa River. One settler even noted the Tallapoosa River was teeming with freshwater trout during the 1700's, a species not found in these waters today (Jackson, 1995). For these reasons, the Creek settlements were numerous in the region, and the natives were mostly accommodating to travelers passing through. The hostilities seemed to erupt when travelers decided to settle.

The War of 1812 between America and Britain brought new conflict to the region. Concurrently, the Creek War between the American settlers and the Creek Nation began to take shape (Jackson, 1995). Because some of the largest issues revolved around the control of the major rivers of this region, some historians have termed these struggles the *War for Alabama* (Jackson, 1995). Hostility and conflicts between the Native Americans and the settlers escalated, and Washington decided the time had come to exert some control over the region. The plan would be to mobilize two large armies that would destroy, or seriously debilitate, the Creek Nation in this region. One would move north up the Alabama River from Mobile to the south, the other would advance south from Tennessee and move along the Coosa and Tallapoosa Rivers. This army was under the control of General Andrew Jackson.

The army moving up from the south quickly gained control of the lower Alabama. However, Jackson's army met significant resistance at several points along their path (Jackson, 1995). A particular faction of the Upper Creek Nation known as the Red Sticks inhabited much of the wild stretches associated with the upper Coosa and Tallapoosa river region. This faction was particularly committed to traditional Creek values, and was particularly resolved to resist Jackson's advances (Jackson, 1995). The fate of the Tallapoosa River and the Upper Creek Nation in this region was essentially decided on March 27th, 1814. On a one-hundred acre peninsula formed by a bend in the Tallapoosa River, Jackson met the Upper Creeks in a decisive battle for the region, and the end of a culture (Partin, 1968). Jackson soundly defeated the Red Sticks, and quickly acquired national fame for his part in the battle for Alabama. This historic battlefield, known as Horseshoe Bend, is located 12 miles north of Dadeville in Tallapoosa county, and is the most historic landmark on the Tallapoosa River.

The Creeks were allowed to maintain some of the land between the two rivers after Horseshoe Bend (Jackson, 1995). However, the Treaty of Cusseta signed in 1832 essentially relinquished Creek holdings east of the Mississippi River (Jackson, 1995). Although small reservations still exist, it was during this period that Native American culture began to disappear from the region.

Unlike the Coosa River, the Tallapoosa was relatively non-navigable to commercial traffic, although flatboats did operate between landings (Jackson, 1995). The falls at Tallassee (Creeks called it Talasi) also made navigation problematic. The first recognized commercial use of the Tallapoosa involved the construction of a dam near Tallassee, just 2 mi. north of E.V. Smith, that allowed for the capture of the hydraulic energy and the construction of the first commercial cotton gin in this part of AL. The last century has seen a series of dams built on the Tallapoosa. Currently four dams exist on the river, and most are used for hydroelectric power generation. The R.L Harris dam, built in 1983, is located in Randolph county. The other three dams are located on the Tallapossa/Elmore county line. The Martin dam, constructed in 1926, led to the development of Lake Martin, the prime recreational destination in the region. This lake has a shoreline of over 500 miles, which at one time ranked it the largest man-made impoundment east of the Mississippi. Although the lake was essentially unusable for recreation in it's

early days due to the high sediment derived from cotton cultivated in adjacent Piedmont uplands, the shift to pine cultivation brought about a relative upgrade in water quality (Partin, 1968). The other two dams, Yates (1926), and Thurlow (1930), are located above and within Tallassee, respectively.

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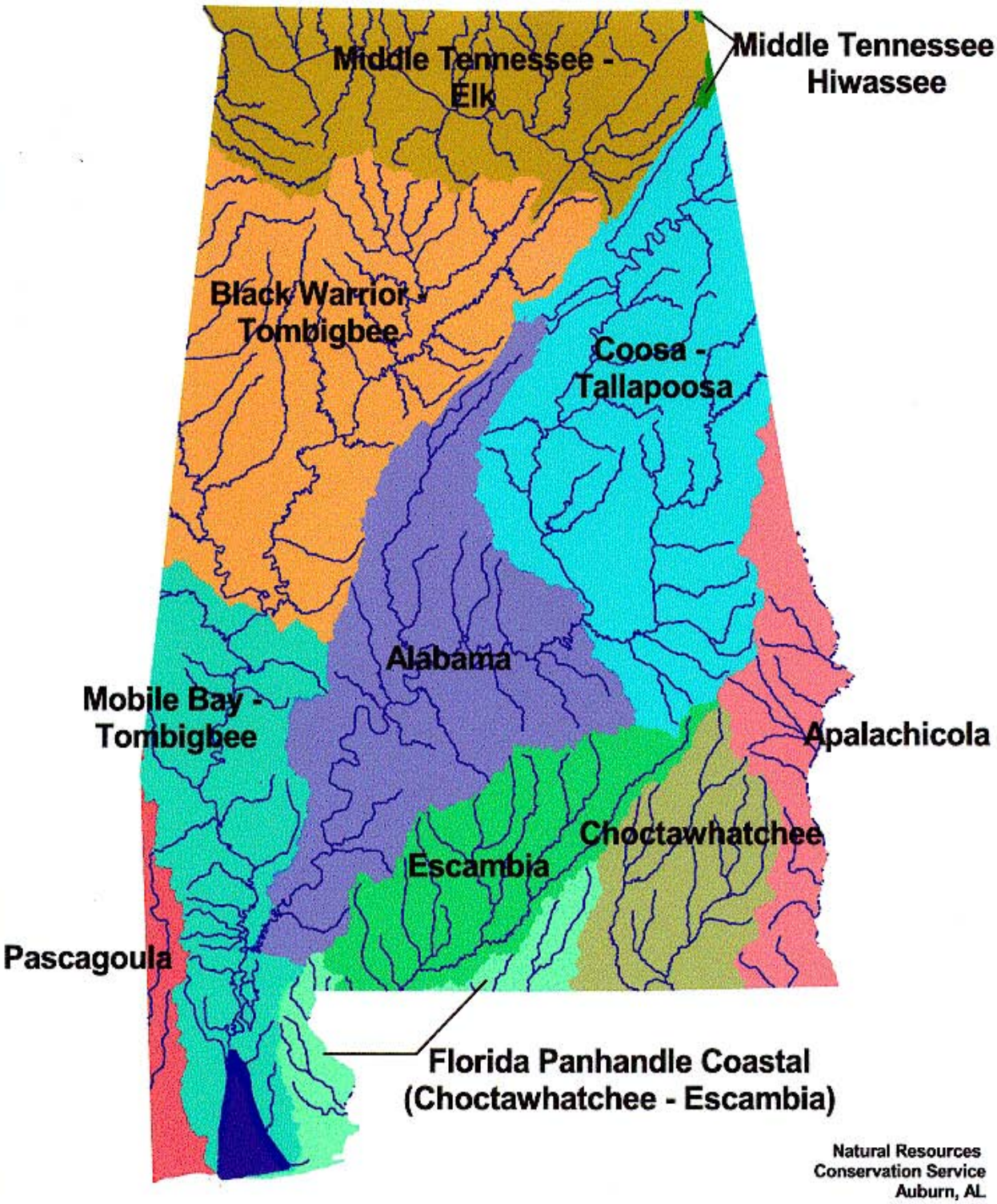
U.S. Department of Agriculture

State of Alabama
Six Digit Hydrologic Unit Map



Natural Resources
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Auburn, AL
24 May 2000

Terrace Study
E. V. Smith Experiment Station

TALLAPOOSA RIVER TERRACES

J.N. Shaw, W.E. Puckett, and P.G. Martin

INTRODUCTION

River Terraces

River terraces are best conceptualized as abandoned floodplains. Terraces are typically composed of the scarp or riser, and the tread or the relatively flat surface associated with each level (Gerrard, 1981). Many studies have shown river valleys may contain many terrace levels, with the lowest and youngest terrace typically residing 1 to 2 m above the active floodplain. Typically, larger order streams possess relatively more distinct terrace systems.

Although models of terrace development are complex, the general steps of formation can be conceptualized relatively easily (Dury, 1970). Formation of the majority of fluvial terraces in the Southeastern U.S. Coastal Plain is thought to be related to climate changes during the Quaternary (Nash, 1980). Most researchers believe a combination of sea level fluctuations due to glacial transgression and regression and arid to humid changes during the Pleistocene resulted in changes in both base levels and stream sediment loads (Nash, 1980). This resulted in periods of both active and inactive stream down-cutting (Nash, 1980). As rivers meander from side to side within an alluvial valley during stable periods, the valley floor typically becomes flat bottomed (Dury, 1970). As streams down-cut to reach new base levels, the old floodplains are left suspended above the present day channel, resulting in formation of sequences of terraces. Thus, intermittent periods of stream incision (down-cutting) and stabilization (alluviation) are necessary for terrace development (Nash, 1980).

Terrace Soils

Soils of alluvial terraces provide unique opportunities for pedologists. Often, the presence of datable materials (in younger terraces) and the relative aging of landscapes as inferred by terrace elevations allow the pedologist to develop timelines of pedogenesis using a state factor approach. Therefore, many chronosequence studies have evaluated soil development on fluvial terraces (Torrent, 1976; Alexander and Holowaychuk, 1983; Dorronso and Alonso, 1994).

Some general properties of soils developed on fluvial terraces can be described. Due to the alluvial nature of the parent materials, terrace soils can be highly spatially variable (Gerrard, 1991). In most terrace systems, soils tend to become better developed proceeding from lower (younger) to higher

(older) terraces. Because of the fining upwards of sediments associated with the fluvial sediments, terrace soils also tend to fine upwards, although pedogenesis and discontinuities often render these trends difficult to interpret.

Numerous studies in the literature indicate results are mixed as to the most reliable indicators of soil age and development in fluvial chronosequence studies. For example, Dorronso and Alonso (1994) found that several soil properties related to the degree of soil development were correlated with the age of fluvial terraces in Spain. These authors found that horizon and soil development indices were strongly correlated with terrace age. However, their results suggest that some soil properties display linear changes with increasing age (e.g. available water holding capacity), some properties initially change relatively rapidly and then slow down with increasing age (solum thickness, dithionite extractable Fe quantities-Fe_d), and some properties possess no correlation with terrace age (e.g. Bt horizon silt content). Markewich et al. (1989) suggest that solum thickness, degree of reddening, increasing clay quantities in the subsoil, and the ratio of (Fe + Al)/Si are good indicators of soil age. Indeed, several studies have indicated Fe_d in the solum increases with soil age (Torrent, 1976; Torrent et al., 1980). However, Alexander and Holowaychuk (1983) found that clay content and Fe_d in the Bt horizon showed no trends with regard to terrace age in a Colombian terrace chronosequence. In their study, the ratio of oxalate extractable Fe (Fe_{ox})/Fe_d proved to be highly correlated with age. Thus, it is apparent that confounded interactions between soil forming factors differentially affect soil properties that portray the degree of profile development.

Fluvial Terrace Studies in Alabama

A few studies have evaluated soil and terrace development in Alabama (Nash, 1980; Markewich and Christopher, 1982a; Markewich et al., 1988). Markewich and Christopher (1982a) evaluated the development of three terraces (t1 thru t3 from youngest to oldest) on Uphapee Creek. Uphapee Creek, a fourth order stream, drains into the Tallapoosa River in western Macon county. In summary, these authors described Uphapee Creek terrace development as occurring in six stages:

1) Down cutting of Uphapee Creek into the Cretaceous aged Tuscaloosa group.

2) Deposition of the t3 deposits during the middle to late Pleistocene.

3) Incision of the creek through the valley fill (probably into the Tuscaloosa group), stabilization and formation of another set of floodplains, then continued entrenchment forming the t2 terrace.

4) Deposition of the t1 sediments.

5) Entrenchment through the t1 sediments.

6) Formation of current floodplain.

The authors concluded that all deposits in the Uphapee Creek valley are Quaternary. Radiocarbon ages suggested the t1 terrace is of middle Holocene age, while soil development suggested t3 is middle to late Pleistocence aged (Markewich and Christopher, 1982a). These authors also found evidence (using carbon dating) of sediment deposition occurring during the late Pleistocence within the t1 valley fill. These authors state that warm, humid climates occurred during these periods resulting in high sea levels and subsequently high base levels. It is proposed high base levels could induce periods of alluviation. However, similar to other researchers, these authors believe sea level induced-base level effects are minimal on streams that are topographically high in the drainage basin (such as the Uphapee). These authors conclude that the exact causes for terrace development are largely unknown, but are related to climate changes.

Markewich et al. (1988) evaluated soil development in two locations on Uphapee Creek and two locations on the Tallapoosa River at the t1 terrace level. The t1 terrace (averages 6.7 m above the current river level with an average elevation of between 70 and 80 m above MSL- Markewich and Christopher, 1982b), thought to be middle Holocene, is continuous for approximately 64 km along Uphapee Creek and the Tallapoosa River (Markewich and Christopher, 1982 a). This terrace occasionally floods. All soils evaluated displayed a textural fining upwards sequence. The soils of Uphapee Creek contained more smectite than the terrace soils associated with the Tallapoosa River. The smectite was thought to be derived from source sediments because certain soils formed off of the Cretaceous aged Tuscaloosa group within the Uphapee Creek drainage basin contain some smectite. The Tallapoosa River predominantly drains kaolinitic soils of the Piedmont region, thus, these young Tallapoosa River terrace soils contained minimal smectite. Sediments appeared to be only slightly weathered since deposition, and soils exhibited irregular decreases in organic carbon with depth. No evidence for clay translocation, Fe release, or weathering of feldspar or muscovite was found in any of these soils (Markewich et al. 1988). Lack of weathering was attributed to the young age of the t1 terrace and the associated soil. These authors suggested that increases in clay in the upper portions of the solum of these pedons were due to depositional rather than pedogenic processes. By Soil Taxonomy, these soils would be classified in Fluventic Dystrudept subgroups.

Nash (1980) evaluated terrace soils of the Alabama River system in Wilcox County. Six terraces (A though F going from oldest to youngest) have been recognized along the Alabama River's path between Elmore and Baldwin counties (Szabo, 1972). The separation of fluvial from marine terraces is sometimes problematic, and it was thought some of the higher and older terraces may in fact have been of marine origin. However, Carlson (1950) found little evidence of marine terraces above the Pamlico terrace (8 to 9 m above MSL) in Alabama. No other workers have established marine terraces above the Pamlico in Alabama. Age relationships for the terraces in this region were developed from work by Clarke (1974) and Szabo (1972). Using the slope of basal gravel, uranium-thorium dating, and assumptions about soil development, the oldest terraces (levels A 135 m above MSL, B 120 m, and C 85 m) were thought to be tertiary (Pliocene) aged (Clarke, 1974). The D terrace (67 m) was thought to be early Pleistocene and the E and F terraces were thought to be late Pleistocene (Clarke, 1974).

Nash (1980) found that clay activity increased in soils as terraces went from older to younger. Paleudults were found on the oldest terraces (A-Typic, B-Rhodic, C-Typic, D-Plinthic, E-Rhodic). Hapludults were found on the youngest terrace (F). Nash (1980) concluded that the soils were in equilibrium with their environment, and soils on terraces A-C were similar, while soils on terraces E and F were similar. The soil on terrace D (Plinthic Paleudult) was interpreted to be intermediate in development with respect to the other soils.

Thus, it is apparent that some relationships between fluvial terraces and soil development have been established in our region. However, many questions still exist. The intent of our study is to continue some of the work that has been conducted on the Alabama fluvial terraces. We have concentrated this portion of the study on the Tallapoosa River terraces in Macon county. It is our intent to develop a chronosequence of soil development with the associated terraces in this region, and thus better relate soil development to Quaternary geology and climate.

Materials and Methods

All sites were located at E.V. Smith Research and Extension Center, a unit of the Alabama Agricultural Experiment Station (AAES), near Milstead, Alabama (Fig. 1). This station is 1540 ha (3800 acres) in size, and is located in the Upper Coastal Plain physiographic province just south of the fall line that separates the Piedmont Plateau from unconsolidated fluvio-marine sediments. The Tallapoosa River flows through the northern portion of the station and a series of river terraces extend from it. Sites were selected based on evaluation of elevations and topographical attributes. Five representative pedons were

evaluated in this study.

Pedons were described, sampled, and classified according to standard Soil Survey techniques (Fig. 1 & 2, Tables 1 through 5). Geomorphic position ranged from floodplain to terrace level 3. Bulk samples were air-dried and weighed, and coarse fragments were removed by crushing the samples and dry sieving the soils through a 2- mm sieve. Particle size determination (PSD) was conducted on all pedon samples by the pipette method after organic matter removal (Kilmer and Alexander, 1949). Sand grains were separated into standard size fractions by sieving in nests of sieves. The base cations (Ca, Mg, K, and Na) were extracted with 1M NH_4OAC (pH 7) utilizing an autoextractor (Soil Survey Investigations Staff, 1996) and measured with atomic absorption spectroscopy (AAS). Cation exchange capacity (CEC) was obtained by the 1 M NH_4OAC (pH 7) method (Soil Survey Investigations Staff, 1996). Aluminum was extracted with 1 M KCl using an autoextractor, and was measured by AAS (Soil Survey Investigations Staff, 1996). Effective cation exchange capacity (ECEC) was calculated by summing the extractable bases and KCl Al. Extractable nutrient levels (Ca, Mg, K, P, Fe, Mn, Zn, Cu, B, and Na) were measured in a Mehlich I extract (Hue and Evans, 1986), and soil organic matter (SOM) was measured by dry combustion (LECO CN-2000). Non-crystalline (poorly crystalline and organically bound) Fe and Al forms were extracted with acid ammonium oxalate (Fe_o), and total Fe oxides and organically bound Fe were extracted with dithionite-citrate-bicarbonate (Fe_d) (Jackson et al., 1986). Bulk density was measured by the clod method (Blake and Hartge, 1986).

Whole soil samples were fractionated using standard techniques (Jackson, 1975). Gibbsite and kaolinite were quantified on certain samples using Mg-saturated clay separates and thermogravimetric analyses (TGA) (using theoretical water losses of 14.0% and 31.2 % for kaolinite and gibbsite, respectively).

Clay samples were oriented using the suction method of Drever (1973), and examined by X-ray diffraction (XRD) using these treatments: Mg-saturation/ glycerol solvation @ 25°C, K saturation @ 25°C, 300°C, and 550°C (Whittig and Allardice, 1986). Sand separates were pulverized using a ball mill grinder, and random powder mounts were examined by XRD analysis. All XRD analyses utilized CuK-radiation with scan speeds of 2° 2 min^{-1}.

Oriented clods from all pedons were collected, air-dried, and impregnated with thermal epoxy. Thin sections were made by standard techniques (Murphy, 1986) and were evaluated with a petrographic microscope.

Results

See following pages.

Pedon 1 (P1)

This pedon, classified as a Fluventic Dystrudept, is situated on a floodplain of the Tallapoosa River at an elevation of approximately 195 feet. A relatively recently deposited pedogenically unaltered surface mantle (43 cm thick) exists over a buried cambic horizon. The whole pedon is relatively high in silt (Table 1). The surface mantle and the buried cambic horizon is high in mica (silt and sand fractions), and clay minerals in the Bwb suggest a weathered sediment source (gibbsite and kaolinite are present)(Fig. 3). However, a 1.4 nm peak-mineral exhibited a relatively complete (compared to the more common HIV) collapse upon heating suggesting minor Al polymer filling of the interlayer, and the presence of a low charge vermiculite. Trace amounts of smectite are also present. In addition, the CEC:clay ratio was relatively high in portions of the profile (0.42), although high subsurface organic matter levels undoubtedly contribute to this (Table 1). Hydroxy interlayered vermiculite, common in highly weathered southeastern Piedmont and Coastal Plain systems, often exhibits a more complete interlayer filling of Al polymers that results in decreased activity and an incomplete collapse upon heating. Thus, it is thought some pedogenic alteration of this mineral has occurred since alluvial deposition, with a concomitant increase in activity. Markewich et al. (1988) also suggested some pedogenic alteration of smectite in young soils of Uphapee Creek.

There was no evidence of clay movement in the buried cambic horizon, but significant movement of Fe has occurred (TS 1 and TS 2). Beneath this, a buried argillic horizon existed below a buried surface horizon (starting at 90 cm). Clay films (ferriargillans) were present in thin section in the buried argillic horizon (TS 3 and TS 4). Interestingly, this zone possessed significant smectite, as well as low charge vermiculite, suggesting a different sediment source compared to the overlying material (Fig. 3). These minerals had a slightly more complete collapse upon heating than the 1.4 nm mineral in the Bwb. An increase in the CEC:clay ratio (values ranged from 0.54 to 0.59 - Table 1) also indicated a mineralogical difference. Markewich et al. (1988) found smectite to be present in low terrace soils of Uphapee Creek, but did not find significant smectite on the Tallapoosa drainage. It is thought the smectite in these soils (and the Uphapee soils) is predominantly derived from the southernmost branches of the Uphapee drainage which drains small fingers of the Blackland Prairie region, and ultimately drains into the Tallapoosa. In addition, some residual soils on the Tuscaloosa and Eutaw formations contain some smectite.

The mineralogical differences suggest changes in source areas between alluviation episodes. It is proposed the more recent sediment (the buried cambic) originated predominantly from the Piedmont Plateau due to the relatively weathered mineralogical suite (only minor smectite identified). The reason for the changes in source areas is unknown.

Pedon 1 - E.V. Smith experimental substation- floodplain
Classification: coarse-loamy, paramicaceous, thermic Fluventic Dystrudept
Sample No. : S00AL-087-003(1-9)
Location: Alabama Agricultural Experiment Station EV Smith Substation
Landscape: Floodplain of Tallapoosa River
Slope: 0 to 2 %
Soil moisture regime: Udic
Drainage Class: moderately well drained
Land use: Adjacent to cultivated crop land
Parent Material: Alluvium derived from the Piedmont Upland Physiographic Province and the upper part of the unconsolidated Tuscaloosa Group of the East Gulf Coastal Plain Province
Described by: J.N. Shaw, P.G. Martin, W.E. Puckett

Ap – 0 to 16 cm; brown (10YR 4/3) loam; weak fine and medium granular structure; very friable; many fine, medium, and coarse roots; many fine flakes of mica; slightly acid; clear wavy boundary.

A – 16 to 32 cm; brown (10YR 4/3) loam; weak medium subangular blocky structure; very friable; many fine, medium, and coarse roots; many fine flakes of mica; strongly acid; clear wavy boundary.

C – 32 to 43 cm; brown (7.5YR 4/3) loam; massive; weakly expressed, thin bedding planes; very friable; common fine and medium roots; many fine flakes of mica; strongly acid; clear wavy bounary.

Bwb – 43 to 78 cm; brown (7.5YR 4/4) loam; weak medium subangular bocky structure; friable; common fine, medium, and coarse roots; many fine flakes of mica; strongly acid; clear wavy boundary.

C'– 78 to 90 cm; dark yellowish brown (10YR 4/4) very fine sandy loam; massive; very friable; few fine and medium roots; many fine flakes of mica; strongly acid; clear wavy boundary.

Ab – 90 to 110 cm; dark yellowish brown (10YR 3/4) sandy loam; weak medium subangular blocky structure; few fine and medium roots; many fine flakes of mica; few fine black concretions (iron and manganese oxides); strongly acid; clear wavy boundary.

BAb – 110 to 143 cm; very dark grayish brown (10YR 3/2) loam; moderate medium subangular blocky structure; friable; common fine and medium roots; few faint clay films on faces of peds; many fine flakes of mica; strongly acid; clear wavy boundary.

Btb1 – 143 to 220 cm; brown (10YR 4/3) loam; moderate medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on faces of peds; many fine flakes of mica; few fine distinct light gray (10YR 6/1) iron depletions; strongly acid; clear wavy boundary.

Btb2 – 220 + cm; dark yellowish brown (10YR 4/4) loam; moderate medium subangular blocky structure; friable; few fine roots; few faint clay films on surfaces of peds; many fine flakes of mica.

Table 1. Pedon 1 - S00AL-087-3-(1-9)

SAMPLE NO.	DEPTH (cm)	HORIZON	(----------Total----------) CLAY	SILT	SAND	(CLAY) FINE	(----------SAND----------) (> 2 mm) VF	F	M	C	VC	Whole Soil
			(----------Pct of < 2 mm----------							) Pct		
	0-16	Ap	20.6	35.6	43.8	--	22.3	17.4	3.5	0.4	0.2	1.8
	16-32	A	18.5	38.5	43.0	--	31.5	10.8	0.6	0.1	0.0	0.2
	32-43	C	14.6	40.3	45.1	--	26.5	16.4	2.3	0.0	0.0	0.0
	43-78	Bwb	16.4	44.6	39.0	--	23.7	13.9	1.5	0.0	0.0	0.1
	78-90	C'	7.7	23.8	68.5	--	36.2	30.0	2.3	0.0	0.0	0.0
	90-110	Ab	10.9	30.9	58.3	--	28.1	25.6	4.2	0.3	0.0	0.0
	110-143	BAb	19.5	41.4	39.1	--	25.9	12.5	0.7	0.0	0.0	1.3
	143-220	Btb1	19.3	40.9	39.9	--	22.8	16.0	1.0	0.0	0.0	0.0
	220+	Btb2	21.8	41.1	37.1	--	23.6	11.7	1.7	0.1	0.0	0.0

DEPTH (cm)	ORGN MAT	Ext P	(----DITH-CIT----) Fe	Al	Mn	(----OXALATE----) Fe	Al	Mn	(-BULK DENSITY-) OVEN DRY
	Pct	ppm	(----------Pct of < 2 mm----------					)	(----g/cc—)
0-16	4.65	6.8	1.56	0.17	--	0.35	0.07	--	--
16-32	2.55	2.9	1.96	0.26	--	0.50	0.14	--	--
32-43	2.50	3.5	1.22	0.17	--	0.49	0.11	--	--
43-78	1.95	3.5	2.06	0.24	--	0.44	0.12	--	1.38
78-90	0.65	3.5	0.67	0.10	--	0.17	0.05	--	--
90-110	0.90	3.6	0.69	0.12	--	0.16	0.06	--	--
110-143	1.60	3.2	0.71	0.09	--	0.32	0.09	--	1.41
143-220	1.20	3.6	1.15	0.12	--	0.28	0.09	--	1.53
220+	0.80	4.5	1.41	0.11	--	0.31	0.09	--	--

DEPTH (cm)	(NH_4OAc Extractable Bases) Ca	Mg	Na	K	Ext Al	(----------CEC----------) SUM	NH_4	ECEC	Base Sat NH_4	pH H_2O 1:2	(------Mehlich extractable------) Zn	B	Mo	Pb	Cr
	(----------meq/100 g----------								)		(----------ppm----------				)
0-16	--	--	--	--	--	--	--	--	--	6.35	4.6	1.3	0.1	0.6	0.8
16-32	--	--	--	--	--	--	--	--	--	5.34	1.7	0.4	0.2	0.8	0.4
32-43	--	--	--	--	--	--	--	--	--	5.20	0.8	0.7	0.4	0.9	0.4
43-78	1.06	0.52	0.12	0.08	1.08	--	6.93	2.86	25.7	5.17	1.1	0.4	0.4	0.9	0.3
78-90	--	--	--	--	--	--	--	--	--	5.32	0.4	0.4	0.1	0.3	0.1
90-110	--	--	--	--	--	--	--	--	--	5.35	0.9	0.3	0.1	0.5	0.1
110-143	4.95	2.11	0.15	0.06	0.71	--	11.03	7.99	65.9	5.39	1.3	0.4	0.2	0.6	0.5
143-220	5.30	2.66	0.18	0.05	0.90	--	11.45	9.10	71.6	5.27	1.1	0.4	0.2	0.6	0.5
220+	3.43	2.94	0.15	0.05	1.45	--	11.89	8.02	55.3	5.22	0.8	0.4	0.1	0.5	0.3

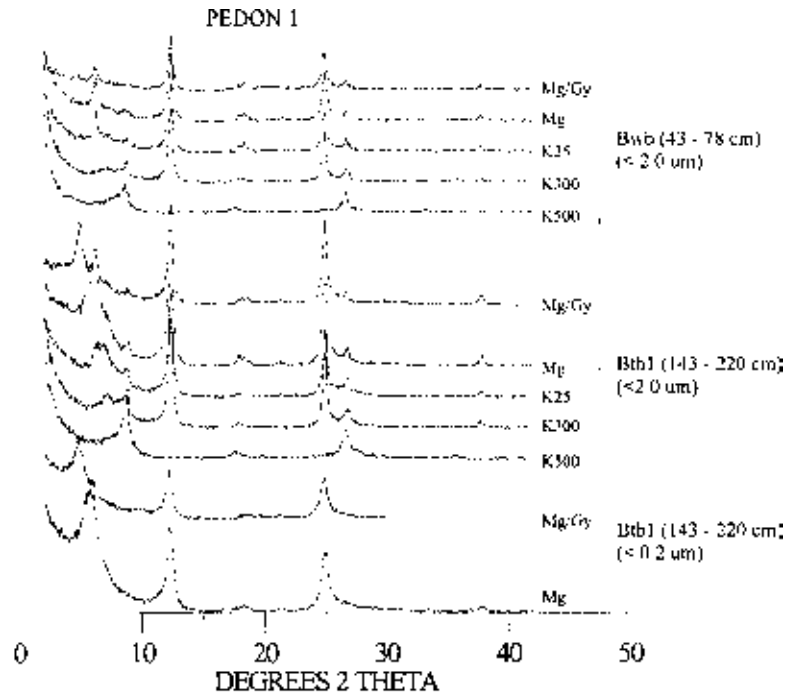

Figure 3. XRD patterns for pedon 1.

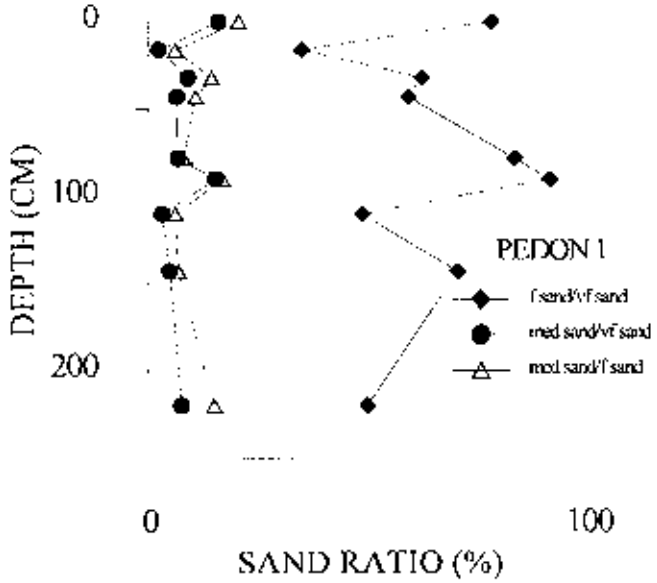

Figure 4. Clay-free sand ratios for pedon 1.

Pedon 2 (P2)

This pedon, located at approximately 202 feet, is a moderately well drained Typic Udifluvent. It is located on the natural levee of an occasionally flooded, floodplain. This level is thought to be the at1 terrace described by Markewich and Christopher (1982b). At this level, Markewich et al. (1988) classified two pedons of the Tallapoosa and two pedons on the Uphapee as Fluventic Dystrudepts. Typical of soils at this level, 61 cm of relatively unaltered alluvium overlays a buried soil.

This pedon is lower in silt than P1, but similar to P1, mica is common throughout the profile (Table 2). Redoximorphic features are common at the base of the recent alluvium, and throughout the buried soils. Base saturation is high, with Ca being the predominant exchangeable cation (Table 2).

Bt horizons existed in the first buried soil (78 to 121 cm), and clay films are common (TS 5 and TS 6), however this zone does not have the clay increase to qualify it is an argillic horizon. Smectite is present in the clay fraction of the Btb1 (78 - 91 cm) and the deeper Btb (138 - 158 cm) horizon (Fig. 5). High CEC:clay ratios also exist in these horizons (Table 2). Small amounts of mica were also present in the clay fraction. Relatively small amounts of the 1.4 nm mineral (compared to the smectite) are found in the buried Bt horizon of P2. Similar to the buried argillic horizon in P1, the expansible minerals exhibited an almost complete collapse upon heating suggesting an incomplete filling of the interlayer with Al polymers. Because of these similarities, it is thought the origin of this alluvium is similar to the second (deeper) buried soil found in P1.

Pedon 2 - E.V. Smith experimental substation- floodplain/ terrace Qa1 or at1
Classification: coarse-loamy, mixed, active, nonacid, thermic Typic Udifluvent
Sample No. : S00AL-087-001(1-9)
Location: Alabama Agricultural Experiment Station; E.V. Smith Substation
Landscape: Floodplain (Natural Levee) of Tallapoosa River
Slope: 0 to 2 %
Soil moisture regime: Udic
Drainage Class: moderately well drained
Land use: Cultivated crop land
Parent Material: Alluvium derived from the Piedmont Upland Physiographic Province and the upper part of the unconsolidated Tuscaloosa Group of the East Gulf Coastal Plain Province
Described by: J.N. Shaw, P.G. Martin, W.E. Puckett

Ap – 0 to 23 cm; brown (10YR 4/3) loamy fine sand; weak fine granular structure; very friable; many fine and medium roots; many fine flakes of mica; clear wavy boundary.

A – 23 to 36 cm; dark yellowish brown (10YR 4/4) loamy fine sand; weak medium subangular blocky structure; very friable; many fine and medium roots; many fine flakes of mica; clearwavy boundary.

C – 36 to 61 cm; brown (10YR 5/3) loamy fine sand; massive; very friable; many fine and medium roots; many fine flakes of mica; few fine faint light yellowish brown (10YR 6/4) masses of iron accumulation; clear smooth boundary.

Ab – 61 to 78 cm; brown (10YR 4/3) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; many fine flakes of mica; few fine faint light brownish gray (2.5Y 6/2) and light yellowish brown (2.5Y 6/3) iron depletions; clear wavy boundary.

Btb1 – 78 to 91 cm; dark yellowish brown (10YR 4/6) fine sandy loam; weak coarse subangular blocks parting to moderate medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on surfaces of peds; many fine flakes of mica; few fine black concretions (iron and manganese oxides); common medium distinct light brownish gray (2.5Y 6/2) iron depletions; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; gradual wavy boundary.

Btb2 – 91 to 121 cm; dark yellowish brown (10YR 4/6) very fine sandy loam; weak coarse subangular blocks parting to moderate medium subangular blocky structure; friable; few fine and medium roots; few faint clay films on surfaces of peds; many fine flakes of mica; few fine black concretions (iron and manganese oxides); common medium distinct light brownish gray (2.5Y 6/2) iron depletions; few fine distinct strong brown (7.5YR 5/8) masses of iron accumulation; clear wavy boundary.

C'– 121 to 138 cm; yellowish brown (10YR 5/6) loamy fine sand/fine sandy loam; massive; very friable; few fine and medium roots; many fine flakes of mica; few fine distinct light brownish gray (2.5Y 6/2) iron depletions; few medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; clear wavy boundary.

B’tb – 138 to 158 cm; dark yellowish brown (10YR 4/6) fine sandy loam; weak medium subangular blocky structure; friable; few fine roots; many fine flakes of mica; common medium distinct light brownish gray (2.5Y 6/2) iron depletions; few fine distinct strong brown (7.5YR 5/8) masses of iron accumulation; clear wavy boundary.

C’’– 158+ cm; dark yellowish brown (10YR 4/6) fine sandy loam; massive; friable; few fine and medium roots; many fine flakes of mica; common medium distinct light gray (10YR 7/2) iron depletions; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation.

Table 2: Pedon 2 - S00AL-087-1-(1-9)

SAMPLE NO	DEPTH (cm)	HORIZON	(----------Total----------) CLAY	SILT	SAND	(CLAY) FINE	(----------SAND----------) VF	F	M	C	VC	(> 2 mm) Whole Soil Pct
			(----------Pct of < 2 mm----------								)	
	0-23	Ap	3.3	15.1	81.6	--	21.7	41.2	17.4	1.4	0.0	0.2
	23-36	A	3.7	15.0	81.4	--	21.3	43.2	15.7	1.1	0.1	0.0
	36-61	C	2.7	14.3	83.0	--	18.6	50.1	13.8	0.4	0.1	0.0
	61-78	Ab	12.2	12.1	75.8	--	16.1	42.4	16.9	0.4	0.0	0.0
	78-91	Btb1	13.3	19.0	67.7	--	26.9	35.5	5.3	0.0	0.0	0.0
	91-121	Btb2	12.9	22.2	64.9	--	30.9	31.1	2.9	0.0	0.0	0.0
	121-138	C'	5.2	19.0	75.8	--	28.6	43.0	4.2	0.0	0.0	0.0
	138-158	B'tb	11.3	22.1	66.6	--	26.0	37.2	3.5	0.0	0.0	0.0
	158+	C"	8.2	15.4	76.4	--	20.7	49.6	6.1	0.0	0.0	0.0

DEPTH (cm)	ORGN MAT Pct	Ext P ppm	(----DITH-CIT----) Fe	Al	Mn	(----OXALATE----) Fe	Al	Mn	(-BULK DENSITY-) OVEN DRY
			(----------Pct of < 2 mm----------						(----g/cc—)
0-23	0.80	25.6	0.22	0.05	--	0.06	0.04	--	--
23-36	0.45	11.2	0.21	0.05	--	0.06	0.03	--	--
36-61	0.20	7.2	0.21	0.04	--	0.06	0.03	--	--
61-78	0.35	19.1	0.78	0.07	--	0.17	0.06	--	--
78-91	0.30	21.3	0.79	0.09	--	0.22	0.06	--	1.68
91-121	0.30	15.8	0.99	0.09	--	0.22	0.07	--	1.62
121-138	0.20	8.1	0.67	0.05	--	0.15	0.04	--	--
138-158	0.20	12.5	1.04	0.08	--	0.22	0.06	--	1.48
158+	0.20	9.3	0.90	0.07	--	0.16	0.04	--	--

DEPTH (cm)	(NH_4OAc Extractable Bases) Ca	Mg	Na	K	Ext Al	SUM	NH_4	(---------CEC----------) ECEC	Base Sat NH_4	pH H_2O 1:2	(------Mehlich extractable------) Zn	B	Mo	Pb	Cr
	(----------meq/100 g----------							)			(----------ppm----------)				
0-23	--	--	--	--	--	--	--	--	--	6.12	1.4	0.2	0.1	0.4	0.1
23-36	--	--	--	--	--	--	--	--	--	5.50	1.1	0.1	0.1	0.4	0.0
36-61	--	--	--	--	--	--	--	--	--	5.38	0.7	0.1	0.0	0.0	0.0
61-78	--	--	--	--	--	--	--	--	--	5.75	0.6	0.2	0.1	0.3	0.1
78-91	2.36	0.89	0.04	0.12	0.11	--	5.72	3.52	59.7	5.77	0.5	0.2	0.1	0.2	0.1
91-121	2.15	0.82	0.04	0.13	0.01	--	5.14	3.14	60.9	5.69	0.3	0.2	0.0	0.1	0.1
121-138	1.39	0.69	0.04	0.05	0.01	--	3.08	2.18	70.6	5.84	0.3	0.2	0.0	0.0	0.0
138-158	2.10	1.18	0.10	0.05	0.11	--	4.92	3.55	69.8	5.78	0.6	0.2	0.0	0.3	0.2
158+	--	--	--	--	--	--	--	--	--	5.86	0.4	0.2	0.0	0.0	0.1

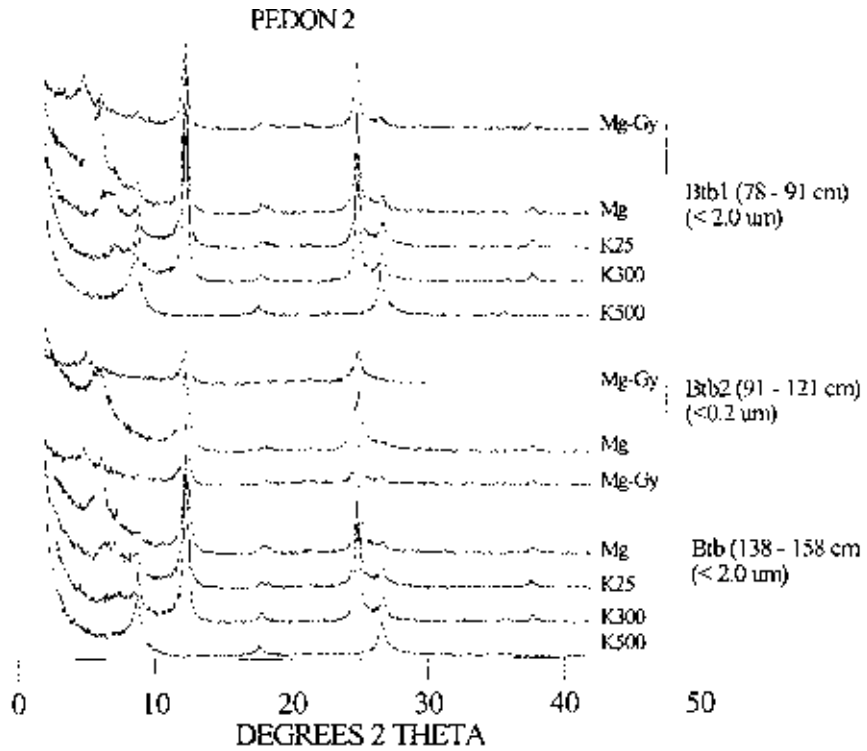

Figure 5. XRD patterns for pedon 2.

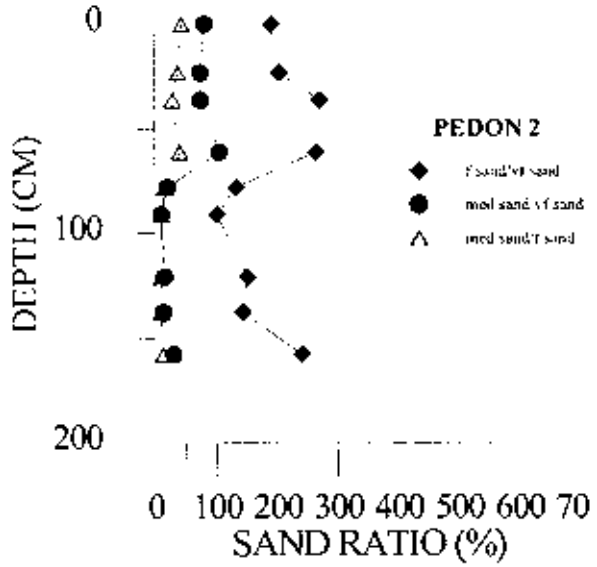

Figure 6. Clay-free sand ratios for pedon 2.

Pedon 3 (P3)

P3 is a moderately well drained Oxyaquic Hapludalf. This pedon is high in silt, and mica is common in the silt and sand fractions. Although located at a similar elevation to P2, this landscape rarely floods, and little evidence of recent alluvium existed. Thus, we interpret this soil to be occupying a low terrace position. Clay films and redox features were abundant in thin section (TS 7, 9, and 10), and this soil exhibited strong pedogenic development.

The base saturation is high (by NH_4OAc method), and it is assumed the pedon will classify as an Alfisol (will run Sum of the Cations) (Table 3). Interestingly, this profile had high exchangeable Mg throughout the solum. Discontinuities as evidenced by sand ratios also existed (Fig. 8). Fragic characteristics were described at a depth of 131 cm (2Btx1 and 2Btx2). Although these horizons do not exhibit properties sufficient to recognize a fragipan (< 60 % fragic characteristics), brittleness, clay films (TS 10), and coarse prisms are evident. It is not uncommon for fluvial terrace soils in this region to exhibit some fragic characteristics, be high in silt, and possess a high base status. However, we have suggested a mid-Holocene age for the major alluviation episodes. These dates seem to be inconsistent with this pedogenic development.

Analyses of the clay fraction of three horizons (Bt1, Bt2, and 2Btx1) indicated little smectite (Fig 7). The 1.4 nm- mineral exhibited a near complete collapse, but not quite as complete as the minerals in P1 and P2. As evidenced by the CEC:clay ratios, P3 possesses a lower activity than P1 or P2. This evidence suggests increased Al polymer infilling in this mineral, and behavior slightly more consistent with HIV.

Pedon 3 - E.V. Smith experimental substation - terrace level 1
Classification: fine-loamy, paramicaceous, thermic Oxyaquic Hapludalf
Sample No. : S00AL-087-002(1-9)
Location: Alabama Agricultural Experiment Station; E.V. Smith Substation
Landscape: Terrace of Tallapoosa River
Slope: 0 to 2 %
Soil moisture regime: Udic
Drainage Class: moderately well drained
Land use: Cultivated crop land
Parent Material: Alluvium derived from the Piedmont Upland Physiographic Province and the upper part of the unconsolidated Tuscaloosa Group of the East Gulf Coastal Plain Province
Described by: J.N. Shaw, P.G. Martin, W.E. Puckett

Ap1 – 0 to 10 cm; dark grayish brown (10YR 4/2) silt loam/loam; weak fine subangular blocky structure; friable; many very fine and fine roots; many fine flakes of mica; few fine black concretions (iron and manganese oxides); clear smooth boundary.

Ap2 – 10 to 19 cm; brown (10YR 4/3) silty clay loam; weak medium subangular blocky structure; friable; few fine and medium roots; common krotovinas of dark brown (10YR 3/3) silt loam; many fine flakes of mica; common fine black concretions (iron and manganese oxides); clear smooth boundary.

Bt1 – 19 to 45 cm; dark yellowish brown (10YR 4/6) silty clay loam; weak coarse prisms parting to moderate medium subangular blocky structure; firm; few fine and medium roots; few distinct yellowish brown (10YR 5/4) clay films on surfaces of peds; many fine flakes of mica; many fine black concretions (iron and manganese oxides); gradual wavy boundary.

Bt2 – 45 to 79 cm; dark yellowish brown (10YR 4/4) clay loam/silt loam/loam; weak coarse prisms parting to moderate medium subangular blocky structure; firm; few fine and medium roots; few distinct yellowish brown (10YR 5/4) clay films on surfaces of peds; many fine black concretions (iron and manganese oxides); common fine distinct pale brown (10YR 6/3) iron depletions; few fine distinct grayish brown (10YR 5/2) iron depletions; clear wavy boundary.

2Bt3 – 79 to 104 cm; dark yellowish brown (10YR 4/6) loam; weak coarse prisms parting to moderate medium subangular blocky structure; firm; distinct yellowish brown (10YR 5/4) clay films on surfaces of peds; many fine flakes of mica; common fine black concretions (iron and manganese oxides); common medium distinct grayish brown (2.5Y 5/2) iron depletions; clear wavy boundary.

2Bt4 – 104 to 131 cm; yellowish brown (10YR 5/6) very fine sandy loam; moderate medium subangular blocky structure; firm; common faint clay films on surfaces of peds; many fine flakes mica; common fine black concretions (iron and manganese oxides); many medium prominent grayish brown (2.5Y 5/2) iron depletions; clear wavy boundary.

2Btx1 –131 to 166 cm; dark yellowish brown (10YR 4/6) fine sandy loam; weak coarse prisms parting to weak medium subangular blocky structure; firm; brittle in 30 % of matrix; common faint clay films on faces of peds; many fine flakes of mica; many medium gray (2.5Y 5/1) iron depletions on faces of prisms; common fine yellowish brown (10YR 5/8) masses of iron accumulation; many fine black concretions (iron and manganese oxides); gradual wavy boundary.

2Btx2 – 166 to 195 cm; dark yellowish brown (10YR 4/6) sandy loam; moderate coarse prisms parting to weak medium subangular blocky structure; brittle in 30 % of matrix; distinct dark yellowish brown (10YR 4/4) clay films on faces of peds; many medium prominent olive gray (5Y 5/2) iron depletions; common medium distinct strong brown (7.5YR 5/8) masses of iron accumulation; clear wavy boundary.

3C – 195 + cm; dark yellowish brown (10YR 4/6) loamy sand/sand; massive; very friable; many fine flakes of mica;

Table 3: Pedon 3 - S00AL-087-2-(1-9)

SAMPLE NO.	DEPTH (cm)	HORIZON	(----------Total----------) CLAY	SILT	SAND	(CLAY) FINE	(----------SAND----------) VF	F	M	C	VC	(> 2 mm) Whole Soil
			(----------Pct of < 2 mm----------								)	Pct
	0-10	Ap1	14.9	48.9	36.3	--	16.2	9.5	7.8	2.0	0.8	0.6
	10-19	Ap2	30.2	50.8	18.9	--	10.5	4.7	3.0	0.4	0.3	0.0
	19-45	Bt1	35.5	48.8	15.7	--	10.6	3.0	1.9	0.2	0.0	0.0
	45-79	Bt2	27.9	47.6	24.5	--	20.9	3.3	0.3	0.0	0.0	0.0
	79-104	2Bt3	21.4	37.2	41.5	--	29.4	11.4	0.5	0.2	0.0	0.0
	104-131	2Bt4	15.6	27.5	56.9	--	30.5	25.4	1.0	0.0	0.0	0.0
	131-166	2Btx1	15.8	27.0	57.2	--	23.3	32.0	1.9	0.0	0.0	0.0
	166-195	2Btx2	16.1	27.3	56.7	--	19.2	25.4	11.7	0.4	0.0	0.0
	195+	3C	4.7	7.5	87.7	--	6.7	32.3	47.3	1.4	0.0	0.0

DEPTH (cm)	ORGN MAT	Ext P	(----DITH-CIT----) Fe	Al	Mn	(----OXALATE----) Fe	Al	Mn	(-BULK DENSITY-) OVEN DRY
	Pct	ppm	(----------Pct of < 2 mm----------					)	(-----g/cc—)
0-10	3.35	5.2	0.95	0.19	--	0.29	0.09	--	--
10-19	1.00	3.8	1.34	0.15	--	0.25	0.08	--	--
19-45	0.50	4.6	1.49	0.14	--	0.34	0.13	--	1.69
45-79	0.30	7.6	1.74	0.13	--	0.34	0.11	--	1.66
79-104	0.25	9.9	1.27	0.14	--	0.32	0.12	--	1.64
104-131	0.20	9.6	1.31	0.13	--	0.28	0.12	--	1.61
131-166	0.20	9.2	1.22	0.11	--	0.27	0.10	--	1.69
166-195	0.20	8.6	1.27	0.10	--	0.19	0.10	--	--
195+	0.15	9.4	0.56	0.05	--	0.10	0.01	--	--

DEPTH (cm)	(NH_4OAc Extractable Bases) Ca	Mg	Na	K	Ext Al	(----------CEC----------) SUM	NH_4	ECEC	Base Sat NH_4	pH H_2O 1:2	(------Mehlich extractable------) Zn	B	Mo	Pb	Cr
	(----------meq/100 g----------								)		(----------ppm----------				)
0-10	--	--	--	--	--	--	--	--	--	5.58	1.8	0.5	0.2	0.6	0.3
10-19	--	--	--	--	--	--	--	--	--	5.36	0.4	0.3	0.1	0.5	0.3
19-45	0.99	2.05	0.17	0.06	1.91	--	12.40	5.18	26.4	5.13	0.5	0.3	0.2	0.6	0.4
45-79	0.55	2.49	0.23	0.05	1.71	--	10.04	5.02	33.0	5.26	0.9	0.3	0.1	0.7	0.5
79-104	0.40	2.53	0.49	0.05	2.52	--	8.90	6.00	39.1	5.39	0.8	0.3	0.2	0.6	0.4
104-131	0.32	2.07	0.24	0.04	1.70	--	6.05	4.37	44.2	5.55	0.7	0.3	0.1	0.5	0.3
131-166	0.20	2.99	0.27	0.04	1.92	--	5.70	5.43	61.7	5.51	1.8	0.3	0.2	0.7	0.4
166-195	--	--	--	--	--	--	--	--	--	5.71	2.7	0.4	0.2	0.8	0.5
195+	--	--	--	--	--	--	--	--	--	6.25	1.3	0.2	0.1	0.4	0.1

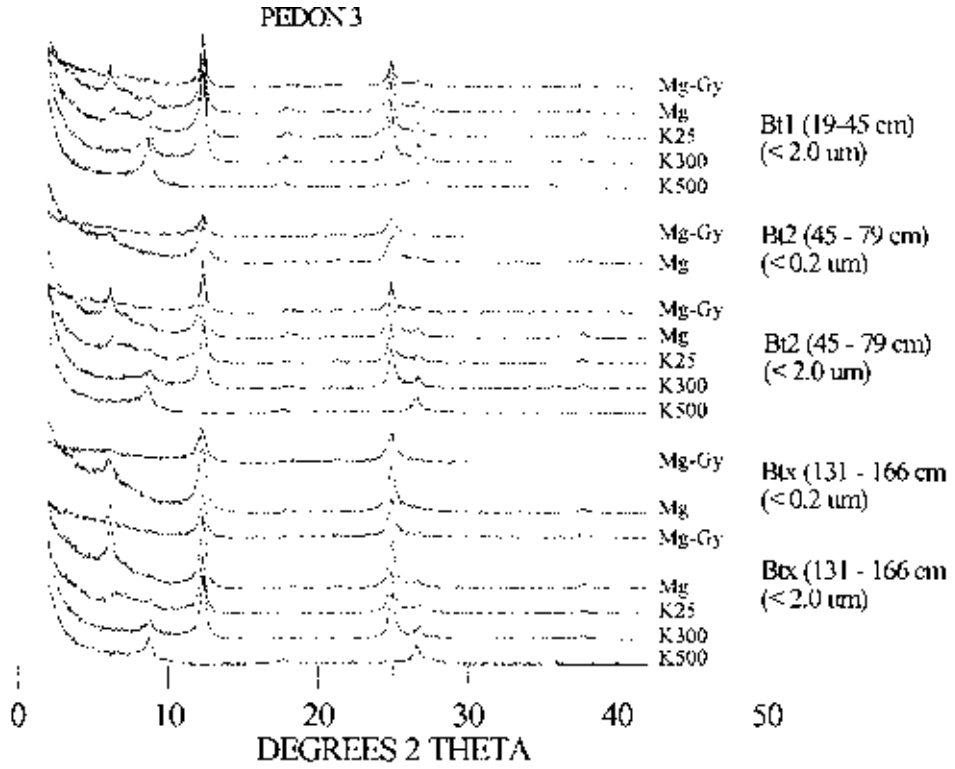

Figure 7. XRD patterns for pedon 3.

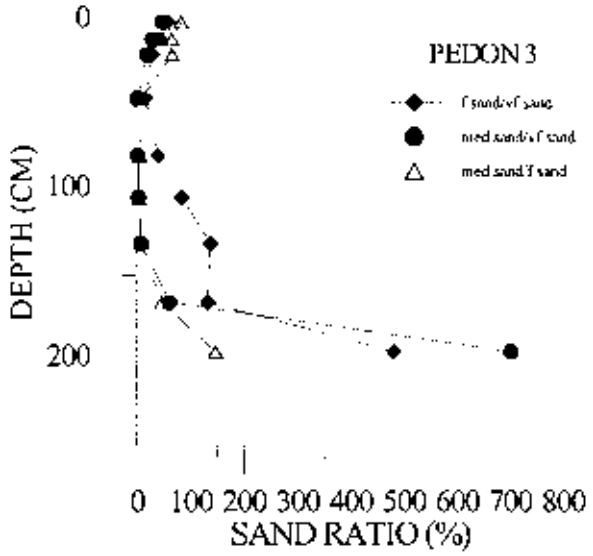

Figure 8. Clay-free sand ratios for pedon 3.

Pedon 4 (P4)

P4 is a well drained Typic Hapludult with gravel located at 105 cm (Table 4). It is located at an approximate elevation of 206 ft. near the base of a scarp that is almost perpendicular with the present day channel. Thus, it is situated on a slightly higher terrace than P3, and will be designated terrace level 2.

This pedon possessed some clay films (TS 11), but they were not abundant in thin section. In addition, the structure was not strongly expressed. We attribute some of this to the relatively coarse texture of the material. However, a general overall reddening and relatively low Fe_o/Fe_d ratio suggests substantial pedogenic development at this level.

Clay minerals of P4 exhibited a lower activity than P1-P3, and the profile classified in a subactive CEC activity class. Overall, reduced quantities of the 1.4 nm mineral were found (Fig. 9). This pedon had a mineralogical signature more characteristic of a highly weathered system.

Pedon 4 - E.V. Smith experimental substation- terrace level 2
Classification: fine-loamy, siliceous, subactive, thermic Typic Hapludult
Sample No. : S00AL-087-004(1-6)
Location: Alabama Agricultural Experiment Station; E.V. Smith Substation
Landscape: Terrace of Tallapoosa River
Slope: 0 to 2 %
Soil moisture regime: Udic
Drainage Class: well drained
Land use: Pecan orchard
Parent Material: Alluvium derived from the Piedmont Upland Physiographic Province and the upper part of the unconsolidated Tuscaloosa Group of the East Gulf Coastal Plain Province
Described by: J.N. Shaw, P.G. Martin, W.E. Puckett

Ap1 – 0 to 9 cm; dark yellowish brown (10YR 4/4) gravelly sandy loam; weak fine granular structure; friable; many fine roots; 15 % quartzite pebbles; abrupt smooth boundary.

Ap2 – 9 to 24 cm; yellowish red (5YR 4/6) sandy loam/sandy clay loam; weak medium subangular blocky structure; firm; common fine and medium roots; < 5 % quartzite pebbles; abrupt smooth boundary.

Bt1 – 24 to 41 cm; yellowish red (5YR 4/6) sandy clay loam; moderate medium subangular blocky structure; firm; common fine and medium roots; few faint clay films on surfaces of peds; < 5 % quartzite pebbles; gradual wavy boundary.

Bt2 – 41 to 67 cm; yellowish red (5YR 5/6) sandy clay loam; moderate medium subangular blocky structure; firm; common fine and medium roots; few faint clay films on surfaces of peds; < 5 % quartzite pebbles; gradual wavy boundary.

Bt3 – 67 to 105 cm; yellowish red (5YR 5/6) sandy clay loam; moderate medium subangular blocky structure; firm; few fine roots; few faint clay films on surfaces of peds; < 5 % quartzite pebbles; abrupt wavy boundary.

2C – 105 to 200+ cm; yellowish red (5YR 5/8) extremely gravelly coarse sand; single grain; few fine roots; 70 % quartzite pebbles.

Table 4: Pedon 4 - S00AL-087-4-(1-6)

			(----------Total----------)			(CLAY)	(----------SAND----------)					(> 2 mm)
SAMPLE	DEPTH	HORIZON	CLAY	SILT	SAND	FINE	VF	F	M	C	VC	Whole Soil
NO.	(cm)		(----------Pct of < 2 mm----------)									Pct
	0-9	Ap1	15.1	20.6	64.4	--	8.3	16.4	26.0	11.4	2.2	15.9
	9-24	Ap2	20.5	20.7	58.8	--	8.7	17.1	23.3	8.7	1.1	3.7
	24-41	Bt1	33.6	18.6	47.8	--	5.8	14.2	20.2	6.5	1.3	4.4
	41-67	Bt2	30.6	17.9	51.6	--	5.4	17.0	22.6	6.2	0.4	0.9
	67-105	Bt3	24.0	14.9	61.1	--	6.5	18.1	27.5	7.9	1.1	0.0
	105-200	2C	5.4	1.1	93.5	--	0.5	2.9	22.4	51.1	16.6	68.1

DEPTH	ORGN	Ext	(----DITH-CIT----)			(----OXALATE----)			(-BULK DENSITY-)
(cm)	MAT	P	Fe	Al	Mn	Fe	Al	Mn	OVEN DRY
	Pct	ppm	(----------Pct of < 2 mm----------)					(-----g/cc—)	
0-9	3.25	9.3	0.85	0.13	--	0.09	0.07	--	--
9-24	0.95	15.4	1.14	0.13	--	0.11	0.10	--	--
24-41	0.65	6.4	1.77	0.22	--	0.12	0.13	--	--
41-67	0.45	5.5	1.65	0.25	--	0.15	0.13	--	1.70
67-105	0.30	7.6	1.45	0.18	--	0.14	0.13	--	1.82
105-200	0.10	7.7	0.55	0.08	--	0.05	0.09	--	--

	(NH_4OAc Extractable Bases)				Ext	(----------CEC----------)			Base	pH	(-----Mehlich extractable-----)				
DEPTH	Ca	Mg	Na	K	Al	SUM	NH_4	ECEC	Sat	H_2O	Zn	B	Mo	Pb	Cr
(cm)	(----------meq/100 g----------)								NH_4	1:2	(----------ppm----------)				
0-9	--	--	--	--	--	--	--	--	--	5.46	1.8	0.4	0.1	0.5	0.1
9-24	--	--	--	--	--	--	--	--	--	5.53	0.2	0.3	0.1	0.4	0.0
24-41	1.94	1.48	0.10	0.16	0.71	--	7.44	4.39	49.5	5.63	0.4	0.4	0.1	0.5	0.1
41-67	1.21	0.48	0.11	0.11	1.26	--	7.03	3.18	27.3	5.17	0.5	0.3	0.1	0.5	0.0
67-105	0.95	0.36	0.06	0.10	1.44	--	4.74	2.91	31.1	5.05	0.8	0.2	0.1	0.8	0.0
105-200	--	--	--	--	--	--	--	--	--	5.15	0.6	0.1	0.0	0.0	0.0

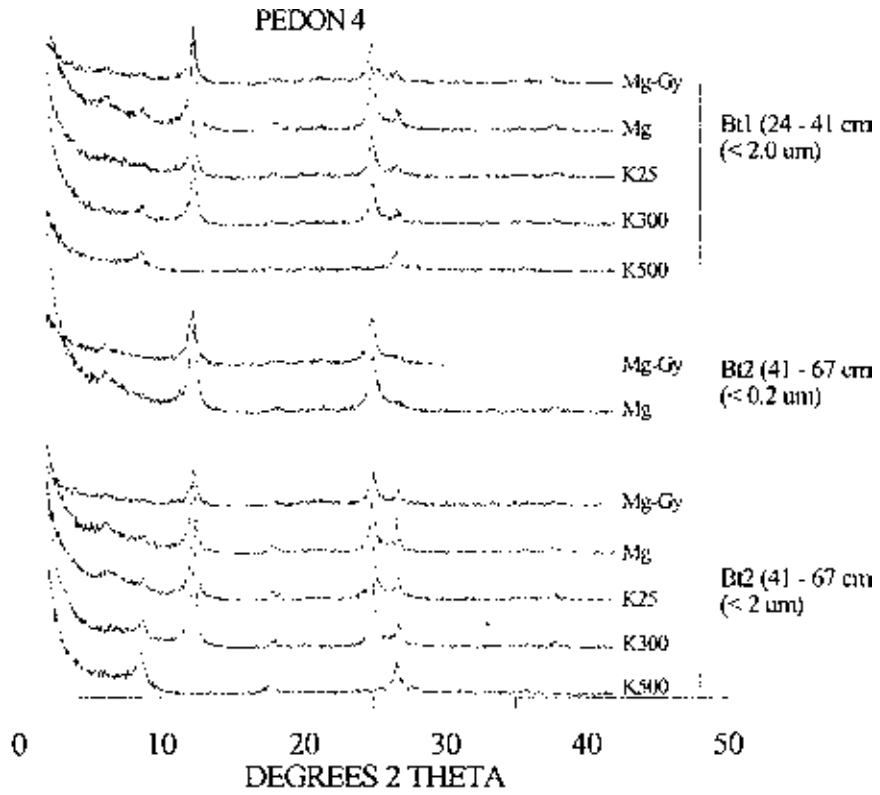

Figure 9. XRD patterns for pedon 4.

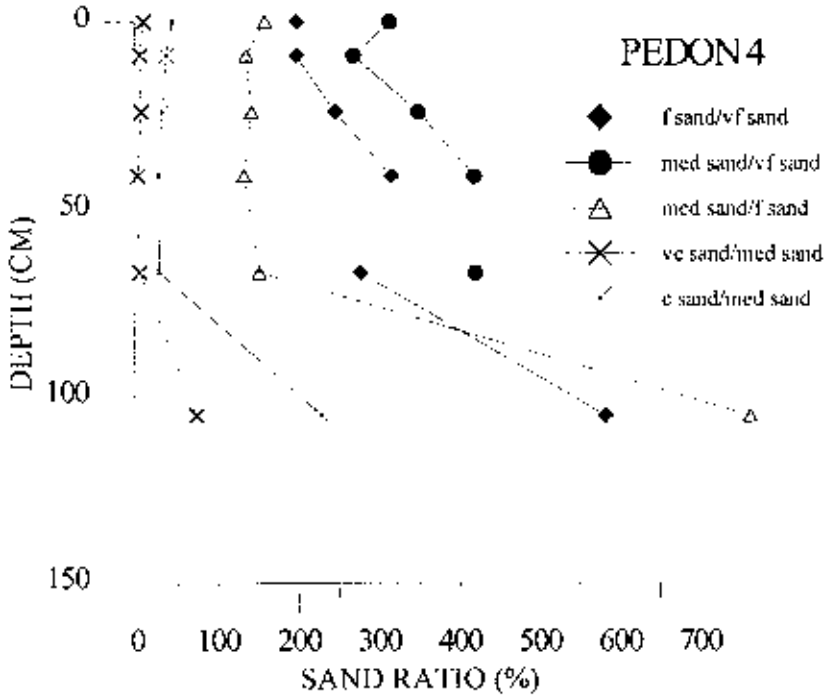

Figure 10. Sand ratios for pedon 4.

Pedon 5 (P5)

P5 is a moderately well drained, coarse-loamy, Typic Hapludult, although it was very close to Pale-. This pedon is bisequal, and the Pale- concept fits better here. Although it's geomorphic association to the fluvial terraces is unclear (it is located at a relatively high elevation- 234 ft), the surrounding landscape suggests it is located on a high fluvial terrace. This landscape shares many of the same characteristics of the at3 terrace mapped by Markewich and Christopher (1982a). Common plinthite, clay films (TS 12), and fragic characteristics in the lower portion of the solum suggest appreciable pedogenic development. A discontinuity is also described.

The 1.4 nm mineral found in the solum of this pedon did not completely collapse upon heating, and would be characterized as the HIV common for this region. Kaolinite and gibbsite were also present, however the profile did not possess a kandic horizon, and possessed a semiactive CEC activity class. The pH's in the upper portion of the solum were very high, suggesting some anthropogenic influence on this heavily cultivated site. The high pH's are most likely partially responsible for the higher than usual clay activity. It is also suggested the drainage class may prevent development of sufficiently low activity for kandic requirements.

Pedon 5 - E.V. Smith experimental substation- terrace level 3+
Classification: coarse-loamy, siliceous, semiactive, thermic Typic Hapludult (Paleudult)
Sample No. : S00AL-087-005(1-11)
Location: Alabama Agricultural Experiment Station; E.V. Smith Substation
Landscape: Terrace of Tallapoosa River
Slope: 0 to 2 %
Soil moisture regime: Udic
Drainage Class: moderately well drained
Land use: Cultivated crop land
Parent Material: Alluvium derived from the Piedmont Upland Physiographic Province and the upper part of the unconsolidated Tuscaloosa Group of the East Gulf Coastal Plain Province
Described by: J.N. Shaw, P.G. Martin, W.E. Puckett

Ap1 – 0 to 7 cm; brown (10YR 4/3) loamy sand; weak medium granular structure; very friable; many very fine and fine roots; abrupt smooth boundary.

Ap2 – 7 to 30 cm; dark yellowish brown (10YR 4/4) loamy sand; weak coarse, subangular blocky structure; very friable; many very fine and fine roots; few thin strands of uncoated sand; abrupt smooth boundary.

BE – 30 to 44 cm; olive brown (2.5Y 4/4) sandy loam; weak coarse subangular blocky structure; very friable; few very fine roots; few thin strands of uncoated sand; 2 % quartzite pebbles; clear smooth boundary.

Bt – 44 to 62 cm; dark yellowish brown (10YR 4/6) sandy loam; weak medium subangular blocky structure; friable; sand grains coated and bridged with clay; 2 % quartzite pebbles; few fine and medium distinct pale brown (10YR 6/3) iron depletions; few medium prominent dark red (2.5YR 4/6) masses of iron accumulation; clear wavy boundary.

Btv – 62 to 82 cm; light olive brown (2.5Y 5/6) sandy loam; weak medium subangular blocky structure; friable; sand grains coated and bridged with clay; few thin streaks of uncoated sand; 2 % plinthite nodules; 2 % quartzite pebbles; few fine distinct pale brown (10YR 6/3) iron depletions; common medium distinct strong brown (7.5YR 4/6) masses of iron accumulation; clear wavy boundary.

B/E – 82 to 94 cm; 60 percent yellowish brown (10YR 5/4) sandy loam (B); weak medium subangular blocky structure; friable; few faint clay films on surfaces of peds; 40 percent very pale brown (10YR 8/2) loamy sand (E); massive; very friable; 2 % plinthite nodules; 5 % quartzite pebbles; clear wavy boundary.

Btvx1 – 94 to 114 cm; yellowish brown (10YR 5/4) sandy loam; moderate very coarse prisms parting to weak coarse subangular blocky structure; firm; brittle in 30 % of matrix; common faint clay films on surfaces of peds; common thin streaks of uncoated sand; 2% plinthite nodules; 5% quartzite pebbles; common fine and medium distinct light gray (10YR 7/2) iron depletions; common fine and medium distinct dark yellowish brown (10YR 4/6) masses of iron accumulation; clear wavy boundary.

Btvx2 – 114 to 175 cm; yellowish brown (10YR 5/4) sandy loam; moderate very coarse prisms parting to moderate medium subangular blocky structure; firm; brittle in 30 % of matrix; common faint clay films on surfaces of peds; 2% plinthite nodules; 5% quartzite pebbles; many medium and coarse distinct light gray (10YR 7/1) iron depletions; many medium and coarse distinct strong brown (7.5YR 4/6) masses of iron accumulation; common fine and medium prominent dark red (2.5YR 4/6) masses of iron accumulation oriented vertically on surfaces of peds; clear wavy boundary.

Btvx3 – 175 to 193 cm; 35 percent strong brown (7.5YR 5/6), 35 percent light gray (10YR 7/1), and 30 percent yellowish red (5YR 4/6) sandy clay loam; weak coarse prisms parting to weak medium subangular blocky structure; firm; brittle in 30 % of matrix; common fine and medium distinct dark red (2.5YR 4/6) masses of iron accumulation; few distinct clay films on surfaces of peds; few very fine flakes of mica; 2 % plinthite nodules; 5% quartzite pebbles; areas of strong brown and yellowish red are masses of iron accumulation; areas of light gray are iron depletions; clear wavy boundary.
Btvx4 – 193 to 297 cm; 35 percent strong brown (7.5YR 5/6), 35 percent light gray (10YR 7/1), and 30 percent yellowish red (5YR 4/6) sandy clay loam; weak coarse prismatic structure; firm; few distinct clay films on surfaces of peds; few very fine flakes of mica; 2% plinthite nodules; 5% quartzite pebbles; areas of strong brown and yellowish red are masses of iron accumulation; common medium prominent dark red (2.5YR 4/6) masses of iron accumulation; areas of light gray are iron depletions; clear wavy boundary.

2C – 297+ cm; light gray (10YR 7/1) clay; massive; firm; few very fine flakes of mica; many fine and medium prominent dark red (2.5YR 4/6) masses of iron accumulation; many fine and medium distinct yellowish brown (10YR 5/6) masses of iron accumulation.

Table 5: Pedon 5 - S00AL-087-5-(1-11)

			(----------Total----------)			(CLAY)	(----------SAND----------)					(> 2 mm)
	DEPTH	HORIZON	CLAY	SILT	SAND	FINE	VF	F	M	C	VC	Whole Soil
NO.	(cm)		(----------Pct of < 2 mm----------)									Pct
	0-7	Ap1	3.1	14.1	82.8	--	10.1	17.4	26.9	21.0	7.5	1.8
	7-30	Ap2	1.4	16.4	82.1	--	10.5	17.5	26.2	20.9	7.0	2.8
	30-44	BE	9.0	18.5	72.5	--	8.8	15.3	23.3	18.8	6.3	1.2
	44-62	Bt	13.2	17.4	69.4	--	8.6	15.6	21.1	17.0	7.1	3.8
	62-82	Btv	8.9	16.5	74.6	--	10.2	16.7	23.9	18.1	5.7	2.6
	82-94	B/E	7.2	17.5	75.4	--	11.9	18.4	23.5	16.4	5.2	2.6
	94-114	Btvx1	9.7	16.4	74.0	--	9.3	15.7	24.0	18.7	6.2	0.9
	114-175	Btvx2	12.9	14.2	72.9	--	7.5	15.4	22.9	18.9	8.2	2.1
	175-193	Btvx3	21.4	8.8	69.8	--	4.2	11.4	25.7	21.4	7.1	2.1
	193-297	BC	26.5	5.6	67.9	--	3.6	11.6	25.1	21.6	6.1	0.0
	297+	2C	51.4	25.2	23.3	--	10.8	7.2	2.8	2.1	0.5	0.0

DEPTH	ORGN	Ext	(----DITH-CIT----)			(----OXALATE----)			(-BULK DENSITY-)
(cm)	MAT	P	Fe	Al	Mn	Fe	Al	Mn	OVEN DRY
	Pct	ppm	(----------Pct of < 2 mm----------)						(-----g/cc—)
0-7	1.25	14.6	0.14	0.07	--	0.02	0.04	--	--
7-30	0.50	26.6	0.14	0.07	--	0.02	0.04	--	--
30-44	0.20	4.1	0.34	0.11	--	0.02	0.05	--	--
44-62	0.25	4.6	0.66	0.18	--	0.05	0.06	--	1.79
62-82	0.20	3.4	0.35	0.16	--	0.05	0.04	--	1.77
82-94	0.10	2.8	0.25	0.10	--	0.04	0.04	--	--
94-114	0.10	1.9	0.34	0.09	--	0.04	0.04	--	1.89
114-175	0.10	0.8	0.35	0.10	--	0.02	0.04	--	1.89
175-193	0.20	1.2	0.33	0.10	--	0.02	0.05	--	--
193-297	0.15	1.1	0.39	0.10	--	0.01	0.06	--	--
297+	0.20	1.9	0.53	0.12	--	0.01	0.11	--	--

	(NH_4OAc Extractable Bases)				Ext	(----------CEC----------)			Base	pH	(----------Mehlich extractable----------)				
DEPTH	Ca	Mg	Na	K	Al	SUM	NH_4	ECEC	Sat	H_2O	Zn	B	Mo	Pb	Cr
	(cm)	(----------meq/100 g----------)							NH_4	1:2	(----------ppm----------)				
0-7	--	--	--	--	--	--	--	--	--	5.72	1.0	0.2	0.1	0.3	0.0
7-30	--	--	--	--	--	--	--	--	--	6.11	0.4	0.2	0.0	0.6	0.0
30-44	0.92	0.82	0.04	0.12	0.11	--	2.81	2.02	67.8	6.43	0.6	0.3	0.1	0.6	0.0
44-62	1.26	1.40	0.12	0.19	0.19	--	3.17	3.16	93.8	6.35	0.4	0.3	0.1	0.4	0.0
62-82	0.63	0.57	0.06	0.10	0.26	--	2.30	1.62	59.3	6.40	0.5	0.2	0.1	0.6	0.0
82-94	--	--	--	--	--	--	--	--	--	5.15	0.8	0.1	0.1	0.5	0.0
94-114	0.19	0.18	0.02	0.06	1.94	--	2.02	2.39	22.2	4.77	0.4	0.1	0.1	0.7	0.0
114-175	0.26	0.20	0.08	0.07	--	--	2.57	--	23.6	4.76	0.4	0.2	0.1	0.8	0.0
175-193	0.21	0.14	0.07	0.06	1.56	--	3.84	2.04	12.5	4.49	0.4	0.3	0.1	0.9	0.0
193-297	--	--	--	--	--	--	--	--	--	4.56	0.4	0.3	0.2	1.2	0.0
297+	--	--	--	--	--	--	--	--	--	4.37	0.6	0.3	0.3	1.7	0.0

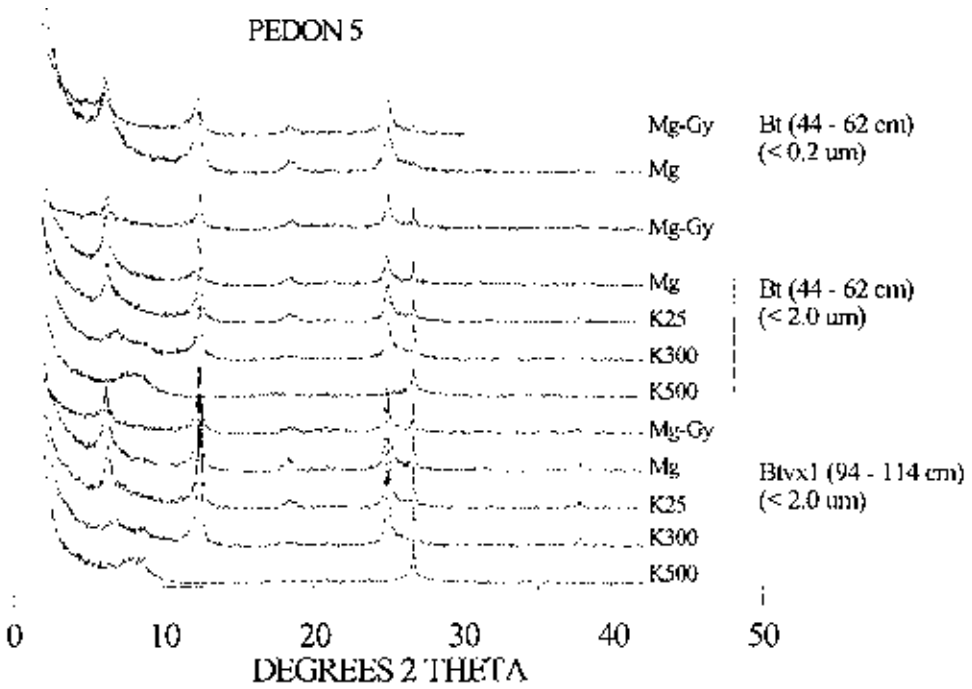

Figure 11. XRD patterns for pedon 5.

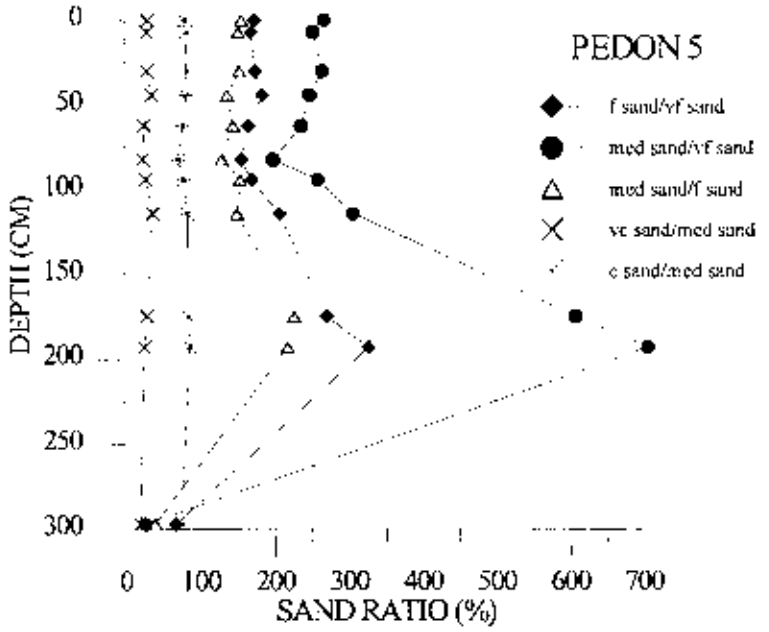

Figure 12. Sand ratios for pedon 5.

Discussion

Age relationships

P1 and P2 are located on floodplain positions. The P2 position, labeled as the Qa1 (Markewich and Christopher, 1982b) or at1 (Markewich and Christopher, 1982a) low terrace in past publications, is of middle Holocene age. Using ^{14}C dating, Markewich et al. (1988) reported a date for this position on the Tallapoosa drainage (west of E.V. Smith) of approximately 5,500 yr B.P. On Uphapee Creek, Markewich et al. (1988) estimated the most extensive alluvial deposition at this level was approximately 6,500 yr B.P. Because the at1 is relatively continuous along the Uphapee and Tallapoosa, we feel this is a reasonable date for this level. The relatively unaltered sediments deposited on the surface of P1 and P2 are interpreted to be more recent, and archeological evidence collected downstream of this site suggests this recent alluvium has been deposited mostly within the last 1000 years.

Topographical evidence suggests the more developed P3 with no recent sediment addition is on the same mid-Holocene level as P2. Although P3 had more silt than the buried soil beneath the recent sediments in P2, landscape attributes indicate these soils are similar in age. Both P3 and the buried profile in P2 had well expressed clay films and structure, and P3 displayed some fragic character. Because of these properties, it is suggested these soils are in fact older than mid-Holocene aged. However, until we find something to date, this is open to discussion.

The P4 pedon is thought to be late Pleistocene in age. This is evidenced by the reddening of the profile, the low Fe ratio numbers, and other general relationships inferred by the position (a higher terrace) and soil development.

Similar to P4, the estimated age of P5 is strictly conjecture. This position is similar to the Qua3 position of Markewich and Christopher (1982a), which these authors (using soil properties) suggested to be mid- to early Pleistocene in age. Using the same rationale, we are estimating a similar age for this terrace.

Chronosequence

As discussed above in the mineralogical section, it was evident that a decrease in clay activity (averaged for measured B horizons) was related to the age of the terrace (Fig. 13). Although some of this is related to the alluvium source, the higher terraces have mineralogical suites more characteristic of the highly weathered systems found in surrounding Upper Coastal Plain systems. In addition, the degree of Al infilling of the interlayers in the low charge vermiculitic mineral showed a systematic increase with terrace age.

Interestingly, Mehlich extractable Ca in B horizons (including buried B horizons) tended to decrease with age (Fig. 14, r= -0.71). Although this could be related to increased liming of the low terraces, it is more probable this is related to soil development and leaching of Ca with replacement by Al and K. Although, no significant correlation between KCl Al and terrace level was found, a significant relationship (r=0.38, p=0.07) existed between terrace level and NH_4OAc extractable K for measured horizons (mostly B's). This

could be due to increased mica weathering at the higher levels and K release causing subsequently higher extractable K levels.

Using a more conventional pedological evaluation, extremely good correlation was found between the Fe_o/Fe_d ratio and terrace level for both B horizons (r=-0.81, Fig. 15) and when all horizons are evaluated (r=-0.81). Similar to other studies, this ratio appears to be a good indicator of soil development and/or geomorphic surface age.

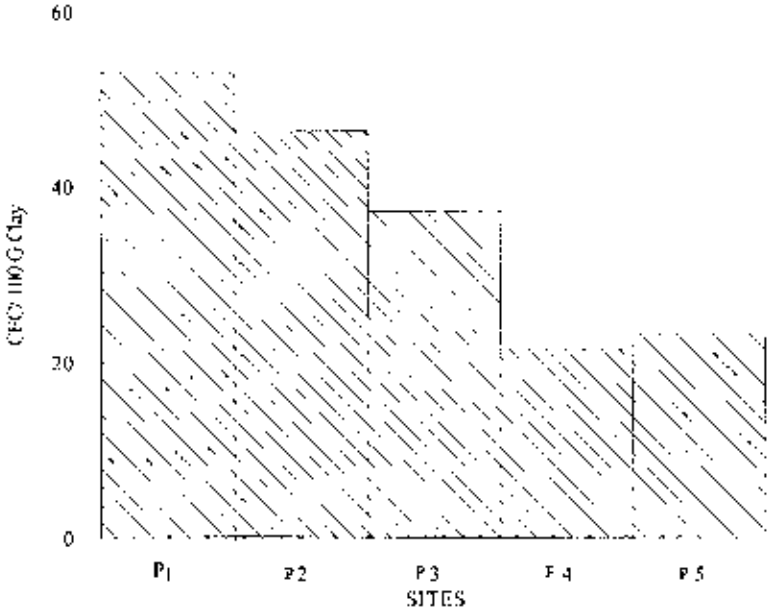

Figure 13. CEC: clay ratios averaged for measured horizons (mainly B's) for the 5 sites

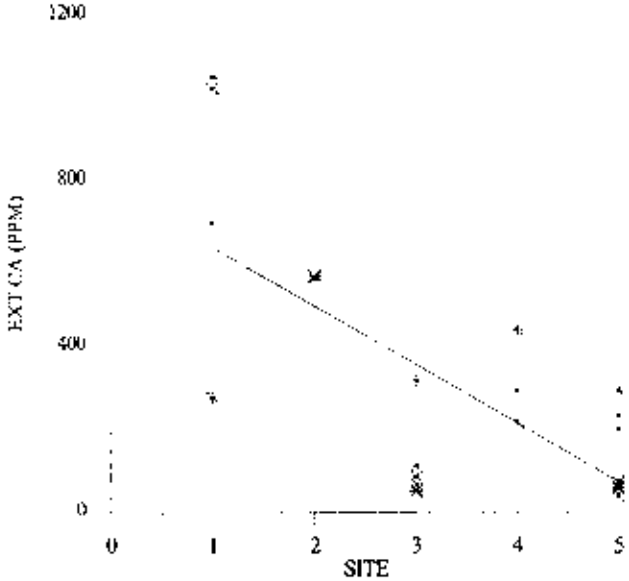

Figure 14. Mehlich ext Ca for B horizons of the 5 sites.

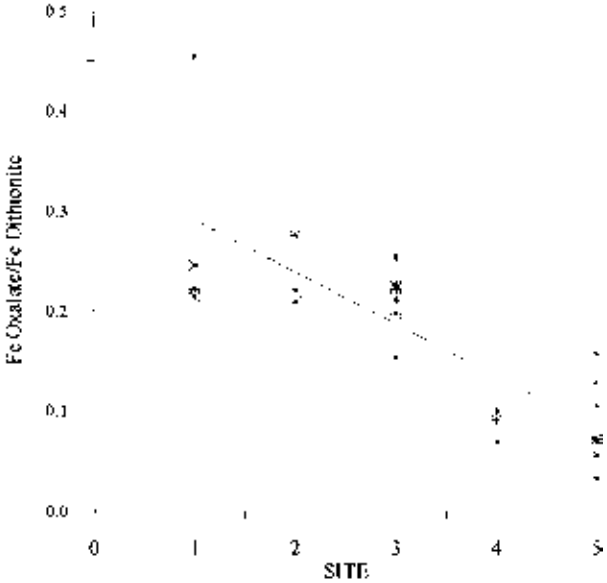

Figure 15. Fe_o/Fe_d ratio for B horizons of the 5 sites.

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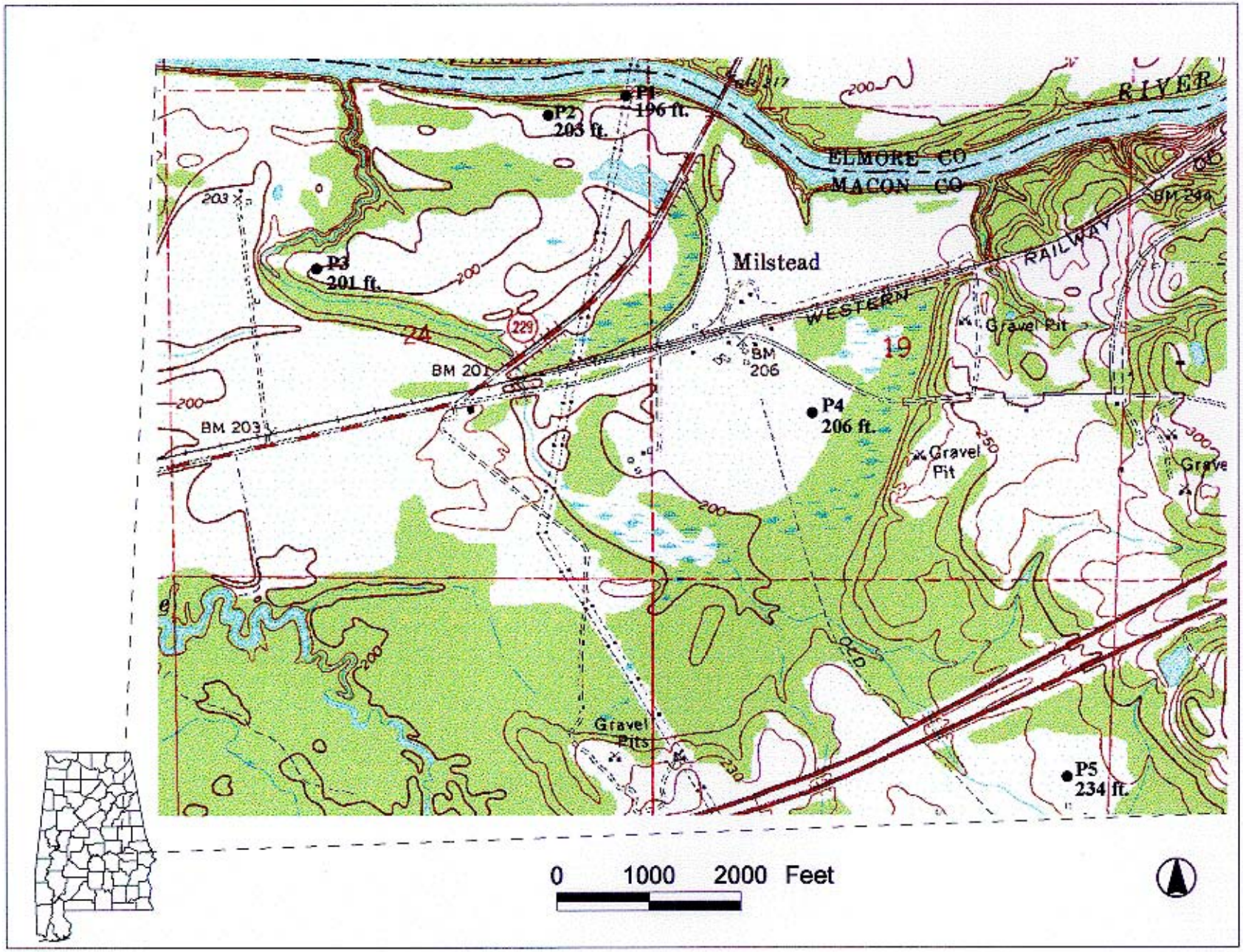
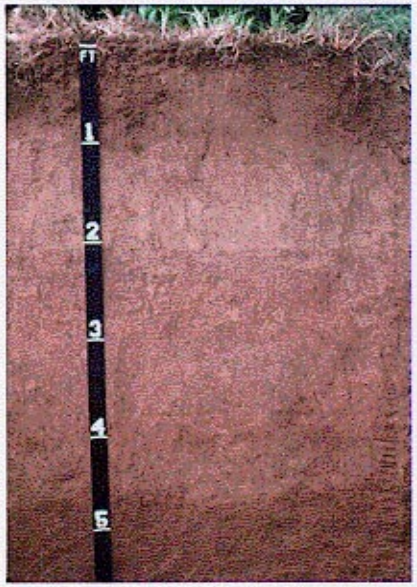
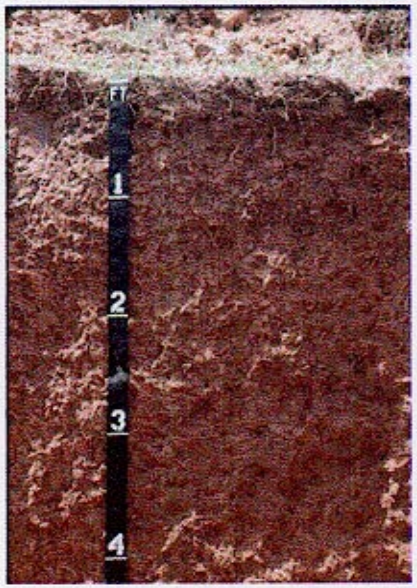
Figure 1. Locations of pedons



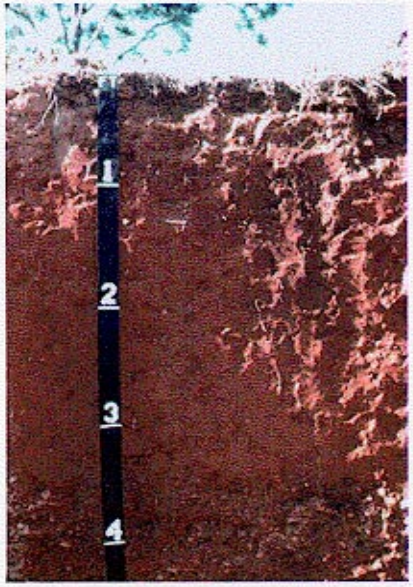
Pedon 1



Pedon 2



Pedon 3



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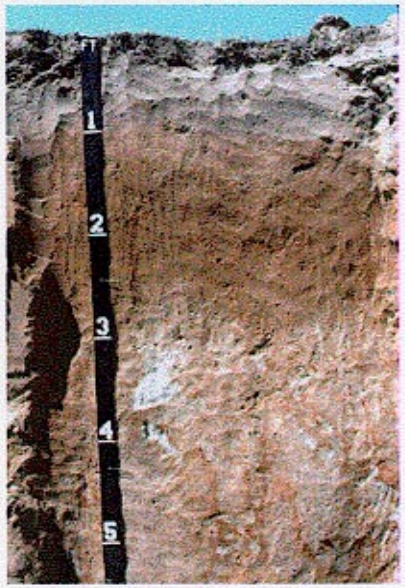
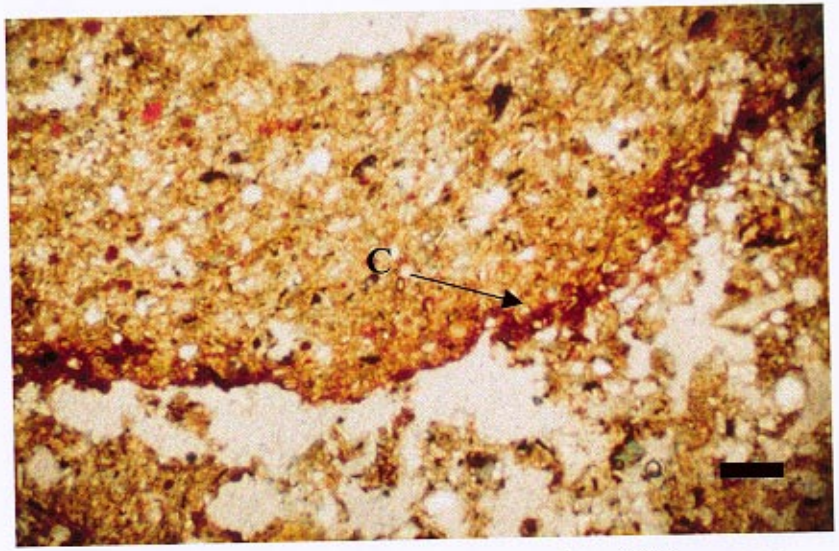
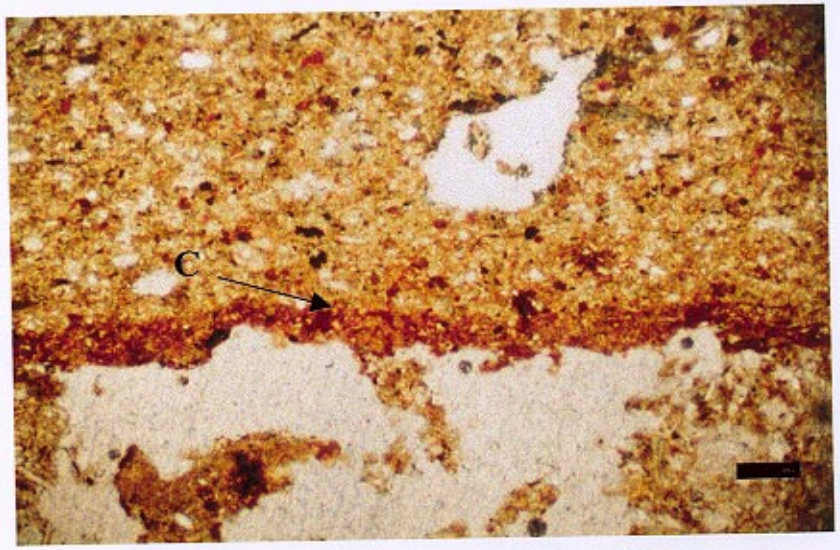


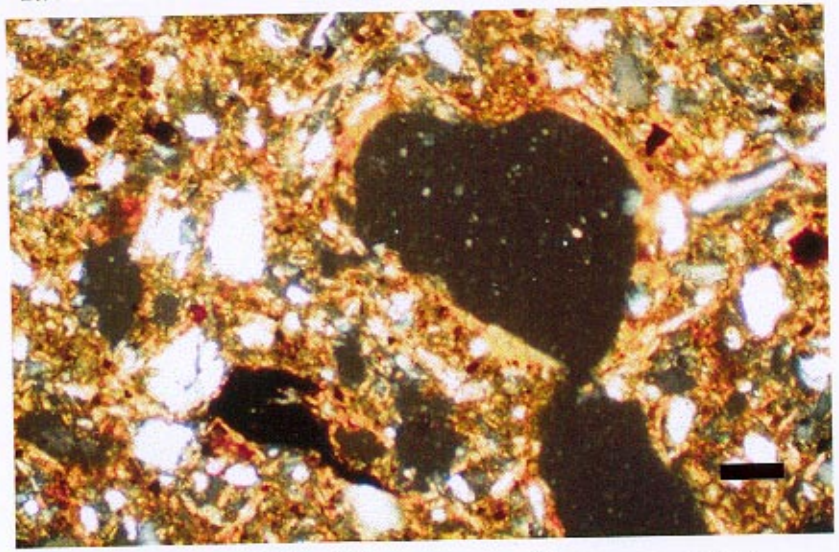
Pedon 5



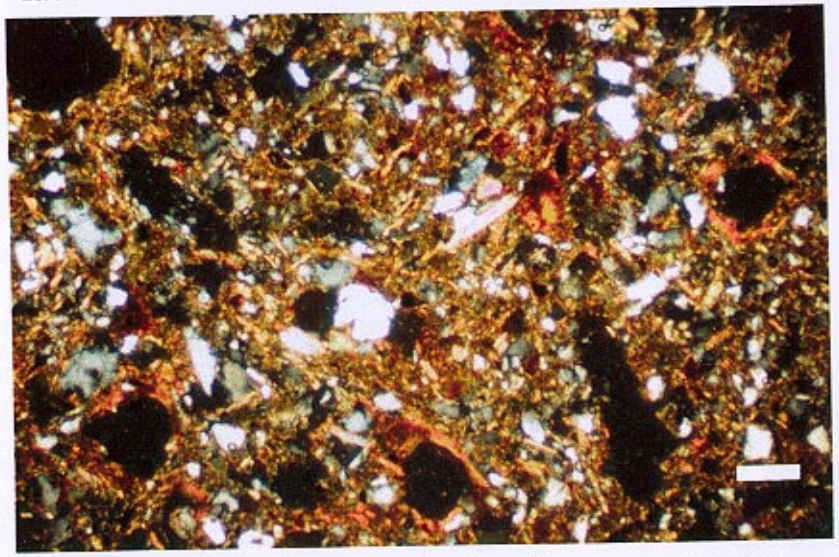
TS 1. P1 Bwb. Fe oxide concentration (C) on ped face. Bar = 200 um. PPl.



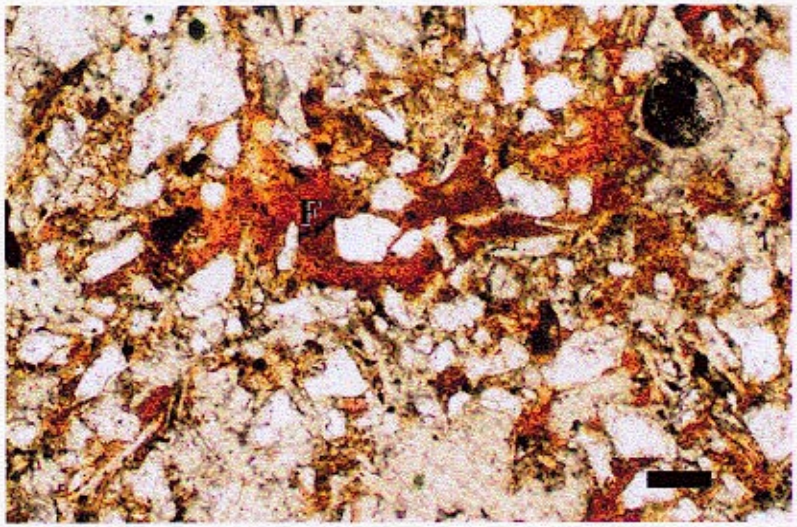
TS 2. P1 Bwb. Fe oxide concentration (C) on ped face. Bar= 200 um. PPl.



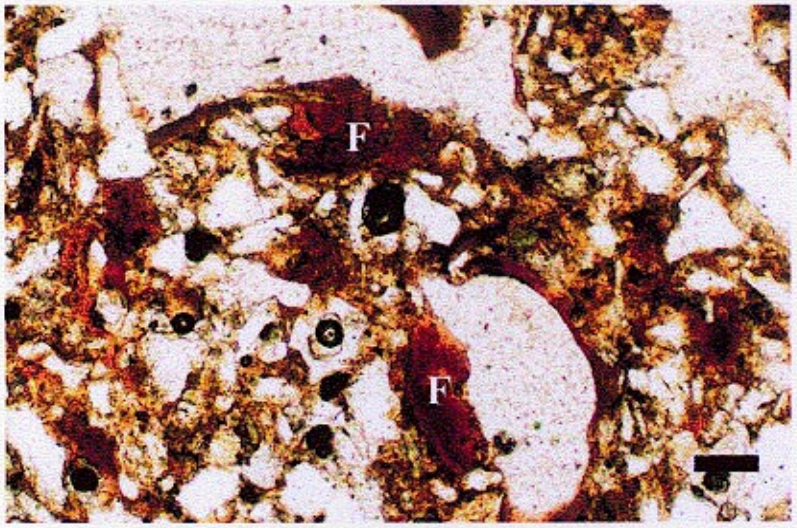
TS 3. P1 BAb. Clay film surrounding pore. Bar = 100 um. XPl.



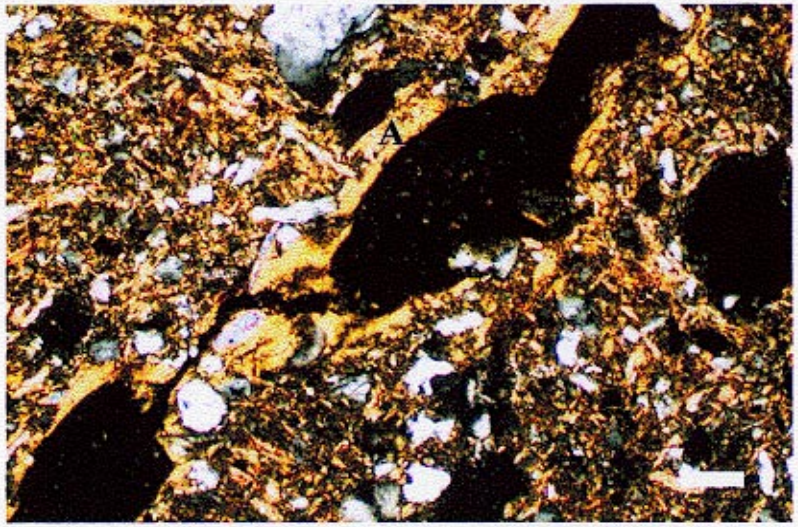
TS 4. P1 Btb1. Common ferriargillans are present. Bar = 200 um. XPl.



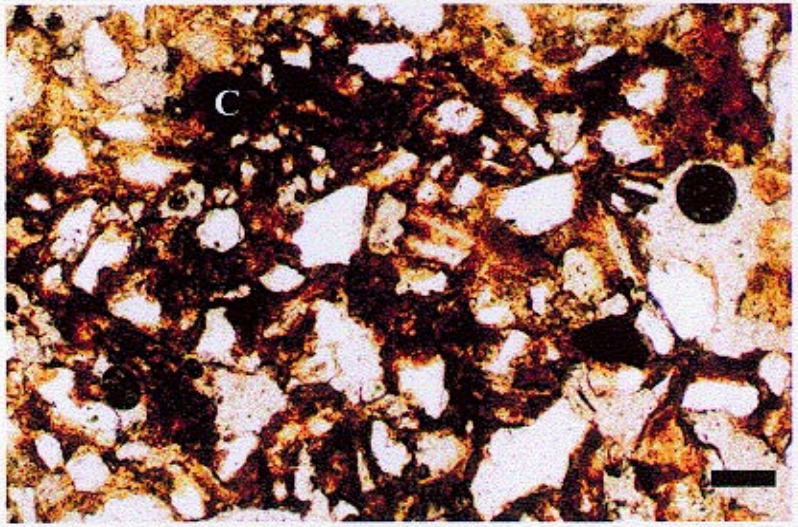
TS 5. P2 Btb. F=ferriargillan. Bar = 100 um. PPl.



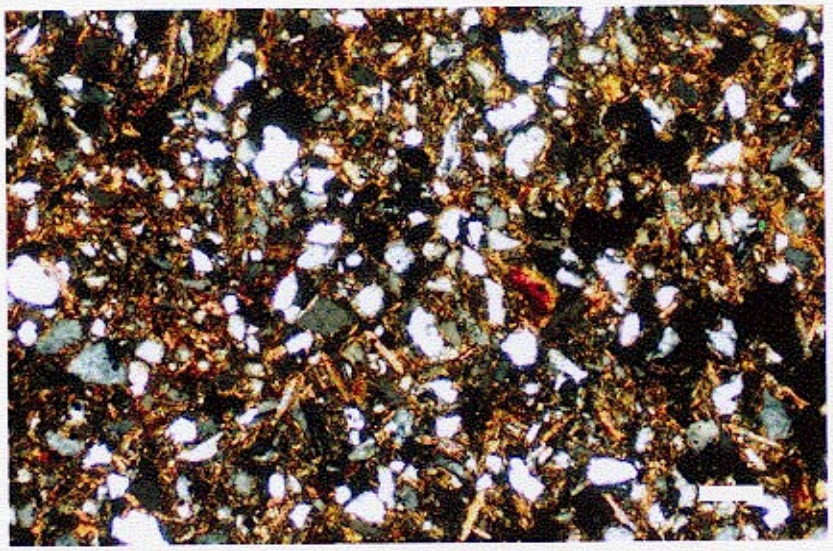
TS 6. P2 Btb2. F=ferriargillan surrounding pore. Bar = 100 um. PPl.



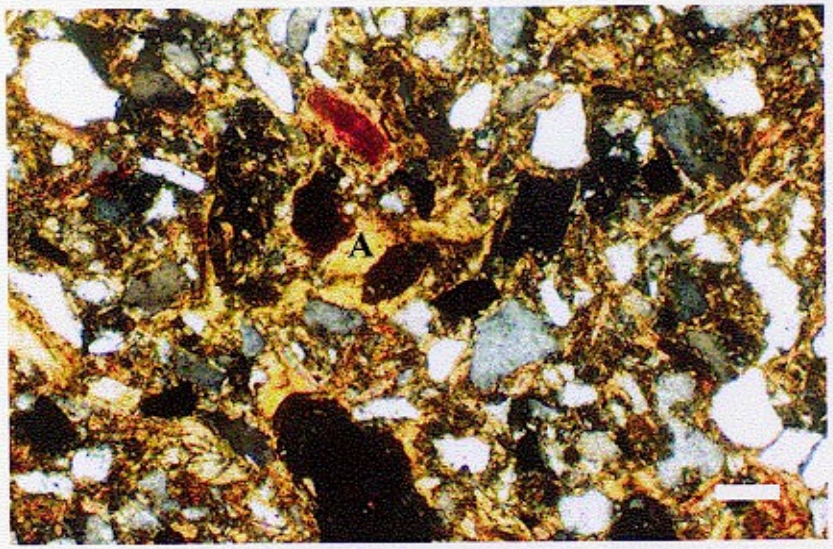
TS 7. P3 Bt1. A=argillan with extinction bands adjacent to void. Bar = 100 um. XPl.



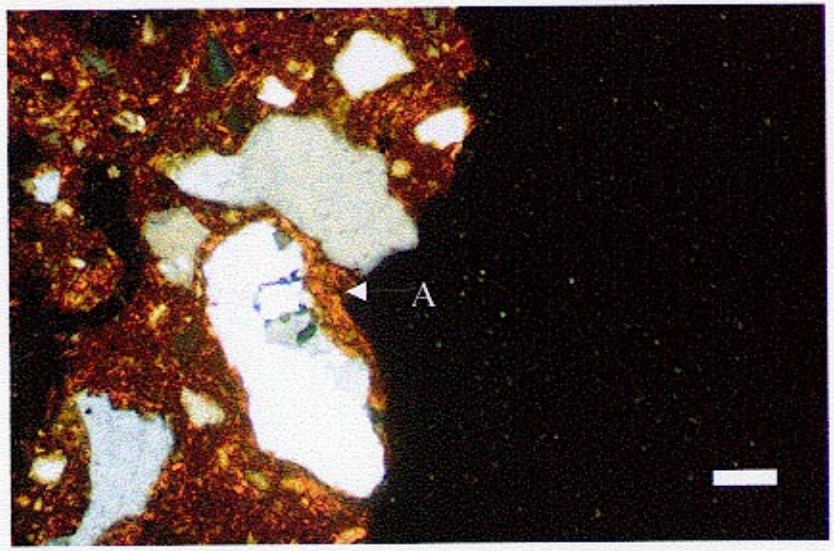
TS 8. P3 Bt4. C=Fe concentration in sandy matrix. Bar= 100 um. PPl.



TS 9. P3 2Btx. Field of view. Bar= 200 um. XPl.



TS 10. P3 2Btx. A= argillan. Bar = 100 um. XPl.



TS 11. P4 Bt2. A=argillan. Bar = 100 um. XPl.

TS 12. P5 Btvx1. Argillans (A) on pore walls. Bar = 200 um. PPl.

Use Dependent Data

SOIL QUALITY AND ITS RELATIONSHIP TO PEDOLOGY

M.L. Norfleet, C.A. Ditzler, and W.E. Puckett

INTRODUCTION

It has been stated that "soil genesis, may be likened to a system of bridges connecting eight islands called chemistry, physics, geology, biology, climatology, geography, anthropology, and agriculture" (Buol et al. 1980). The melding of concepts and disciplines began with the work of V.V. Dokuchaev on the Steppe region of Russia, was furthered through the efforts in the U.S.A. of G. N. Coffey, C. F. Marbut, C. E. Kellogg, and G. D. Smith, and continue today. It is the basis for our knowledge of how soils form, their distribution on the landscape, and how their properties influence and react to land use. It moved the classification of soils from being functionally classified to our current system of Soil Taxonomy (Soil Survey Staff, 1999), a more property-oriented, genetically based system from which landuse interpretations can be made. Prior to the 19th century, the more classical sciences such as geology, geography, chemistry, and botany classified soils in functional terms related to the concerns and state of knowledge of their individual disciplines. A soils' use or its relationship to the primary concern of the particular science was more likely to be recognized than was its properties. Thus geologists would recognize granitic soils, shale soils, or limestone soils; geographers had upland soils, valley soils, or floodplain soils; and botanists, prairie soils, pine soils, and hardwood soils.

In a similar sense, the concept of soil quality attempts to bridge the physical, chemical, and biological sub-disciplines of soil science with today's concerns about agricultural sustainability, economic viability, and environmental quality. Hence, the definition of soil quality is "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" (Karlen et al. 1997). It embodies both the inherent properties of a soil and its ability to react to various stresses with emphasis on near surface phenomena. The evaluation of a soil's capacity to function depends upon the specific landuse or service the soil provides in relation to its inherent capabilities. The focus is on the examination of dynamic soil properties and on whether management has enhanced, sustained, or degraded its ability to

provide its chosen service, while not adversely effecting its surroundings. Although the coining of the term "soil quality" is relatively recent, recognizing the need to assess the effects of our past management is not. The 1938 Yearbook of Agriculture (USDA, 1938) stated "How to use the land better than we have is at once a national problem, a local problem, and an individual problem."

The objectives of this paper are to compare the science of pedology with the concept of soil quality and describe the role of pedology in the application of the goals of soil quality.

Comparisons of Soil Quality and Pedology

The development of the science of pedology came from society's need to be able to assess a soil's suitability for agricultural development and eventually grew into assessments for multiple landuses. This goal for understanding soil is exemplified in comments by the first director of soil survey, Milton Whitney (1899), when he stated "we needed to be able to transfer experience, from research or the use of soils, from the fields or areas where we have experience, to other soils or areas where it is applicable" (Smith, 1986). Early leaders of the Soil Conservation Service, stated "the purpose guiding the use of the soil resources should be to maintain the highest possible standard of living for the people of the United States." Pedology, especially through the use of soil classification (to group similar soils), and soil survey (to show the location of the soils in the landscape), became the vehicle for transferring knowledge about soil behavior through the characteristics of selected soil properties. It also became the basis for guidance in landuse planning and management decisions.

The recent focus on soil quality and the need to assess changes can be linked to statements like "*Protecting soil quality, like protecting air and water quality, should be a fundamental goal of national policy"* from the1993 National Research Council Report, Soil and Water Quality: An Agenda for Agriculture. The goals of soil quality are to evaluate changes in the soil's ability to function for its intended purpose due to changes in landuse or management practices. Just as Whitney described the need for soil survey to be able to transfer experiences in soil suitability, soil quality needs to be able to transfer experiences in soil management. Therefore, the concepts of soil quality follows the implementation of landuse planning and management decisions by evaluating changes in the soil properties which originally influenced decision making.

Soil classification and mapping, for practical reasons, have focused primarily on inherent, more or less permanent characteristics of soil. Variations in properties which change as a result of use and management (especially in the surface layer) are not accommodated well by either Soil Taxonomy or soil survey. When asked about this (Smith, 1986), Guy Smith said, "It has been suggested that properties of surface soil horizons be used as family criteria to enhance interpretive values. But no, I see no way that can be done economically. The physical, chemical properties of the plow layer, admittedly are critical to the growth of plants, and yet they can vary enormously from one system of management to another on what is essentially the same kind of soil. You will see field boundaries in which the growth of the vegetation on one side of the fence is enormously different from that on the other side of the fence, and yet the kinds of soil along that fence line may be very similar. If the man with the poor crops changes his management to the same as that of the man with the good crops, in the course of time, generally a few years, there will be no difference along that fence line. The poor physical and chemical properties that stunted the crops of the man with poor management will have disappeared and you will have good chemical and physical properties on both sides of the fence. To build this into the taxonomy is difficult. It is readily changed by the death of an owner or the sale of a farm, to bring in a new manager with higher managerial skills. That means you have to go back and re-map every few years, and it is much better to have a stable taxonomy and to make your interpretations according to the level of management and the properties which will exist under different levels of management".

Dr Charles Kellogg, recognizing the difference between inherent and temporal soil properties wrote "Thus it becomes important that we distinguish clearly between soil characteristics, which can be seen and measured in the field or measured in the laboratory, and soil qualities, which result from interactions between these characteristics and practices. The first are relatively permanent, whereas the second are subject to frequent change."

In R. W. Arnold's (1983) review of the concepts of soil and pedology, he stated, from Strzemski (1975), there are two general ways to consider soils: (1) on the basis of the nature of its properties; and (2) on the basis of specified functions or use of soil. Similarly, soil quality can be viewed in two ways: (1)

as inherent soil quality, which is the soil's inherent properties as determined by the five soil forming factors (Jenny, 1980); and (2) as dynamic soil quality, which is the change in soil properties as influenced by human use and management (Seybold et al. 1999). In both, the first consideration deals with the origins of soil and processes of soil development. These inherited "qualities" or properties along with our theories of pedogenesis provide the basis for soil classification and ultimately have directed the concepts and procedures for mapping soils in the US. Inherent qualities are often used to compare one soil to another and to evaluate the suitability of a soil for a particular use or the modifications necessary for the intended use. This comparison can be in a broad sense by comparing the productive capacity of Mollisols versus Ultisols or more specific by comparing the water-holding capacity of a loamy textured surface against one that is sandy.

The second way to view or consider soil is not as well aligned. The function of soil referred to by Strzemski and Arnold describes the role soil plays in our lives as influenced by its properties (Strzemski) and the use we have chosen for a particular soil. Inherent properties or qualities of soil, coupled with economic and societal needs dictate this role in large part (the latter often overrides best-suited use). For example, the function of the soil beneath a home is to provide support for its foundation or the role of the soils we plant crops is to provide food and fiber. In this regard "function" is more like a "job description". Conversely, the term "function" for dynamic soil quality is more similar to a "performance appraisal". It is the examination or evaluation of changes in a soil's ability to perform as effected by certain landuses and management practices and how this impacts its surroundings. These functions were outlined by Karlen et al. (1997) into five primary services provided by soil: (1) Sustaining biological activity, diversity, and productivity; (2) Regulating and partitioning water and solute flow; (3) Filtering, buffering, immobilizing, and detoxifying organic and inorganic materials; (4) Storing and cycling of nutrients and other elements; and (5) Providing support for socioeconomic structures and protection of archeological treasures associated with human habitation. The measurement of key soil properties, or indicators, such as infiltration rates, CEC, soil organic matter, etc are the means by which soil functions are inferred or assessed to determine if they are improving or degrading under its current land management.

Therefore, in actuality, the second viewpoints described by the statements of Strzemski and Seybold follow one another, not mirror as the first did. A landuse or role is chosen for a soil due its inherent properties and/or socioeconomic needs. Along with this landuse selection comes the selection of specific management practices. These practices alter the original properties and it these dynamic properties, their degree of change, and the effect this change has on the surroundings that is addressed by soil quality.

Soil Forming Factors and Soil Quality

Regardless of viewpoint, the basic model of soil by Jenny (1980) can be applied to both the inherent nature of soil and the dynamic properties addressed by soil quality. Soil as a function of climate, relief, and organisms *acting* upon parent material over time (c,r,o,p,t) implies that soils are dynamic, geographical systems, and in fact, provides the basis for geographic distribution of soils themselves (Arnold, 1983). The differences in the model between pedology's viewpoint and the concepts of soil quality are those of the organisms influencing pedogenesis, and of scale, spatial and temporal.

With respect to spatial scale, the differences can be linked back to the originating concepts and needs of each viewpoint. The science of pedology and eventually the mapping of soils developed from the need to know what types of soil existed on the landscape. There was also the need to understand the properties of these soils which dictated their potentials and limitations. The objective was to determine what can we do with these soils, what are the soil resources available for future growth. In addition, the backgrounds of many of the early scientist were that of geology and geomorphology. The concepts of soil behavior began with observing changes in soil properties linked to changes in geologic materials and geomorphic surfaces. Thus, soils were viewed as part of this larger, broader landscape and there was a need to map these changes. On the other hand, dynamic soil quality evaluates soil on a much finer scale, typically from a point or individual pedon up to the field or plat scale. It is based on management units and not landscape segments. The need to understand changes in soil properties reflects a soil management point of view, and mapping, if necessary, is on scale and frequency better suited to precision agriculture. The hierarchy of making distinctions are no longer driven by geology or geomorphology, but more aligned with management decisions; no-till versus conventional till, crop rotation or monoculture. The

objective is not "what can we do with these soils?" but follows that decision with "what have we done to these soils?" Interestingly, our understanding of soil behavior at the larger scale makes it possible for the expansion of knowledge gained by experiences assessing these dynamic soil properties.

Temporal points of view are another distinction between pedology and soil quality. Again, the frame of reference for pedology tends toward the geologic scale of time, while that of soil quality tends to be more seasonal to generational. In pedology, soil properties are the result of geologic events, paleoclimates and cycles of climax vegetation that have produced a steady state system, very near equilibrium. Change tends to occur at a nearly imperceptible rate, 10 to 100 mm yr^{-1} (Yaalon, 1983). These seemingly time invariant properties are typically the ones in which the higher categories of soil classification are based. For soil quality, the opposite tends to guide assessments. Larson and Pierce (1991) suggested a minimum data set of soil attributes be chosen from those where trend changes can be measured over one to ten years. Therefore, evaluation of changes in aggregate stability due to tillage management and other near surface properties is of greater importance to soil quality than the weathering environment and time that produced the mineralogy or particle size distribution of the control section.

The major distinction between pedology and soil quality in the model for soil formation is the role of organism in the development of soil properties. In soil quality humans play the largest role in effecting soil properties and our role as organisms in Jenny's equation becomes the dominant force in soil formation and soil functions. With pedology, the traditional and most widely used example of the effect of organisms on soil formation is the comparison of prairie versus forest vegetation. Prairie soils have thicker, darker horizons, mollic epipedons from years under perennial grass. The lighter, thinner surfaces of forest soils are often underlain by an eluvial horizon which tends to be absent under prairie vegetation and clay illuviation tends to also be more pronounced in forest soils. The expression of these horizons is the result of thousands of years under a given organisms' effect. In contrast, humans can, and have, in a very short time changed the nature of the soil through their management. The thick, dark horizons have been thinned drastically in many areas, often changing mollisols to alfisols or inceptisols. Likewise, many eluvial and spodic horizons have been eliminated through mixing by tillage and erosion and the processes

of desertification and acidification can be greatly enhanced by the activities of humans. It may also be argued that our management can effect ongoing pedogenic processes, such as what effect has reduced infiltration had on illuviation. However, not all activities can be viewed as negative, through fertilization, increased biomass inputs, and irrigation, properties such as nutrient status and organic carbon can exceed native levels and thus enhance certain soil functions. It is precisely for these reasons soil quality and an understanding of management effects on dynamic soil properties is becoming of great importance.

Pedogenesis and Soil Quality

However, the most important linkage between pedology and soil genesis with soil quality is that the genetic properties dictate the range in which a dynamic property exists. For example, regardless of management or landuse, highly weathered soils dominated by kaolinitic mineralogy will have a range for CEC from the inorganic fraction dictated by pH dependent charge. No matter how much lime and fertilizer is added the inherent nutrient holding ability of this soil is fixed. The same is true for water holding capacity and its relationship with particle size distribution and mineralogy. This inherent ability of the inorganic fraction of soil to supply nutrients and water then dictates the limits of organic carbon levels in soil, given the same landscape position and vegetation. These same inherited factors provide the limits to numerous other dynamic properties such as aggregate stability and infiltration. A good analogy to these genetic constraints can be found in our manipulations of corn (*Zea mays*). We have altered its growth habits to develop commercial varieties to better suit differing growing conditions and growing seasons. We have also selectively changed its character to fit various uses; corn for silage, corn for feed, corn for milling, and corn for table use. However, if we use protein content as a benchmark, we cannot get a top performing corn plant (20%) to equal that of the poorest (35%) soybean (*Glycine max*). In this regard, there appears to be a large role for the science of pedology to fill in the determination of landuse specific ranges for dynamic soil properties. The need is particularly keen with regard to site-specific or precision agriculture. To add inputs and efforts to areas that are at or near their genetic limits for key production properties may be economically and environmentally unwise.

Over the past 100 plus years the study of pedogenesis has developed many sound theories and concepts on how the factors of soil formation have interacted to produce the soils we see today. The process of soil formation goes through cycles of landscape stability and instability as effected by uplift and erosion, climate change, sea level fluctuations, and millions of years of biological evolution. Pedologists see these changes recorded in the soils we study today and with some certainty reconstruct the past. This comes from our understanding of individual inherent soil properties and the pedogenic processes necessary for their expression. Soil quality presents a new challenge for pedology in its focus on the dynamic properties. Instead of examining inherent properties and reconstructing the geologic past, there is now a need to look at the dynamic properties and reconstruct the past management practices that produced them. Similarly, the inherent properties that we used to develop landuse interpretations need to be followed by interpretations for dynamic properties and the subsequent management recommendations for achieving their genetic limits.

CONCLUSIONS

Soil quality and pedology have strong similarities in their ties to inherent properties developed by the soil forming factors. Their primary difference is that of scale, temporal and spatial, and in the analysis of the effects man has had in a relatively short time. It is in this regard that soil quality can actually be considered part of the science of pedology with a focus on the dynamic character of soil and the influences of intense human use. From this perspective, the future of research for pedologists points to the need to understand the limits of various dynamic properties as dictated by the genetic properties of soil. There is also a need to understand use and management effects on these properties and be able to classify these changes so the transfer of knowledge is made possible.

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EV Smith Project

Studies were conducted on E. V. Smith experimental substation to evaluate use-dependent soil properties within one soil map unit. Scientists from Auburn University, the NRCS-Soil Quality Institute, National Soil Survey Center, and the USDA-ARS Soil Dynamics Laboratory collaborated on these experiments. Results from two projects are given. The first report was written by Dr. Bob Grossman on a project in which several near surface soil properties on under different land use were measured. The second report is for data collected evaluating different tillage practices in a rainfall simulation experiment conducted at E. V. Smith.

United States Department of Agriculture

Natural Resources Conservation Service

National Soil Survey Center
Federal Building, Room 152, MS 36
100 Centennial Mall North
Lincoln, NE 68508-3866
Phone 402-437-5499; FAX 402-437-5336

SUBJECT: MGT – Trip Report - Near Surface Measurements, Auburn, Alabama, November 30-December 2, 1999 Date: May 31, 2000

TO: Files File Code: 330-7

Purpose: The objective was to obtain a small preliminary database on properties that may be important to the evaluation of near-surface soil quality.

Participants:
Craig A. Ditzler, Director, Soil Quality Institute, NRCS, Ames, IA
Robert B. Grossman, Research Soil Scientist, NSSC, NRCS, Lincoln, NE
Lee M. Norfleet, Soil Scientist, Soil Quality Institute, NRCS, Auburn, AL
Dr. Wayne Reeves, ARS, National Soil Dynamics Lab, Auburn, AL
Dr. Joey Shaw, Assistant Professor, Auburn University, Auburn, AL
Terry Sobecki, Landscape Ecologist, NRCS, Washington, DC
Dr. Ben Hajek, Professor (Retired), Auburn University, Auburn, AL

The soil studied was Compass, coarse-loamy, siliceous, thermic Plinthic Paleudults. The tillage zone is largely loamy sand textured. Coarseness of the tillage zone probably reduces the differences in properties among the uses.

We made measurements on 4 land uses:

- Conventional tillage. Plot 410 E.V. Smith Farm
- No-till. Plot 412 E.V. Smith Farm
- Bermuda Grass Pasture. E.V. Smith Farm
- Loblolly Pine Adjacent to E.V. Smith

Analyses
The principal analyses measured infiltration using the Cornell Sprinkler Infiltrometer. Infiltration was also measured with a small double ring assembly. Ksat was measured with a Compact Constant Head Permeameter (Amoozemeter). A morphology index for 0-30 cm was obtained and the strength at a shallow depth was measured by a variation of the Singleton Blade method. For all measurements, 30 cm diameter areas were initially wetted with 10 cm of water.

Results follow:

Sprinkler Infiltrometer
A Cornell Sprinkler Infiltrometer was employed. Triplicate measurements were made at distances from each other of 1 to 5 m. The ring on which the body of the infiltrometer rests was inserted 15 cm. The sites were wetted by flooding initially with 10 cm of water placed in a 30 cm diameter ring. Runoff was maintained for 30 minutes after initiation before measurements were

made. The amount of water in inches per hour that enters the soil during the 30 min. period is approximately half of the infiltration rate. Runoff was collected at 2 min. intervals over about 20 min. The difference between the decrease in height of the water in the reservoir per unit time and the runoff expressed in thickness per unit time is the infiltration rate. The median for the difference between rates of water addition and runoff is reported (10 measurements). The prior wetting, the 30 minutes of runoff before measurement, and the 15 cm depth of the ring that holds the infiltrometer should favor minimum values. Taken together, the results for the 4 treatments are quite similar.

Soil Use	Infiltration Rate	
	Individual	Median
	in hr^{-1}	
Conventional tillage, Plot 412	0.31, 0.85, 3.2	0.85
No-till, Plot 410	2.2, 0.54, 1.3	1.3
Bermuda Grass Hay	2.0, 0.73, 0.94	0.94
Loblolly Pine Plantation	1.5, 0.73, 0.76	0.76

Small Double Ring Infiltrometer

Measurements were made using a flood infiltrometer with a 30 cm outside and a 15 cm inside ring. The outer ring was inserted and 10 cm of water was placed in it. After the water had infiltrated, the inside ring was inserted in the middle of the outer ring to a depth of 15 cm. No additional water was added to the outside ring. A short-term and a long-term infiltration was measured. The short-term is for 5 minutes and the long term for a variable length of time (usually 1 to 2 hours). The long-term measurement is begun immediately after the short-term. Prior to the short-term measurement, the soil is wetted with about 1 inch of water. After most of this water has infiltrated, the remainder is removed. The objective is to have an initial wet condition that is somewhat defined. The results (below) indicate the short-term infiltration rate, as would be expected, is higher than the long-term. It is thought the short-term rate would be more applicable to quality of the near surface and the long-term to the final infiltration rate pertaining to the hydrologic group. Comparison of the infiltration value over the short and long-term together (called "overall") to the sprinkler infiltration indicates reasonable, if not close, agreement.

Soil Use	Double Ring Infiltration			Sprinkler Infiltration
	Short Term	Long Term	Overall	
E.V. Smith, Plot 410 Conventional Tillage, Plot 412	0.79	0.25	0.29	0.85
E.V. Smith Plot 412, No-till	1.9	1.0	1.1	1.3
E.V. Smith, Grass-pasture	4.9 0.65 1.5	0.69 0.53 0.67	0.90 0.55 0.70	0.94
Loblolly Pine	3.7 2.0 3.8	2.0 0.69 2.4	2.1 0.77 2.5	0.76

Ksat

Ksat was measured with the Amoozemeter (in triplicate) in the vicinity of where the infiltration was measured. A consistent difference between the measured Ksat and infiltration was not observed.

Soil Use	Ksat		Sprinkle Infiltration
	Individual	Median	Median
	in hr^{-1}		
E.V. Smith Plot 412, Conventional	0.40, 0.30, 0.35	0.35	0.85
E.V. Smith Plot 410, No-till	0.50, 2.4, 0.45	0.50	1.3
E.V. Smith Bermuda grass pasture	0.60, 0.25, 0.50	0.50	0.94
Loblolly Pine	1.3, 2.3, 3.3	2.3	0.76

Morphology Index

The index is computed from the structure and moist rupture resistance at 0-30 cm plus the crust and the surface connected macropores. The soil must be very or moderately moist. The index is weighted toward the uppermost 10 cm. For the loamy sand texture, which predominates in the upper 0-30 cm, the higher index for structure and rupture resistance is used because structure usually is weak or absent. The moist consistence is very friable which leads to a high index. A very friable index for 0-5 cm is reduced from 5 to 2 if associated with weak structure or massive conditions because of the susceptibility to erosion.

The index is also reduced by crust. For the conventional tillage site the crust had a thickness of 5 mm and a strength of 11 N, which places it in quality class 3. For the other soil uses it is assumed that the crust does not reduce the index. No macropores were observed and so no adjustments were made.

Indices:

Conventional tillage - 3.3=58
No-till - 4.0=75
Bermuda grass pasture - 5.0=100
Loblolly Pine - 3.4=60

Singleton Blade Strength

A single blade is inserted vertically to 2 cm depth. Common paint scrappers 10 to 15 cm wide are used. The force necessary to rotate the blade 45° is measured 5 cm from the centerline of the depth to which the blade is inserted in the soil. Measurements are made at 0-2 and 4-6 cm. A pocket penetrometer is used to measure the force. The measurements follow:

Soil Use	Strength
	kg dm^{-2}
E.V. Smith Plot 412, Conventional tillage	
0-2 cm	<0.6
4-6 cm	1.1
E.V. Smith Plot 410, No-till	
0-2 cm	1.4
4-6 cm	0.6
E.V. Smith, Bermuda Grass Pasture	
0-2 cm	9.5
4-6 cm	19
Loblolly Pine	
0-2 cm	2.5
4-6 cm	3.2

The roots for the Bermuda Grass site increase the strength. The 0-2 cm depth differs considerably between the conventional and no-till sites.

ROBERT B. GROSSMAN
Research Soil Scientist

Rainfall Simulation Results:

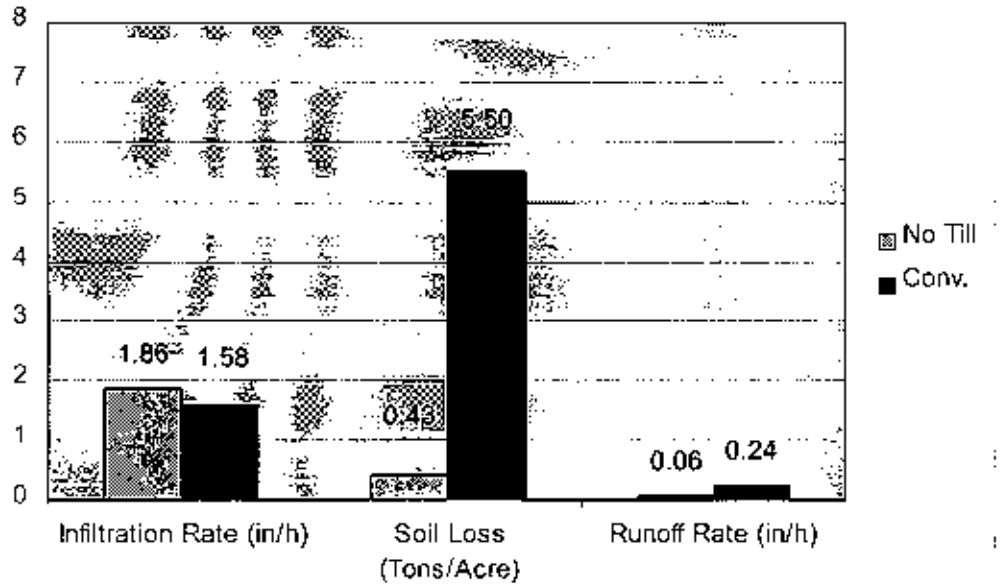


Fig. 1. Comparison of no-till vs conventional tillage treatments as measured after the first hr of rainfall simulation under dry antecedent conditions.

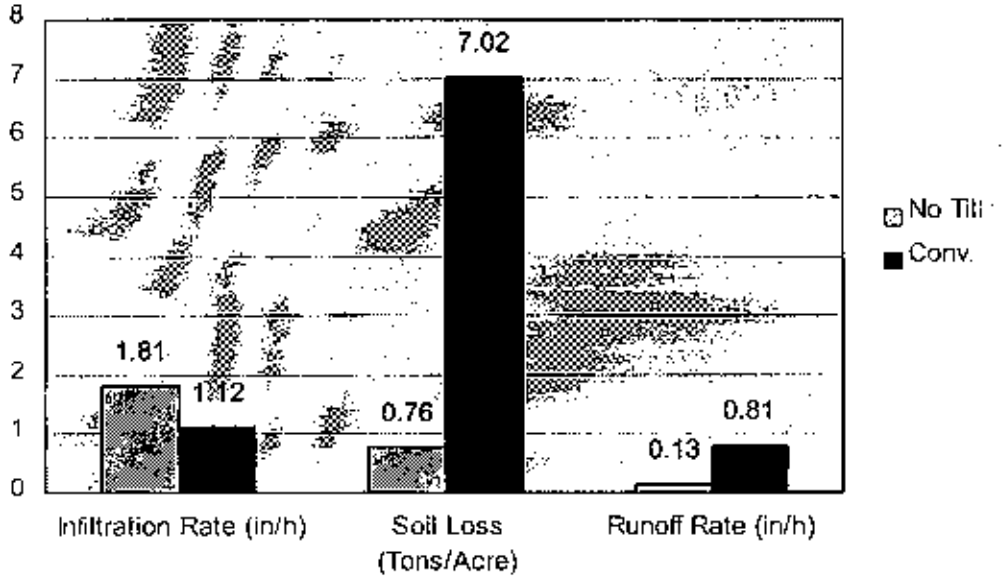


Fig. 2. Comparison of no-till vs conventional tillage treatments as measured after the 2nd hr of rainfall simulation (wetter conditions).

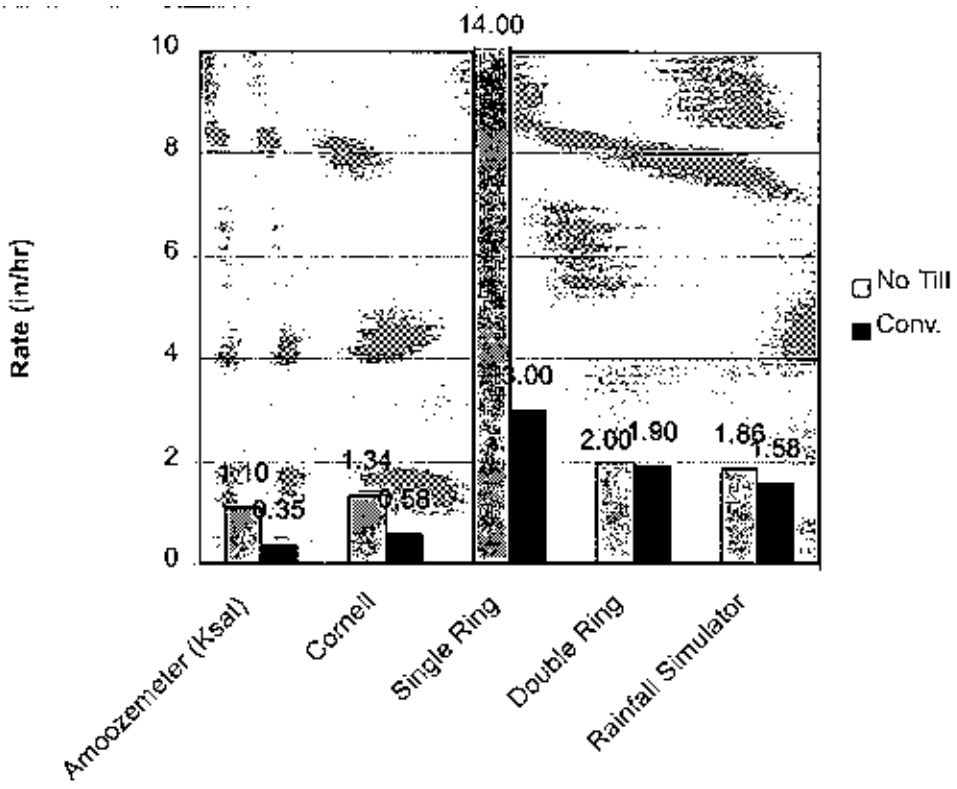


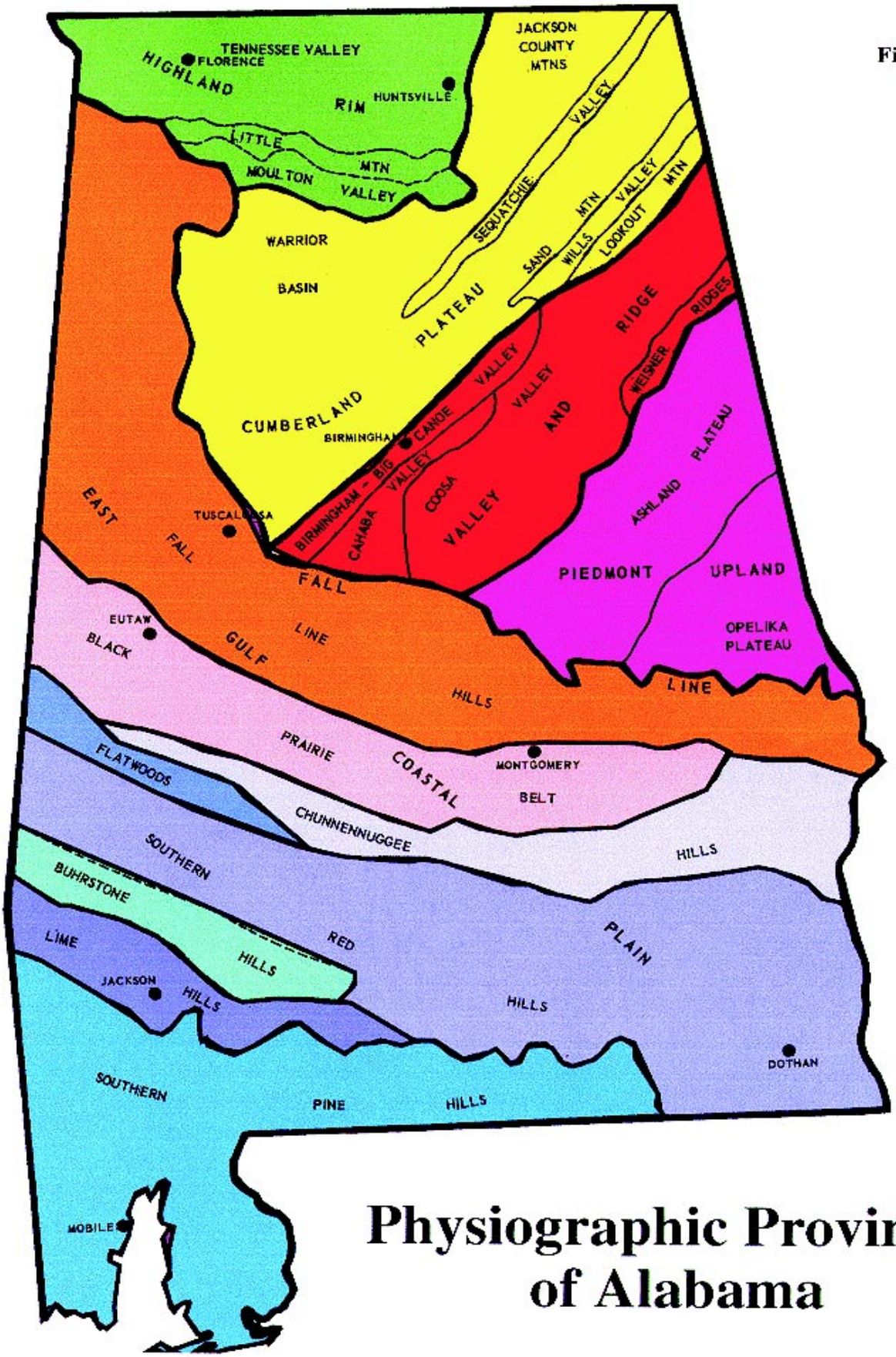
Fig. 3. Summation of hydraulic assessment techniques.

Table 1. Selected chemical and physical properties.

property	no tillage	conventional tillage
soil organic C (%) 0-1"	1.6	0.6
soil organic C (%) 1-6"	1.0	0.6
aggregate stability (%)	64	46
bulk density g cm^{-3}	1.53	1.55
water dispersible clay (% clay basis)	4	29

FIGURES AND TABLES

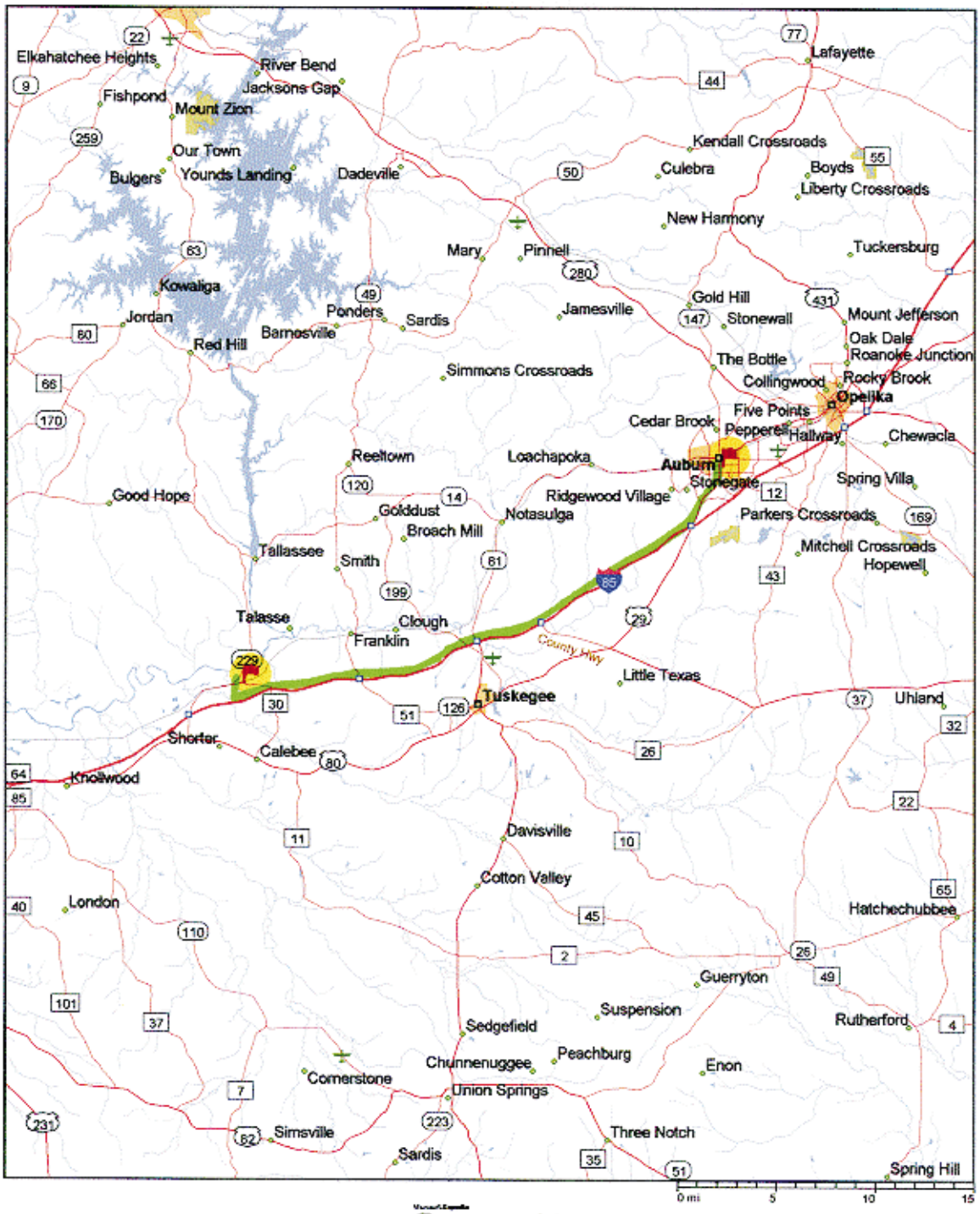
Figure 1



Physiographic Provinces of Alabama

Figure 2

Field Trip -- Southern Soil Survey Conference



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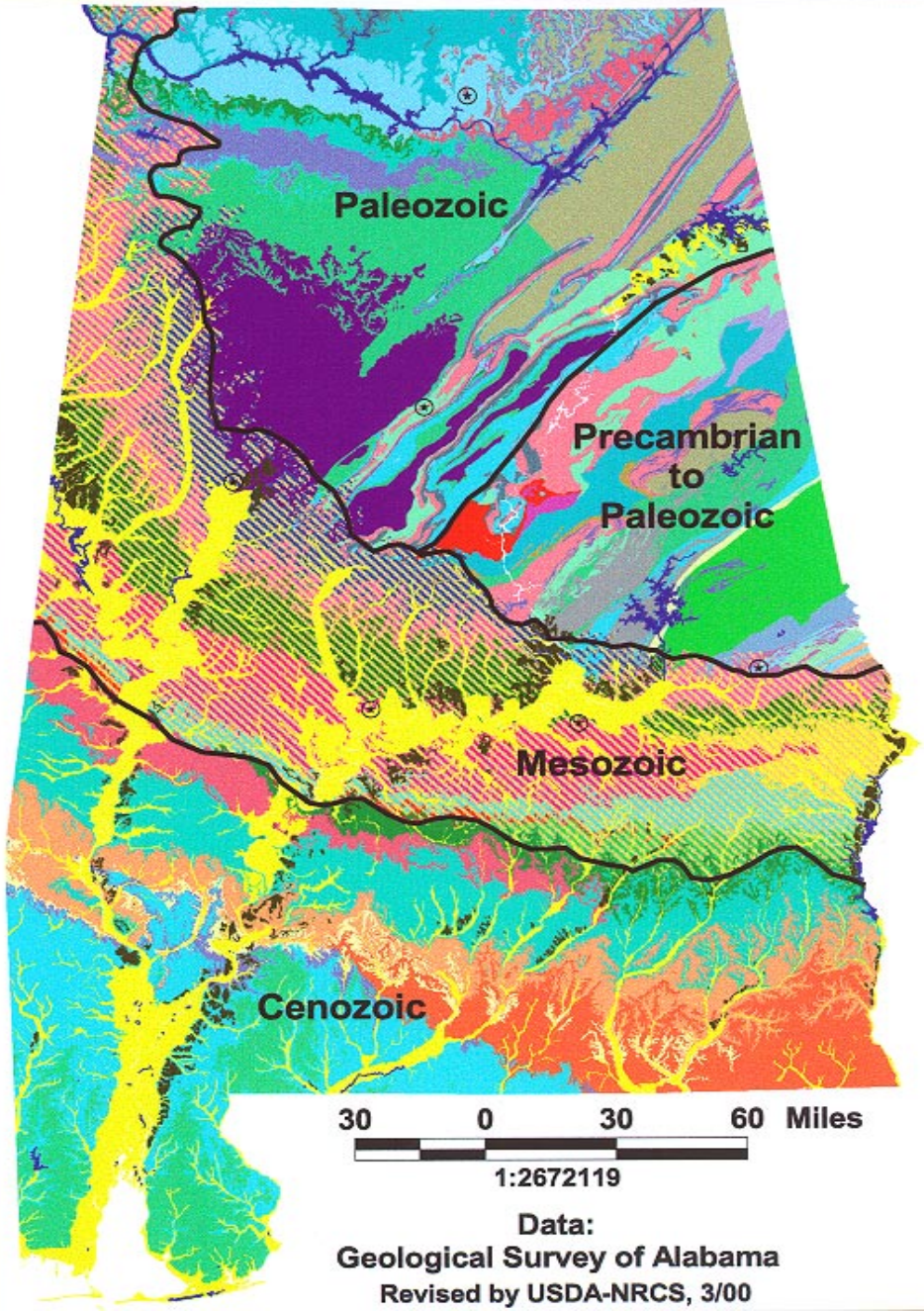

Geologic Formations Of Alabama

N
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S

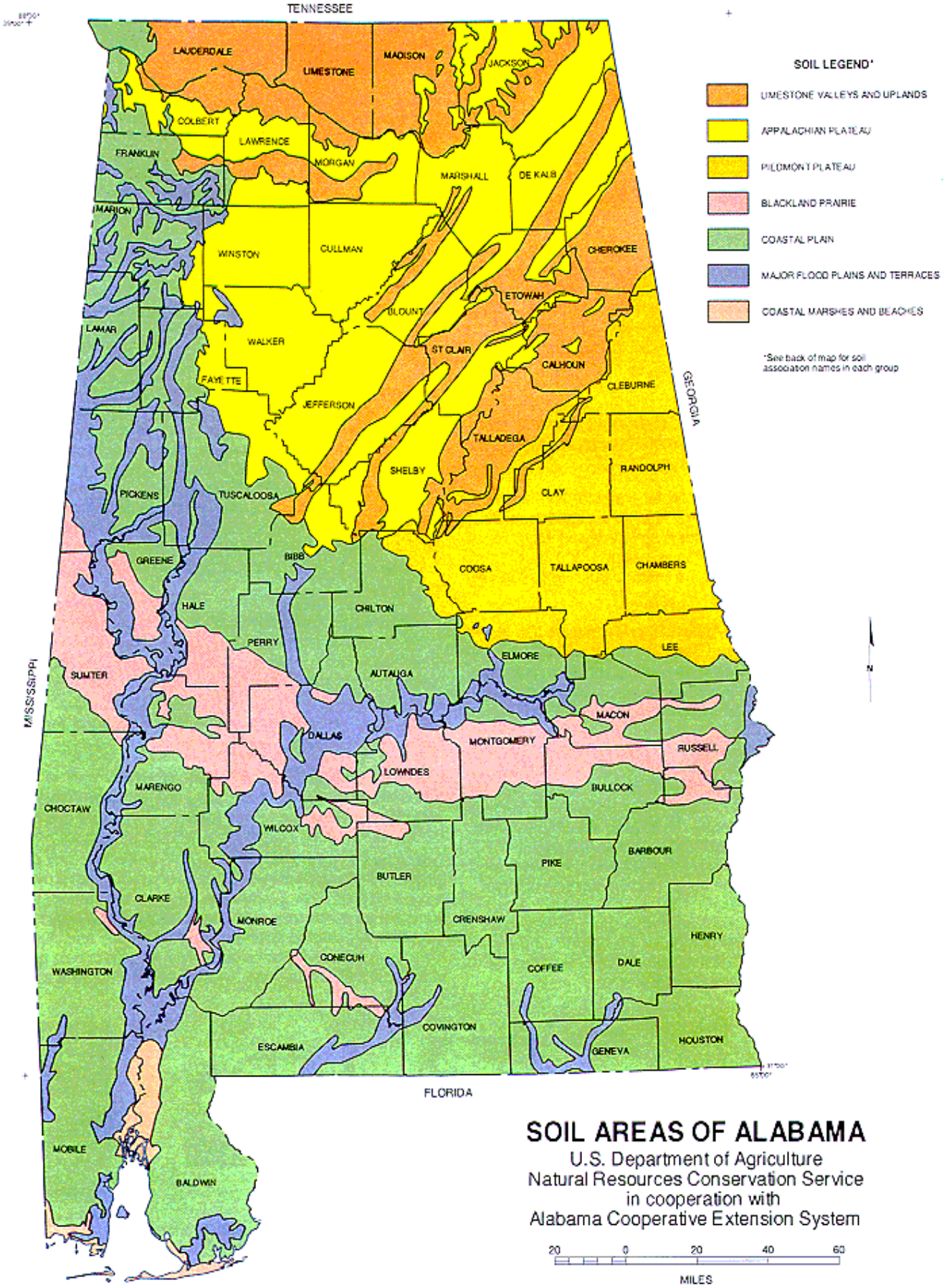
Geologic Formations

CENOZOIC
- Alluvial, coastal and low terrace deposits
- High terrace deposits
- Residuum
- Citronelle Formation
- Miocene Series undifferentiated
- Oligocene Series undifferentiated
- Claiborne Group
- Wilcox Group
- Midway Group
- Clayton Formation

MESOZOIC
- Prairie Bluff Chalk
- Providence Sand
- Ripley Formation
- Demopolis Chalk
- Blufftown Formation
- Mooreville Chalk
- Eutaw Formation
- Gordo Formation
- Coker Formation

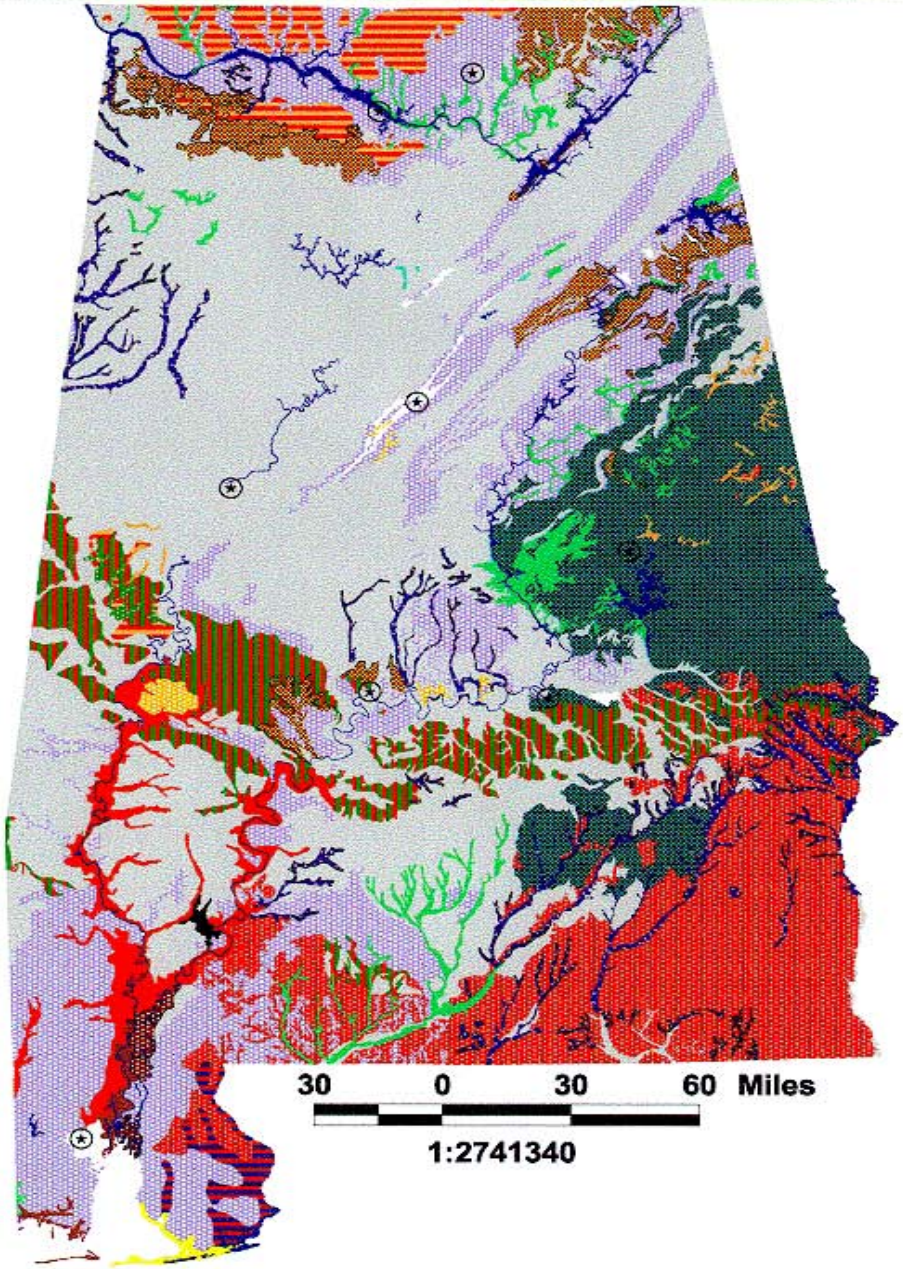
PALEOZOIC
- Pottsville Formation (upper part)
- Pottsville Formation
- Pottsville Formation (lower part)
- Parkwood, Pennington and Floyd Shale Formations undifferentiated
- Bangor Limestone
- Floyd Shale
- Hartselle Sandstone
- Monteagle Limestone
- Pride Mountain Formation and Monteagle Limestone undifferentiated
- Tuscumbia Limestone and Fort Payne Chert undifferentiated
- Fort Payne Chert
- Chattanooga Shale and Frog Mountain Sandstone undifferentiated
- Silurian System undifferentiated
- Ordovician Systems
- Knox Group undifferentiated
- Cambrian Systems

PRECAMBRIAN TO PALEOZOIC
- Hillabee Greenstone
- Talladega Group
- Heflin Phyllite
- Sylacauga Marble Group
- Kahatchee Mountain Group
- Higgins Ferry and Poe Bridge Mtn. Group
- Hatchet Creek Group
- Mad Indian Group
- Wedowee Group
- Emuckfaw Group
- Mafic & Ultramafic Rocks (Amphibolite)
- Intrusive Rocks (Granite, Gneiss, Diorites)
- Jacksons Gap Group
- Dadeville Complex
- Opelika Complex
- Pine Mountain Group
- Wacoochee Complex
- Moffits Mill Schist & Motts Gneiss
- Uchee Complex
- Mylonitic & Cataclastic Rocks
- Water
- City



SOIL AREAS OF ALABAMA

U.S. Department of Agriculture
Natural Resources Conservation Service
in cooperation with
Alabama Cooperative Extension System



Great Groups

- Endoaqualfs & Epiaqualfs
- Hapludalfs
- Paleudalfs
- Fluvaquents
- Hydraquents
- Udifluvents
- Udorthents
- Quartzipsamments & Alaquods
- Sulfihemists
- Haplosaprists
- Dystrudepts
- Eutrudepts
- Endoaquepts & Epiaquepts
- Rendolls
- Epiaquults
- Paleaquults
- Umbraquults
- Fragiudults
- Hapludults
- Kandiudults
- Kanhapludults
- Paleudults
- Epiaquerts
- Dystruderts & Hapluderts
- No Data
- Water

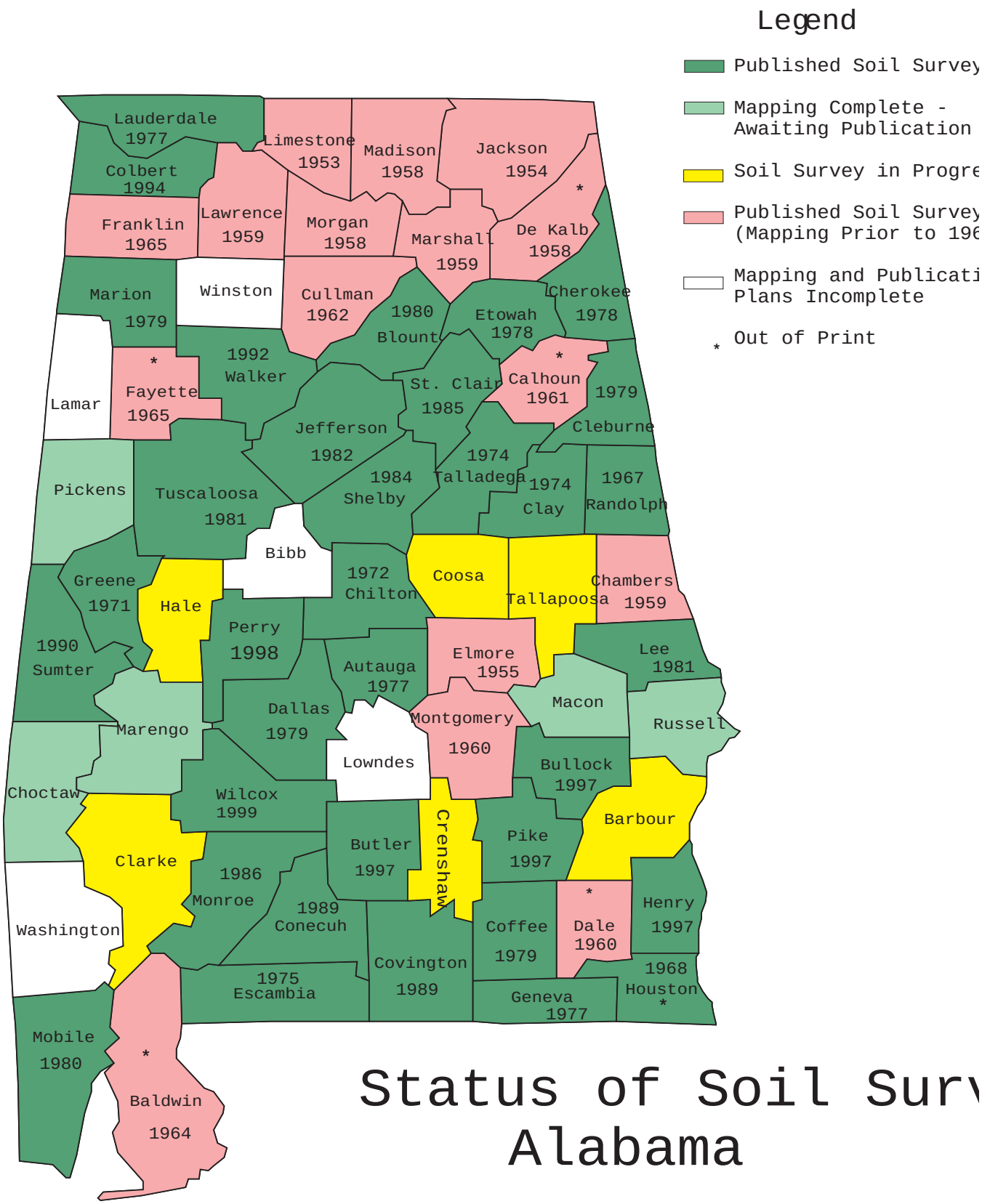
Soil Great Groups of Alabama

Data Source: State Soil Survey Geographic Database (STATSGO)
Projection: Universal Transverse Mercator
Zone: 16
Datum: NAD27

N

USDA-Natural Resources Conservation Service
Major Land Resource Area - Soil Survey Region 15
GIS/Map Compilation Section
Auburn, Alabama
February 11, 2000

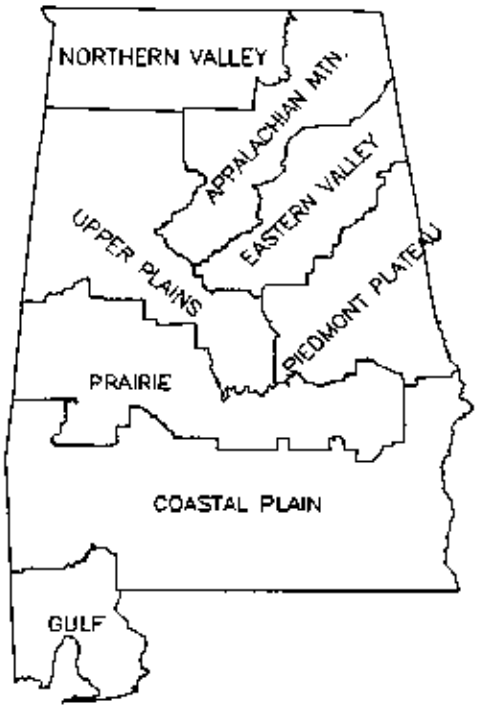
Figure



Status of Soil Surv
Alabama

USDA, Natural Resources Conservation Service
MLRA-15, Auburn, AL

by
Vivian Kendrick



Weather Area	Total Precipitation	Average Temperature
	Inches	Degrees
Northern Valley	54.35	62.8
Appalachian Mtn.	57.43	62.5
Upper Plains	58.74	63.7
Eastern Valley	53.63	63.9
Piedmont Plateau	53.41	63.4
Prairie	52.33	66.0
Coastal Plain	67.19	66.7
Gulf	85.85	68.7

Weather Area	Precipitation - Inches of Water											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Northern Valley	8.86	6.95	4.86	4.43	4.33	2.44	5.61	2.99	0.97	2.01	3.32	7.58
Appalachian	8.07	7.18	5.58	6.96	2.91	3.83	4.79	4.37	0.87	1.10	4.78	6.99
Upper Plains	8.90	7.17	4.84	5.59	2.66	3.86	7.72	3.73	2.36	1.59	4.00	6.32
Eastern Valley	6.44	9.00	5.60	6.36	3.01	2.86	4.88	3.23	2.08	0.94	4.34	4.89
Piedmont	6.27	8.82	6.08	6.40	2.45	3.86	5.08	2.70	5.23	0.84	2.65	3.03
Prairie	8.70	7.80	4.69	3.75	1.57	3.28	6.06	2.21	7.81	1.59	2.17	2.70
Coastal Plain	8.16	7.33	8.51	4.91	1.50	2.56	6.87	3.59	17.2	1.28	2.90	2.30

Weather Area	Average Temperatures - Degrees Fahrenheit											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Northern Valley	44.9	45.7	50.4	59.2	71.8	79.7	80.4	78.6	77.1	64.8	53.6	62.8
Appalachian	44.4	45.5	49.9	58.6	71.1	78.1	80.3	78.3	76.6	65.1	54.2	47.6
Upper Plains	45.2	47.3	51.5	60.0	72.2	79.7	81.3	79.7	77.2	65.7	56.0	48.5
Eastern Valley	46.4	47.1	51.8	60.4	72.7	79.2	81.4	78.9	77.5	65.5	56.0	49.9
Piedmont	45.9	46.9	51.2	59.9	72.3	79.0	80.7	78.3	75.1	64.9	56.3	49.8
Prairie	48.3	49.9	54.3	62.1	74.4	81.8	82.9	81.0	78.6	67.6	58.6	52.1
Coastal Plain	50.0	51.2	55.2	63.2	74.9	82.2	82.4	80.9	77.6	68.0	60.7	54.5
Gulf	52.6	53.4	56.9	65.4	76.1	82.0	83.4	82.9	78.6	71.0	64.0	57.8

Source: National Oceanic and Atmospheric Administration, Environmental Data and Information Service.

GEOLOGIC TIME SCALE OF ALABAMA'S EXPOSED STRATIGRAPHIC UNITS[1]

AGE (millions)	ERA	SYSTEM	SERIES	GROUP	FORMATION
0.01	CENOZOIC	Quaternary	Holocene		Alluvial, coastal and low terrace deposits
2			Pleistocene		High terrace deposits
5		Tertiary	Pliocene		Citronelle Formation
23			Miocene		Miocene Series, undifferentiated
23			Oligocene	Upper	Paynes Hammock Sand
					Chickasawhay Limestone
				Vicksburg (Lower)	Byram Formation
					Marianna Limestone
37					Forest Hill Sand, Red Bluff Clay, and Bumpnose Limestone
37			Eocene	Jackson	Yazoo Clay and Crystal River Formation
				Claiborne	Moody Branch Formation
					Gosport Sand and Lisbon Formation
					Tallahatta Formation
58				Wilcox	Hatchetigbee Formation
			Paleocene		Tuscahoma Sand
					Nanafalia Formation, Salt Mountain Limestone
				Midway	Naheola Formation
					Porters Creek Formation
66					Clayton Formation
66	MESOZOIC	Cretaceous	Upper	Selma	Prairie Bluff Chalk
					Ripley Formation
					Demopolis Chalk
					Mooreville Chalk
					Eutaw Formation
				Tuscaloosa	Gordo Formation
144					Coker Formation
208		Jurassic			
245		Triassic			
286	PALEOZOIC	Permian			
		Carboniferous			
320		Pennsylvanian	Lower		Pottsville Formation
320		Mississippian	Upper		Parkwood Formation
					Pennington Formation
					Bangor Limestone and Floyd Shale
					Hartselle Sandstone
					Pride Mountain Formation and Monteagle Limestone
					Tuscumbia Limestone
360			Lower		Ft. Payne Chert
360		Devonian	Upper		Chattanooga Shale
			Middle Lower		Frog Mountain Sandstone
408		Silurian			Silurian System, Undifferentiated (Wayne Group, Brassfield Limestone, and Red Mountain Formation)
438		Ordovician			Sequatchie Formation
					Leipers Limestone
					Inman Formation
					Colvin Mountain Sandstone
					Chickamauga Limestone, Colvin Mountain Sandstone, and Greensport Formation
					Nashville and Stone River Group Undifferentiated
					Attalla Chert Conglomerate Member of the Chickamauga Limestone
					Athens Shale
					Little Oak and Lenoir Limestones, Undifferentiated
					Newala Limestone

AGE (millions)	ERA	SYSTEM	SERIES	GROUP	FORMATION
					Longview Limestone
					Chepultepec and Copper Ridge Dolomites Undifferentiated and Knox Group Undifferentiated
505		**Cambrian**			
		Cambrian			Bibb Dolomite
					Ketona Dolomite
					Brierfield Dolomite
					Conasauga Formation
					Rome Formation
					Shady Dolomite
					Chilhowee Group, Undifferentiated
					Weisner and Wilson Ridge Formations, Undifferentiated
					Nichols Formation
					Cochran Formation
> 570	**PRECAMBRIAN**				

[1] Map based on: Szabo, M., Osborne, E., Copeland, C., and Neathery, T. 1988. Geologic Map of Alabama. Alabama Geological Survey Special Map 220.

GEOLOGIC TIME SCALE OF ALABAMA'S EXPOSED STRATIGRAPHIC UNITS[1]
PIEDMONT PROVINCE

AGE (millions)	SYSTEM	GROUP OR COMPLEX	Northern Piedmont
			Low-Grade Metamorphic Rocks
360	Pz		Hillabee Greenstone
	Silurian?-Devonian	Talladega Group	Jemison Chert and Chulafinnee Schist, Undifferentiated
			Butting Ram Sandstone
			Lay Dam Formation
			Cheaha Quartzite Member of Lay Dam Formation
	Cambrian?		Heflin Phyllite
	Cambrian?-Ordovician?	Sylacauga Marble Group	Gantts Quarry Formation
			Gooch Branch Chert
			Shelvin Rock Church Formation
			Fayetteville Phyllite
			Jumbo Dolomite
	Precambrian?-Cambrian?	Kahatchee Mountain Group	Wash Creek Slate
			Kalona Quartzite Member of Wash Creek Slate
			Stumps Creek Formation
			Brewer Phyllite
			Sawyer Limestone Member of Brewer Phyllite
			Waxahatchee Slate
		HIGH-GRADE METAMORPHIC AND IGNEOUS ROCKS	
	Precambrian to Paleozoic		Higgins Ferry Group
			Poe Bridge Mountain Group
		Hatchet Creek Group	Pinchoulee Gneiss
			Hanover Schist
			Mad Indian Group
		Wedowee Group	Wedowee Group Undifferentiated
			Hackneyville Schist
			Cornhouse Schist
		Emuckfaw Group	Emuckfaw Group Undifferentiated
			Glenloch Schist
		MAFIC AND ULTRAMAFIC ROCKS	
			Mitchell Dam Amphibolite
			Ketchepedrakee Amphibolite
			Beaverdam Amphibolite
			Ultramafic rock
		INTRUSIVE ROCKS	
			Elkahatchee Quartz Diorite Gneiss
			Rockford Granite
			Hissop Granite
			Almond Trondhjemite
			Zana Granite
			Kowaliga Gneiss
			Bluff Springs Granite

AGE (millions)	SYSTEM	GROUP OR COMPLEX	Northern Piedmont
		Brevard Fault Zone	
		Jacksons Gap Group	Jacksons Gap Group, Undifferentiated
			Tallassee Metaquartzite
		INNER PIEDMONT	
		HIGH-GRADE METAMORPHIC AND IGNEOUS ROCKS	
		Dadeville Complex	Agricola Schist
			Ropes Creek Amphibolite
			Waresville Schist
			Waverly Gneiss
			Mafic and Ultramafic Rock
			Camp Hill Granite Gneiss
			Rock Mills Granite Gneiss
		Opelika Complex	Loachapoka Schist
			Auburn Gneiss
			Bottle Granite
		SOUTHERN PIEDMONT	
		HIGH-GRADE METAMORPHIC AND IGNEOUS ROCKS	
		Pine Mountain Group	Manchester Schist
			Chewacla Marble
			Hollis Quartzite
		Wacoochee Complex	Halawaka Schist
			Whatley Mill Gneiss
			Phelps Creek Gneiss
			Motts Gneiss
			Moffits Mill Schist
		Uchee Complex	Phenix City Gneiss
>570			Hospilika Granite

[1] Map based on: Szabo, M., Osborne, E., Copeland, C., and Neathery, T. 1988. Geologic Map of Alabama. Alabama Geological Survey Special Map 220.

Minutes of the Southern Soils Conference
Business Meeting
June 21, 2000

Berman Hudson called the meeting to order and read the Minutes of the 1998 Business Meeting.

MOTION: Wayne Hudnall, LA, moved approval of the minutes as read; second by Bill Craddock, KY. The motion carried.

The group looked at the fourteen items on the Action Register from the 1998 business meeting and made the following comments:

Completed Action Register items:

1. New officers of the university group:
   Chair - Tom Ammons
   Vice-Chair - Larry West
   Secretary - Tom Hallmark

4. The government agency group will include a university observer in future group meetings.
   Wayne Hudnall represented the university group at the 2000 government agency group meeting.

5. Hudnall will process breakout group reports into action items.

6. Hudnall will post the minutes, by-laws, and action register on the LSU Home Page.

7. Puckett will present concerns of the Southern Regional Cooperative Soil Survey Conference at the southern Regional Agricultural Experiment Station Conference.

8. Committee members from the 1998 Conference will remain active until action registers are in place.

10. Virginia will be removed from the by-laws as a member of the Southern Region.

11. The year 2000 conference will be held in Alabama.

Status of other Action Register Items:

2. Larry West will pursue "Soils of the South Region Project"
   West is preparing the maps. The maps will be STATSGO based. The project should be completed by October 2000

3. The university group voted to establish a Southern Regional Experiment Station Home Page. Larry West will take the lead to develop.

West is still working on this project. It should be completed by September 2000

9. A Taxonomy Committee Co-Chair was established. This person will be an NRCS representative and will rotate with each biannual conference. This co-chair will be elected by friendly consensus. All NRCS members must submit their nomination to Jerry Daigle no later than July 15, 1998.

   Michael Golden, TX, volunteered to serve as the Taxonomy Committee Co-Chair. The group accepted his offer.

12. A Southern Regional Research Needs Committee was approved; expanding the research needs committee formed by the university group. The MO Leaders will decide the NRCS lead. Craig Ditzler volunteered for this rotation. Wayne Hudnall and Allen Tiarks are University representatives.

    Craig Ditzler took another position shortly after the 1998 meeting. Bill Puckett, AL, volunteered to serve as the MO leader on the Southern Regional Research Needs Committee. The group accepted his offer.

13. Bill Puckett and Bobby Ward were nominated to be on the National Committee on Research Needs.

    The question arose, "Is there a National Committee on Research Needs?"

    MOTION: Larry West, GA, nominated Berman Hudson to look into this matter; second by Bill Smith, SC.

    This item is still open pending response to this question.

14. A Southern Regional Technical Committee for Hydric Soils was approved.
    Universities (3): David Pettry (3 years), Mike Vepraskas (2 years), Wayne Hudnall (1 year) and Larry West (3 years-starting in 2000)
    NRCS (3): Jerry Daigle (3 years), John Gagnon (2 years), Ben Stuckey (1 year), Wes Miller (3 years-starting in 2000)
    CORPS (1): TBD
    USFWS (1): TBD
    EPA (1): TBD
    USFS (1): TBD
    Since NRCS is the permanent chair of the National Technical Committee for Hydric Soils, Jerry Daigle will act as chair of the regional committee until all members have been designated and the first meeting is conducted.

    Daigle made initial contacts to complete the roster of committee member. After talking with Wade Hurt, he was informed that the National Technical Committee would select the other committee members. No further action has taken place.

Discussion followed. Hudnall asked Hudson's opinion of the following:

If the group felt a regional committee would be beneficial, would the national committee support the concept and cooperate with them?

If the regional committee was formed, will the national committee invite the regional committee chair to attend the national committee meetings?

Hudson responded that he certainly felt that if the regional committee was formed, the group should select the committee members, and "yes" the chair would be invited to participate in the national committee meetings.

After much discussion, the group decided to reappoint the membership.

MOTION: Darwin Newton, TN, made a motion that the group implement the committee as conceived at the 1998 meeting; there was a second by Warren Lynn, NE. Motion carried.

Two university representatives on the committee need to be replaced: Pettry has retired and Vepraskas is now on the national committee. Larry West, GA, volunteered to take the lead in getting these replacements.

MOTION: Bill Smith, SC, made a motion that the group accept West's offer; the second was by Joey Shaw, AL. Motion carried.

West will poll the university representatives via e-mail.

<u>Follow-up from Breakout Group discussions from the June 1998 Conference:</u>

Group 1: Identify the process with specific tasks and methods required to "add value" for an MLRA soil survey. Identify partnership roles, responsibilities and contributions.

Cameron Loerch will coordinate a committee of MO Leaders. The goal will be to increase the technical knowledge base through enhanced communication, field visits, and interaction across state and county lines. The target audience is state conservationists, experiment station directors, and department heads.

Cameron Loerch accepted another position and this committee never was formed. The group agreed that it is a goal to move forward with. The purpose of the goal is to enhance communication and interaction among the targeted audience.

Puckett and Newton cited the recent combined MO-13, MO-14, MO-15 regional meeting as an evidence of a success in this area. There were 13 state conservationists present at the meeting. The meeting provided opportunities for very good interaction among state soil scientists and state conservationists.

Hudson indicated that he would contact the Association of Southern Experiment Stations and try to get an invitation to attend their meeting.

Group 2: Identify additional uses of soil resource data to be tested in the southern region. Develop an action plan.

Phosphorus, precision agriculture, urban interpretations, water movement/permeability all surfaces as areas of need. Phosphorus, precision agriculture, and urban interpretation are being addressed at a national level. This topic will be carried over to the next conference.

John Jenkins, TN, was a member of this working group. The item was sent to Mary Collins, FL, for suggestions. They received no reply.

The group agreed that this is an area that should be pursued.

MOTION: Larry West, GA, made a motion that the group express continued interest in identifying additional uses of soil resource data; second by Warren Lynn, NE.

Lee Norfleet, AL, volunteered to spearhead the project.

Group 3: Identify and develop strategies or methods to be used to increase the visibility of soil resources and the use of soil resource inventory products.

Suggested options:

Option 1: Fund a co-op student in marketing to develop a marketing package. The Southern Regional Research Needs Committee would review proposals and make recommendations. This committee would also draft a research proposal.

Option 2: Contract with a media firm to develop an information campaign. Purdue University has a lot of stuff already. Texas has "Soils Talk".

Hudnall commented that there still is confusion about the Southern Regional Research Needs Committee--who is the chair?

There is no evidence of progress in this area.

Group 4: Identify products to deliver soil resource information into the future…hard copy in the field, shrink wrap hard copy, SSURGO, CD-ROM, World Wide Web?

This item must be elevated to the national level. There can be no action at the regional level.

New business:

The group looked at the request from Horace Smith dated July 19, 1999, in which he asked:

1. The Regional NCSS Conferences to include an agenda item dealing with a charge to develop a plan for collecting measured soil chemical and physical properties and hydraulic conductivity measurements in the field and laboratory to populate the NCSS database under the stewardship of NRCS.
2. The next National Conference in year 2001 address the plans developed by the regional conferences and formulate a national strategy for populating the NCSS database.

Item 1 discussion: The group emphasized that the data must be accurate, that there should be a priority list of data to be collected, and that there is a world of data already available that needs to be recorded.

MOTION: Larry West, GA, made a motion that the national office consider having a reporting item for time that field soil scientists spend collecting data on soil properties; seconded by Moye Rutledge, AR.

Discussion followed. Ben Stuckey, SC felt that a reporting item was not needed. Michael Golden, TX, indicated that we need to get in the database what we already have collected. John Jenkins asked, when you get the data, what do you populate?

After discussion, West amended his motion to read:

AMENDED MOTION: That the national office encourage field soil scientists to gather data on hydraulic conductivity properties; seconded by Bill Smith, SC. Motion carried.

Item 2 discussion:

MOTION: Wayne Hudnall, LA, made a motion that the group follow the guidelines and refer this topic to the Regional Research Committee; seconded by Bill Puckett, AL. Motion carried.

Other topics:

MOTION: Bill Craddock, KY, called attention to the death of Charlie McElroy. Charlie was Head of the Soil Mechanics Laboratory in Fort Worth, TX for many years; he was an active participant of the Southern Soils Conference. Bill made a motion that the Southern Soils Conference send a letter of condolence to Charlie's family; second by George Martin, AL.

Bill Puckett, AL, indicated that the agency has made good progress in the area of technology. Somehow the conference needs a regional research project to utilize the new technology.

MOTION: Wayne Hudnall, LA, made a motion that an action item for national conference next year should include an agenda item featuring technology; seconded by Darwin Newton, TN. Motion carried.

Location of the meeting in 2002: It is Mississippi's turn to host the meeting in 2002, but the State Soil Scientist and the University representative have just retired. In light of this action, Edward Ealy, GA, invited the group to meet in Georgia in 2002. The group accepted his gracious invitation.

MOTION: Larry West, GA, commended Dr. Shaw and Dr. Puckett for hosting the meeting in Alabama in 2000; second by Bill Smith, SC. Motion carried.

MOTION: Bill Puckett made a motion that the meeting be adjourned; seconded by Larry West. Motion carried.

The meeting was adjourned at 3:30 PM.

Notes taken by,

JULIE A. BEST
Public Affairs Specialist
for MLRA Soil Survey Region #15

Action Register
Southern Soils Conference
June 18-22, 2000
Auburn, AL

1. Soils of the South Region Project -- West to complete by October 2000

2. Southern Regional Experiment Station Home Page -- West to complete by September 2000

3. Taxonomy Committee report

4. Southern Regional Research Needs Committee report

5. Determine if there is a National Committee on Research Needs -- Berman Hudson is to look into this matter.

6. Southern Regional Technical Committee for Hydric Soils
   Daigle to chair, solicit members for TBD slots, and call the first meeting.
   West to poll university representatives to get replacements for Pettry and Vepraskas

7. Promote the value of an MLRA project soil survey.
   Encourage combined meetings where state conservationists, state soil scientists, and university representatives have opportunities for interaction.
   Hudson to attempt to get an invitation to the Association of Southern Experiment Stations meeting.

8. Identify additional uses of soil resource data to be tested in the southern region -- Norfleet to spearhead the project

9. Identify and develop strategies or methods to be used to increase the visibility of soil resources and the use of soil resource inventory products.

10. Request from Horace Smith that the conference develop a plan for collecting measured soil chemical and physical properties and hydraulic conductivity measurements in the field and laboratory to populate the NCSS database under the stewardship of NRCS.
    Suggest that the national office encourage field soil scientists to gather hydraulic properties data.

11. Request from Horace Smith to formulate a national strategy for populating the NCSS database.
    Refer to the Regional Research Needs Committee the task of formulating a strategy for populating the NCSS database.

12. Send a letter of condolence to the family of Charlie McElroy.

13. Refer to the National Conference planning committee the suggestion to include an agenda item featuring technology.

14. Georgia will host the 2002 meeting.

Participants
Business Meeting
Southern Soils Conference
Auburn, AL
June 21, 2000

1. Achen, Aaron .....USDA-NRCS, Lincoln, NE (assigned to Auburn, AL)
2. Anderson, Scott .....USDA-NRCS, Auburn, AL
3. Best, Julie A. .....USDA-NRCS, Auburn, AL
4. Branson, Janice.....University of Tennessee, Knoxville, TN
5. Cortés, Milton .....USDA-NRCS, Raleigh, NC
6. Craddock, Bill ..... USDA-NRCS, Lexington, KY
7. Daigle, Jerry ..... USDA-NRCS, Alexandria, LA
8. Ealy, Edward .....USDA-NRCS, Athens, Athens, GA
9. Emino, Everett R. .....University of Florida, Gainesville, FL
10. Fielder, Rick .....USDA-NRCS, Little Rock, AR
11. Ford, Jimmy ..... USDA-NRCS, Stillwater, OK
12. Fox, Bobby .....USDA-NRCS, Decatur, AL
13. Golden, Mike.....USDA-NRCS, Temple, TX
14. Griffin, Edward .....USDA-NRCS, Temple, TX
15. Harris, MacArthur C. .....USDA-NRCS, Greensboro, AL
16. Henderson, Warren..... USDA-NRCS, Gainesville, Gainesville, FL
17. Hudnall, Wayne H..... Louisiana State University, Baton Rouge, LA
18. Hudson, Berman.....USDA-NRCS, Lincoln, NE
19. Jenkins, John .....USDA-NRCS, Nashville, TN
20. Kelley, John.....USDA-NRCS, Raleigh, NC
21. Latimore, Jr., Mark.....Fort Valley State University, Fort Valley, GA
22. Lawrence, Steve ..... USDA-NRCS, Athens, GA
23. Long, Sylvia .....USDA-NRCS, Auburn, AL
24. Lubich, Ken..... USDA-NRCS, Madison, WI
25. Lynn, Warren .....USDA-NRCS, Lincoln, NE
26. Manu, Andrew..... Alabama A&M University, Huntsville, AL
27. Martin, George .....USDA-NRCS, Auburn, AL
28. Murphy, Ken .....USDA-NRCS, Jackson, MS
29. Newton, Darwin L.....USDA-NRCS, Nashville, TN
30. Norfleet, Lee..... USDA-NRCS, Soil Quality Institute, Auburn, AL
31. Pringle, Russ.....USDA-NRCS, WLI, Baton Rouge, LA
32. Puckett, William E. .....USDA-NRCS, Auburn, AL
33. Ragus, Jerry..... USDA-Forest Service, Atlanta, GA
34. Rutledge, E. Moye.....University of Arkansas, Fayetteville, AR
35. Sample, Chuck .....USDA-NRCS, Stillwater, OK
36. Santiago, Carmen L..... USDA-NRCS, Hato Rey, PR
37. Shaw, Joey.....Auburn University, Auburn, AL
38. Smith, Bill R.....Clemson University, Clemson, SC
39. Steptoe, Jr., Levi.....USDA-NRCS, Nacogdoches, TX

40. Stuckey, Ben.....USDA-NRCS, Columbia, SC
41. Ward, Larry.....USDA-NRCS, Little Rock, AR
42. West, Larry.....University of Georgia, Athens, GA
43. White, Christie L..... Alabama Department of Public Health, Montgomery, AL

MINUTES
NRCS Business Meeting
Southern Region Soil Survey Work Planning
Conference
Auburn, Alabama
June 19, 2000

Berman Hudson called the meeting to order at 4:45 PM. Thirty-four persons attended the meeting.

There was no old business from the last meeting. The group reviewed the proposed new business agenda items. **John Jenkins**, TN, asked that Publication of the Soil Survey be added to the list of topics for discussion.

Berman opened the meeting with a discussion, as suggested by John Jenkins, of the publication of the soil survey. John indicated that it is discouraging to soil users to have to wait several years for a traditionally published soil survey. The technology is there to produce the survey in a relatively short period of time. Numerous people spoke to this issue. It is possible to issue a digital survey in a relatively short period of time—it can be done, it has been done. The issue seems to be that there needs to be consistency in the way that it is done.

MOTION: Jerry Daigle, LA, recommended that the National Cooperative Soil Survey initiate policy to put forth a set of guidelines to enable states to issue a digital soil survey as soon as the correlation is signed. There was a second by **John Jenkins**, TN. **Motion carried.**

1. Update from MLRA Office 13, 14, & 15 Board of Directors Meeting

   Bill Puckett indicated that at the recent MO-13, 14, 15 Board of Directors Meeting, a topic of discussion was realignment of MO boundaries (i.e. MLRAs 129 and 148). State Conservationists determined that there must have been a reason for the boundaries to have been drawn as they were. The State Conservationists decided to leave the boundaries the way they are.

2. General Soils Maps created from SSURGO

   The technology is already available to do this.

3. Recommendation to Soil Survey Division to make NASIS more user friendly

   The NASIS system is not user friendly. Clients outside our agency have difficulty using NASIS to get information. Ideally, the data needs to be user friendly and available via the Internet.

   The State Conservationists will make a recommendation to the Soil Survey Division to see how this can be rectified.

4. What numbers are in NASIS for T-factors? Where is the historical information? Is the data consistent?

   Consensus is that there needs to be national input to give the MO's and states the capability to modify data.

5. Are states consistent in using Land Capability Classifications?

   NRCS doesn't use land capability classifications. However, customers like the information and want it to be up-to-date. State governments use the data for various purposes.

6. MLRA Super Project Offices (how many and where?)

   The Super Project Office concept is a consideration in many states. Because of this, **Horace Smith** wants a national plan to provide consistency. He wants to know how many offices there should be, where they will be located, and how they will be staffed.

   Mike Golden, TX, indicated that MO's-9 and 16 have already set up super project offices.

7. Update on status of STATSGO

   Scott Anderson, AL, indicated that there are two things going on: 1) MO's were queried to determine what is needed, what is missing, and at what ratio. 2) The database is being converted from the old 3SD to NASIS. MO's are to report errors before the data is merged.

Berman called on **Maurice Mausbach** for comments. Maury addressed three areas:

1. He indicated that the Farmland Policy Protection Act (FPPA) is a current issue and they are putting appropriate staff on the FPPA at NHQ.
2. Maury emphasized that **Marcy Kaptur, OH,** is a legislator who is concerned about the loss of farmland. There are legislators who want information about prime farmland.
3. He is concerned about attribute data. He indicated that the Agency needs to take a look at state boundaries and insure attribute consistency.

John Kelley, NC, indicated that some states cease to map erosion phases. He wanted to know how headquarters feels about this. **Maury** responded by saying that if you think you can do it consistently, do so. It is difficult to maintain consistency among states.

Wayne Hudnall, LA, Experiment Station representation to the NRCS group, asked about the function of the Southern Regional Soil Taxonomy Committee—is it still in action, who is the chair, and who are the members? If not, why not? He had the same questions about the National Soil Taxonomy Committee.

Southern Regional Soil Taxonomy Committee: The by-laws state that the permanent chair is the lead scientist, Soil Taxonomy. Permanent members of the committee include the team

leaders for MO's 9, 13, 14, 15, and 16. Three experiment station representatives will be elected on a rotating basis. The term of office for the rotating members is three years, with two members elected at each biennial conference. One member's term will begin immediately and the other will begin one year later.

The mechanism is in place for the committee to function. A key element seems to be the election of a co-chair. This group needs to make a commitment to elect the co-chair.

Bill Puckett, AL, asked about the status of the Southern Regional Hydric Soils Committee. **Jerry Daigle**, LA, indicated that after the meeting in Baton Rouge, he made the preliminary contacts to organize the committee. He later heard from Wade Hurt that the National Committee for Hydric Soils would select the committee members. Nothing more has been done.

Berman indicated that in his role as an advisor to the National Hydric Soils Committee, he would think about this issue and make a recommendation about the committee.

Berman stated that prior to the next business meeting in 2002, he would query states for agenda items.

The meeting adjourned at 6:10 PM.

Notes taken by:

Julie A. Best
Public Affairs Specialist
MO-15

IEG-22 Business Meeting Minutes
June 19, 2000
Auburn, Alabama

The meeting was called to order at 4:50 p.m. by Vice-chair Larry West, in the absence of Chair Tom Ammons.

Old Business

Minutes of the June 23, 1998 meeting in Baton Rouge, LA, were distributed, then approved without dissent.

Dr. Everett Emino reported from the Southern Regional Experiment Sation Directors (SRESD). He indicated that each work group must renew every five years and IEG-22 was due for renewal. After discussion on how the work group could/should operate between biennial meetings, Dr. Emino agreed to file the renewal request with the SRESD. Some discussion was favorable in support for meeting yearly as the format of meeting with the Regional Soil Survey Workshop does not allow sufficient time to pursue subjects of most interest to IEG-22 in detail. No decision was made on meeting annually.

Dr. Emino expressed concern on the lack of progress on updating *Soils of the Southern States and Puerto Rico*. Dr. West reported that the maps for each state will be as great groups and should be available in September or October, 2000, for review. Bill Puckett is helping to produce the maps.

Warren Lynn asked for other comments on STATSCO maps relative to their use in teaching. Two views emerged as some favored the maps while most preferred other map units for a teaching format.

Mary Collins reported that the National Soil Survey Advisory Committee no longer exists after the 1998 meeting in San Antonio, TX.

Vice-chair West indicated that he would send a copy of the By-Laws and the minutes to all members of the workgroup.

New Business

Mary Collins pointed out shortcomings in the web-available data bases and encouraged NRCS to update these. All agreed that updating was important but that time was a major limitation.

New members of the Southern Regional Soil Taxonomy Committee were elected. Members and terms are as follows:

Mary Collins (January 1, 1998 to December 31, 2000)
Mike Vepraskas (January 1, 1999 to December 31, 2001)
Larry West (January 1, 2000 to December 31, 2002)
Moye Rutledge (January 1, 2001 to December 31, 2003)
Joey Shaw (January 1, 2002 to December 31, 2004)

Format for the Southern Soils Conference was discussed. Consensus was that the length as reflected in the Auburn meeting was about right. The work group voted to support Mississippi as the host for the 2002 Southern Soils Conference.

Discussions were opened to consider the purpose of the working group and a central project to which each could contribute, part of which included "putting the cooperative" back into soil survey. One suggestion was a regional training project. Because of time limitations, Mary Collins, Moye Rutledge and Larry West will constitute a committee to investigate a regional project concerned with training soil scientists.

Since Tom Ammons was unable to attend, the election of new officers was postponed and current officers were asked to serve in the same capacity for another term. Officers for the next two years will remain as:

Chair - Tom Ammons
Vice-chair - Larry West
Secretary - Tom Hallmark

The minutes note that Wayne Hudnall was our IEG-22 representative to the concurrent agency meeting, and his report of that meeting will be attached to the minutes.

The meeting was adjourned at 6:30 p.m.

Attendance:

Name	University/Agency	e-Mail Address
Janice Branson	Univ. of Tennessee	jbranso1@utk.edu
A-xing Zhu	Univ. of Wisconsin-Madison	axing@geography.wisc.edu
Juan G. Perez-Bolavar	Univ. of Florida	jgp@gnv.ifas.ufl.edu
Mary E. Collins	Univ. of Florida	mec@gnv.ifas.ufl.edu
Everett R. Emino	Univ. of Florida	ere@gnv.ifas.ufl.edu
Warren Lynn	NRCS, Lincoln, NE	warren.lynn@nssc.nrcs.usda.gov
Randy Brown	Univ. of Florida	rbb@gnv.ifas.ufl.edu
Mark Latimore, Jr.	Fort Valley State Univ.	latimorm@fvsu.edu
Moye Rutledge	Univ. of Arkansas	erutledg@comp.uark.edu
Joey Shaw	Auburn Univ.	jnshaw@acesag.auburn.edu
Tom Hallmark	Texas A&M Univ.	hallmark@tamu.edu
Larry West	Univ. of Georgia	lwest@arches.uga.edu

BY-LAWS FOR THE SOUTHERN REGIONAL COOPERATIVE SOIL SURVEY CONFERENCE

ARTICLE I NAME

Section 1.0 The name of the Conference shall be the Southern Regional Cooperative Soil Survey Conference.

ARTICLE II GEOGRAPHIC BOUNDARY

Section 1.0 The Southern Region corresponds to the Agricultural Experiment Station Southern Region and includes the states of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and the Caribbean Area.

ARTICLE III PURPOSE

Section 1.0 The purpose of the Southern Regional Cooperative Soil Survey Conference is to bring together representatives of the National Cooperative Soil Survey in the southern states for discussion of technical, scientific, and other general questions and issues of importance to the Cooperative Soil Survey Program. Through the actions of committees and conference discussions, experience is summarized and clarified for the benefit of all; new areas are explored; procedures are synthesized; and ideas are exchanged and disseminated. The conference also functions as a clearinghouse for recommendations and proposals received from individual members and state conferences for transmittal to the National Cooperative Soil Survey Conference.

ARTICLE IV PARTICIPANTS

Section 1.0 Permanent participants of the conference are the following:

Section 1.1 The NRCS State Soil Scientist, Staff Soil Scientists, and the MLRA Office Soil Scientists responsible for each of the states and U.S. Territories assigned to the South Region.

Section 1.2 The Experiment Station or University's National Cooperative Soil Survey Leader(s) of each of the states and U.S. Territories assigned to the South Region.

Section 1.3 Representatives from the 1890 Land Grant Universities and Tuskegee University.

Section 1.4 Soil Scientists assigned to the NRCS Southeast and South Central Regional Offices.

Section 1.5 National Soil Survey Center Liaisons assigned to the MLRA Offices within the South Region.

Section 1.6 Representative from the National Cartography and Geospatial Center.

Section 1.7 Representative from the Information Technology Center at Ft. Collins, Colorado.

Section 1.8 Representatives from the regional soils staff of the USDA Forest Service.

Section 1.9 Soils discipline representative from the Tennessee Valley Authority.

Section 1.10 Representative from the National Society of Consulting Soil Scientists, Inc.

Section 2.0 On the recommendation of the Steering Committee, the Chair of the conference may extend invitations to other individuals to participate in committee work and in the conference. Any soil scientist or other technical specialists of any state or federal agency or private consultant whose participation is helpful for particular objectives or projects of the conference may be invited to attend.

ARTICLE V ORGANIZATION AND MANAGEMENT

Section 1.0 Steering Committee

A Steering Committee assists in the planning and management of the biennial conference, including the formulation of committee memberships, selection of the committee chair and vice-chair, and organizing the program of the conference.

Section 1.1 Steering Committee Membership

The Steering Committee consists of five members:

a. The conference chair.
b. The conference vice-chair.
c. Soil Scientist assigned to either the Southeast or South Central Regional Office of NRCS.
d. One MLRA Team Leader.
e. The past conference chair.

Appendix III contains a schedule that can be used to determine the appropriate rotations of assignments.

The Steering Committee is chaired by the Soil Scientist serving under item 3 above.

The Steering Committee may designate a conference chair and vice-chair if the persons designated in Section 2.0 are unable to fulfill their obligations.

Section 1.2 Meetings and Communications

A planning meeting will be held about 1 year prior to the conference. The chair may schedule additional meetings if the need arises.

Most of the steering committee's communications will be in writing. Copies of all correspondence between members of the committee shall be sent to all members of the steering committee.

Section 1.3 Authority and Responsibilities

Section 1.3.1 Conference participants

The Steering Committee formulates policy on conference participants, but final approval or disapproval of changes in policy is by consensus of the participants.

The Steering Committee makes recommendations to the conference for extra and special participants in specific conferences.

Section 1.3.2 Conference Committees

The Steering Committee formulates the conference committee membership and selects the committee chair and vice-chair.

The Steering Committee is responsible for the formulation of committee charges.

Section 1.3.3 Conference Policies

The Steering Committee is responsible for the formulation of statements of conference policy. Final approval of such statements is by consensus of the conference participants.

Section 1.3.4 Liaison

The Steering Committee is responsible for maintaining liaison between the regional conference and:

1. The Experiment Station Directors within the Southern Region.
2. The State Conservationists, NRCS, for the states within the Southern Region.
3. The Regional Conservationists for the Southeast and South Central NRCS regions.
4. Director, Soils Division, NRCS.
5. Regional and national offices of the U.S. Forest Service.
6. The National Cooperative Soil Survey Conference.
7. Southern Forest Soils Research Council.
8. Other cooperating and participating agencies and private individuals.

Section 1.4 Responsibilities of the Steering Committee Chair are:

Section 1.4.1 Call a planning meeting of the Steering Committee about 1 year in advance of the conference to plan the agenda, and if possible, at the scheduled location of the conference.

Section 1.4.2 Develop with the Steering Committee the conference's committees and their charges.

Section 1.4.3 Send committee assignments to committee members. The committee assignments will be determined by the Steering Committee at the planning meeting. The proposed chair and vice-chair of each committee will be contacted personally by a member of the conference steering committee and asked if they will serve prior to final assignments.

Section 1.4.4 Compile and maintain a conference mailing list (can be copies on mailing labels).

Section 2.0 Conference Chair and Vice-Chair

The conference chair and vice-chair are the State Soil Scientist and Experiment Station Soil Survey Leader from the state where the next conference is to be held. These officers serve a two-year term from close of conference to close of conference. The chair position, for each two-year period, alternates between the state soil scientist and experiment station representative. This sequence may be altered by the Steering Committee for special situations.

Section 2.1 Responsibilities of the conference chair:

Section 2.1.1 Functions as chair of the biennial conference.

Section 2.1.2 Planning and management of the biennial conference.

Section 2.1.3 Serve as a member of the Steering Committee.

Section 2.1.4 Send out a first announcement of the conference about 9 months prior to the conference.

Section 2.1.5 Send out written invitations to all speakers or panel members and representatives from other regions. These people will be contacted beforehand by phone or in person by various members of the steering committee.

Section 2.1.6 Send out written requests to Experiment Station representatives to find out if they will be presenting a report at the conference.

Section 2.1.7 Notify all speakers, panel members, and Experiment Station representatives in writing that a brief written summary of their presentation will be requested after the conference is over. This material will be included in the conference's proceedings.

Section 2.1.8 Preside over the conference.

Section 2.1.9 Provide for appropriate publicity for the conference.

Section 2.1.10 Preside at the business meeting of the conference.

Section 2.1.11 Appoint a recording secretary to take minutes of the business meeting and prepare minutes for inclusion in the proceedings of the conference.

Section 2.2 Responsibilities of conference vice-chair:

Section 2.2.1 Serve as Program Chair of the biennial conference.

Section 2.2.2 Serve as a member of the Steering Committee.

Section 2.2.3 Act for the chair in the chair's absence or disability.

Section 2.2.4 Develop the program agenda of the conference. Time is to be provided on the conference agenda for separate state and federal meetings.

Section 2.2.5 Make the necessary arrangements for lodging accommodations for conference members, for food or social functions, for meeting rooms, including committee rooms, and for local transport for official functions. Notify all persons attending the conference of the arrangement for the conference (rooms, etc.). Included in the last mailing will be a copy of the agenda.

Section 2.2.6 Compile and distribute the proceedings of the conference. If these by-laws are amended, the proceedings shall contain a copy of the new by-laws.

Section 3.0 Past Conference Chair

The primary responsibility of the past conference chair is to provide continuity from conference to conference. Additional responsibilities include the following:

Section 3.1 Serve as a member of the Steering committee.

Section 3.2 Assist in planning the conference.

Section 4.0 Administrative Advisors

Administrative advisors to the conference consist of a NRCS State Conservationist (usually, but not necessarily, from the state where the conference is held) and an Experiment Station Director (usually, but not necessarily from the state where the conference is held). In addition, other advisors may be selected by the steering committee or the conference.

ARTICLE VI TIME AND PLACE OF CONFERENCE

Section 1.0 The conference convenes every two years, in even-numbered years. During the biennial business meeting, invitations from the various states are considered, discussed and voted upon. A simple majority vote decides the location of the next conference. Appendix I can be used as a guide for determining meeting locations. The date and specific location will be determined by the Steering Committee.

ARTICLE VII CONFERENCE COMMITTEES

Section 1.0 Most of the work of the conference is accomplished by duly constituted committees.

Section 2.0 Each committee has a chair and vice-chair. A secretary or recorder may be selected by the chair, if necessary. The committee chair and vice-chair are selected by the Steering Committee.

Section 3.0 The kinds of committees and their members are determined by the Steering Committee. In making their selections, the Steering Committee makes use of expressions of interest filed by the conference participants.

Section 4.0 Much of the work of committees will of necessity be conducted by correspondence between the times of biennial conferences. Committee chairs are charged with the responsibility for initiating and carrying forward this work.

Section 5.0 Each committee shall make an official report at the designated time at each biennial conference. Chair of committees is responsible for submitting the required number of committee reports promptly to the vice-chair of the conference.

Section 5.1 Suggested distribution is:

Section 5.1.1 One copy to each participant on the mailing list.

Section 5.1.2 One copy to each State Conservationist, NRCS, and Experiment Station Director in the Southern Region

Section 5.1.3 Five copies to the Director of Soils, NRCS, for distribution to National Office staff.

Section 5.1.4 Ten copies to the National Soil Survey Center (NSSC) for distribution to staff in the Center.

Section 5.1.5 Three copies to the Soil Scientists representing the Southeast and South Central NRCS regions for distribution and circulation to both the NRCS and cooperators within their regions.

Section 5.1.6 Five copies to the Forest Service Regional Soil Scientist.

ARTICLE VIII REPRESENTATIVES TO THE NATIONAL AND REGIONAL SOIL SURVEY CONFERENCES

Section 1.0 At least one state and one federal member will represent this conference at the National Cooperative Soil Survey Conference. Selections are to be made by the appropriate administrators. Representatives will report back to their respective state or federal group.

Section 2.0 One member of the Steering Committee will represent the Southern Region at the Northeast, North Central and West Regional Soil Survey Conference. If none of the members of the Steering Committee can attend a particular conference, a member of the conference will be selected by the Steering Committee for this duty.

ARTICLE IX SOUTHERN REGIONAL SOIL TAXONOMY COMMITTEE

Section 1.0 Membership of the standing committee is as follows:

a. Lead Scientist, Soil Taxonomy (permanent chair).
b. MLRA Team Leaders representing MLRA Regions 9, 13, 14, 15, and 16 (permanent members).
c. Three experiment station representatives (rotating members).

Section 2.0 At their respective business meetings, the experiment station representatives will be elected to serve on this committee. The term of membership is three years, with two members elected at each biennial conference. One member's term will begin immediately and the other will begin one year later.

ARTICLE X SOUTHERN REGIONAL TECHNICAL COMMITTEE FOR HYDRIC SOILS

Section 1.0 Membership of the standing committee is as follows:

1. Three university members
2. Three USDA Natural Resources Conservation Service (NRCS) members
3. One U.S. Environmental Protection Agency (EPA) member
4. One U.S. Army Corps of Engineers (CORPS) member
5. One U.S. Fish and Wildlife Service (FWS) Member
6. One USDA Forest Service (FS) members
7. One member of the National Society of Consulting Soil Scientists, Inc. (NSCSS).

Section 2.0 At their respective business meetings during the biannual conference, the university and NRCS representatives will be elected to serve on this committee. The term of membership is three years, with two members elected at each biannual conference. One newly elected member's term will begin immediately and the other will begin one year later.

The method for placing members on the committee used by the other agencies will be determined by those agencies' regional or national leadership.

ARTICLE XI AMENDMENTS

Section 1.0 Any part of this statement of By-Laws may be amended any time by majority agreement of the conference participants.

By-Laws Adopted June 9, 1990
By-Laws Amended July 11, 1968
By-Laws Amended May 7, 1970
By-Laws Amended May 25, 1984
By-Laws Amended June 22, 1990
By-Laws Amended April 19, 1996
By-Laws Amended June 26, 1998

Appendix I: Southern Regional Soil Taxonomy Committee

NSSC Lead Soil Scientist Bob Ahrens (Permanent Chair)

NRCS MLRA Team Leaders (Permanent Members):
(Co-chair elected by NRCS friendly consensus)

MO-09	Michael L. Golden
MO-13	Stephen G. Carpenter
MO-14	Craig A. Ditzler
MO-15	Cameron J. Loerch
MO-16	Charles L. Fultz

University Members (Rotating Membership):

1.
2.
3.

Appendix II: Southern Regional Technical Committee for Hydric Soils

Affiliation	1998	1999	2000	2001	2002
University	David Pettry	David Pettry	David Pettry	David Pettry	
University	Mike Vepraskas	Mike Vepraskas	Mike Vepraskas		
University	Wayne Hudnall	Wayne Hudnall			
NRCS	Jerry Daigle	Jerry Daigle	Jerry Daigle	Jerry Daigle	
NRCS	John Gagnon	John Gagnon	John Gagnon		
NRCS	Ben Stuckey	Ben Stuckey	Wes Miller	Wes Miller	Wes Miller
EPA					
CORPS					
FWS					
FS					
NSCSS					

APPENDIX III **RECOMMENDATIONS FOR FUTURE CONFERENCE LOCATIONS; CONFERENCE CHAIR AND VICE CHAIR; STEERING COMMITTEE CHAIR; AND MLRA OFFICE REPRESENTATIVE TO STEERING COMMITTEE.**

YEAR	HOST STATE	CONFERENCE CHAIR	CONFERENCE VICE CHAIR	STEERING CHAIR	STEERING MLRA REP.
1998	LA	SSS - LA	EXP STA - LA	SOUTH CENTRAL	RALEIGH
2000	AL	EXP STA - AL	SSS - AL	SOUTHEAST	TEMPLE
2002	MS	SSS - MS	EXP STA - MS	SOUTH CENTRAL	MORGANTOWN
2004	GA	EXP STA - GA	SSS - GA	SOUTHEAST	LITTLE ROCK
2006	OK	SSS - OK	EXP STA - OK	SOUTH CENTRAL	AUBURN
2008	FL	EXP STA - FL	SSS - FL	SOUTHEAST	TEMPLE
2010	TX	SSS - TX	EXP STA - TX	SOUTH CENTRAL	RALEIGH
2012	KY	EXP STA - KY	SSS - KY	SOUTHEAST	LITTLE ROCK
2014	TN	SSS - TN	EXP STA - TN	SOUTH CENTRAL	AUBURN
2016	PR	EXP STA - PR	SSS - PR	SOUTHEAST	TEMPLE
2018	NC	SSS - NC	EXP STA - NC	SOUTH CENTRAL	MORGANTOWN
2020	AR	EXP STA - AR	SSS - AR	SOUTHEAST	LITTLE ROCK
2022	SC	SSS - SC	EXP STA - SC	SOUTH CENTRAL	RALEIGH
2024	LA	EXP STA - LA	SSS - LA	SOUTHEAST	TEMPLE

In addition to the above, the past conference chair also serves on the steering committee.

Southern Soils Conference

Participants List - June 18-22, 2000, Auburn, AL

Name	Title	Address	Phone #	Fax	Email
Achen, Aaron	Editor	USDA-NRCS 100 Centennial Mall N Room 152, MS 33 Lincoln, NE 68508-3866	402-437-4157		aaron.achen@nssc.nrcs.usda.gov
Anderson, Scott	Soil Data Quality Specialist	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4565	334-887-4551	scott.anderson@al.usda.gov
Best, Julie A.	Public Affairs Specialist	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4549	334-887-4551	julie.best@al.usda.gov
Brannon, Greg	Soil Data Quality Specialist	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4563	334-887-4551	greg.brannon@al.usda.gov
Branson, Janice		8409 Wood Dr Corryton, TN 37721	865-685-6101	865-974-7997	jbranso1@utk.edu
Brown, Randall B.	Professor & Chair	Soil and Water Science 106 Newell Hall University of Florida Gainesville, FL 32611-0510	352-392-1803, ext. 344	352-392-3399	rbb@gnv.ifas.ufl.edu
Burns, John	Soil Scientist	USDA-NRCS 203 North Midway St Clayton, AL 36016	334-775-3266	334-775-9524	john.burns@al.usda.gov
Carter, Emily A	Research Soil Scientist	USDA-Forest Service 520 DeVall Drive Auburn, AL 36849	334-826-8700	334-821-0037	ecarter@fs.fed.us

Collins, Mary E.	Professor of Environmental Pedology	PO Box 11029 University of Florida Gainesville, FL 32611-0290	352-392-1951	352-392-3902	MEC@GNV.IFAS.UFL.EDU
Cortes, Milton	Asst State Soil Scientist	USDA-NRCS 4405 Bland Rd, Ste 205 Raleigh, NC 27549	919-873-2171	919-873-2181	milton.cortes@nc.usda.gov
Craddock, Bill	State Soil Scientist	771 Corporate Drive Suite 110 Lexington, KY 40503-5479	859-224-7369	859-224-7410	bill.craddock@ky.usda.gov
Daigle, Jerry J.	Assistant State Conservationist (Soil & Resources Assessment)	3737 Government Street Alexandria, LA 71302	318-473-7757	318-473-7771	jerry.daigle@la.usda.gov
Ealy, Edward P.	State Soil Scientist	USDA-NRCS 355 E. Hancock Ave MS 208 Athens, GA 30601	706-546-2278	706-546-2145	edward.ealy@ga.usda.gov
Emino, Everett R.	Professor	University of Florida PO Box 110200 Gainesville, FL 32611-0200	352-392-1787	352-392-4965	ere@gnv.ifas.ulf.edu
Fielder, Richard	Soil Scientist - MO-16	90 Windsong Cove Cobot, AR 72023	501-301-3172	501-301-3189	rick.fielder@ar.usda.gov
Ford, Jimmy G.	State Soil Scientist	100 USDA Suite 208 Stillwater, OK 74074-2655	405-742-1247	405-742-1201	jimmy.ford@ok.usda.gov
Fox, Bobby	Resource Soil Scientist	USDA-NRCS 4511 Hwy 31 South Decatur, AL 35603-9175	256-353-6143	256-355-8285	bobby.fox@al.usda.gov
Fristoe, Thomas "Conner"	Regional Silviculturist The Timber Company	PO Box 717 Crossett, AR 71635	870-567-5352	870-567-5049	conner.fristoe@timbercompany.com

Fultz, Charles	State Soil Scientist	7600 Eagle Point Dr N. Little Rock, AR 72116	501-301-3116	501-301-3189	charles.fultz@ar.usda.gov
Golden, Mike	MO-9 Team leader	USDA-NRCS 101 South Main Temple, TX 76501	254-742-9851	254-742-9859	mike.golden@tx.usda.gov
Gray, David	Prof Soil Classifier	AL Public Health Detp RSA Tower Suite 1250 201 Monroe St Montgomery, AL 36130	334 206-5375	334-260-5788	davidgray@adph.state.al.us
Griffin, Edward L.	Soil Data Quality Specialist	5111 Waterford Court Temple, TX 76502	254-742-9856	254-742-9859	egriffin@tx.nrcs.usda.gov
Guthrie, Richard	Associate Dean	College of Agriculture Auburn University Auburn, AL 36849	334-844-3211	334-844-4814	guthrrl@auburn.edu
Hairston, James E.	Professor & ACES Water Quality Coordinator	202 Funchess Hall Auburn University, AL 36849-5633	334-844-3973	334-844-3945	jhairsto@acesag.auburn.edu
Hajek, Ben	Professor Emeritus	Auburn University Auburn, AL 36849			
Hallmark, Tom	Professor	Soil & Crop Sciences Texas A&M University College Station, TX 77843-2474	979-845-4678	979-845-0456	hallmark@tamu.edu
Harris, MacArthur	Project Leader	USDA-NRCS 1006 Centreville St Greensboro, AL 36744	334-624-7577		macarthur.harris@al.usda.gov
Henderson, Warren G.	State Soil Scientist	2614 NW 43rd Street Gainesville, FL 32609	352-338-9535	352-338-9578	warren.henderson@fl.usda.gov

Hoper, Heinrich	Visiting Soil Scientist	Soil Quality Institute Auburn, AL			
Hudnall, Wayne H.	Professor	104 Sturgis Hall Louisiana State Univ Baton Rouge, LA 70803	225-388-1344	225-388-1403	whudnall@agctr.lsu.edu
Hudson, Berman D.	National Leader, Soil Survey Interpretations	USDA-NRCS Federal Bldg, Rm 152 100 Centennial Mall, N Lincoln, NE 68508-3866	402-437-4084	402-437-5996	berman.hudson@nssc.nrcs.usda.gov
Hulcher, Richard	Chief, Permits	ADEM PO Box 301463 Montgomery, AL 36130-1463	334-394-4309		rsh@adem.state.al.us
Jackson, Alfred K.	Soil Evaluator	433 Carriage Dr Birmingham, AL 35214	205-791-0298		
Jenkins, Johnson C.	SDQS-MO-13	USDA-NRCS 675 U.S. Courthouse 801 Broadway Nashville, TN 37203	615-736-5476	615-736-7764	jjenkins@tn.nrcs.usda.gov
Johnson, Ken	Resource Soil Scientist	USDA-NRCS 127A Clarke St Grove Hill, AL 36451	334-275-3185	334-275-8888	ken.johnson@al.usda.gov
Jones, Michael	Asst Proj Mgr	208 S. Main St Warren, AR 71671	870-226-7854	Same	soilmap@ipa.net
Kelley, John A.	Soil Scientist	USDA-NRCS 4406 Bland Rd, Ste 205 Raleigh, NC 27609	919-873-2137	919-873-2181	john.kelley@nc.usda.gov
Kpomblekou-A, Kokoasse	Res Asst Prof	211 Campbell Hall Tuskegee University Tuskegee, AL 36088	334-724-4521	334-724-4451	kka@tusk.edu

Latimore, Mark	Extension Specialist - Agronomy	PO Box 4061 - FVSU Fort Valley State Univ Fort Valley, GA 31030-4313	912-825-6269	912-825-6299	latimorm@mail.fvsu.edu
Lawrence, Steve	Soil Scientist	USDA-NRCS 355 East Hancock Ave Athens, GA 30601	706-546-2077	706-546-2114	steve.lawrence@ga.usda.gov
Lindbo, David L	Assistant Professor	V. James Res & Ext Ctr 207 Res Station Rd Plymouth, NC 27962	919-793-4428	919-793-5142	david_lindbo@ncsu.edu
Long, Sylvia A.	Resource Data Collection Specialist	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4566	334-887-4551	sylvia.long@al.usda.gov
Lubich, Kenneth	National Soil Survey Digitizing Coordinator	6515 Watts Road Madison, WI 53719	608-276-8732, ext. 248	608-276-5890	ken.lubick@wi.usda.gov
Lynn, Warren C.	Soil Scientist	NRCS-Soil Survey Lab Federal Bldg Rm 152 MS41 Lincoln, NE 68508-3866	402-437-5135	402-436-5760	warren.lynn@nssc.nrcs.usda.gov
Manu, Andrew	Professor	Alabama A&M University Plant & Soil Science Normal, AL 35762	256-858-4229	256-852-5429	amanu@aamu.edu
Martin, P. George	Soil Data Quality Specialist	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4562	334-887-4551	george.martin@al.usda.gov
Mausbach, Maurice J.	Deputy Chief, Soil Survey & Resource Assessment	USDA-NRCS 1400 Independance Ave Washington, DC 20250	202-690-4616	202-690-4390	maurice.mausbach@usda.gov
McGhee, Lawrence	Project Leader	USDA-NRCS 1995 Cherokee Road, Suite C Alexander City, AL 35010	256-234-5271	256-234-2468	lawrence.mcghee@al.usda.gov

Murphy, Ken	Soil Scientist	USDA-NRCS, Ste 1321 Federal Bldg 10 West Capitol St Jackson, MS 39269	601-965-5424, ext.239	601-965-4430	kmurphy@ms.nrcs.usda.gov
Newton, Darwin L.	Assistant State Conservationist (Soil Resources)	USDA-NRCS 675 U.S. Courthouse 801 Broadway Nashville, TN 37203	615-736-5476	615-736-7764	dnewton@tn.nrcs.usda.gov
Norfleet, lee	Soil Scientist	USDA-NRCS Soil Quality Institute 411 S. Donahue Dr. Auburn, AL 36832	334-844-4651	334-844-4789	norfleet@eng.auburn.edu
Page, Sandy	Project Leader	USDA-NRCS 1310B Hwy 43N Jackson, AL 36545	334-246-0245	334-246-9577	sanderson.page@al.usda.gov
Perez, Juan		2701 NW 23rd Blvd J-81 Gainesville, FL 32605	352-371-2213	352-391-1952	JGP@GNV.IFAS.UFL.EDU
Pringle, Russ	Soil Scientist	NRCS-LSU 104 Sturgis Hall Baton Rouge, LA 70803	225-388-1337	225-388-1403	rpringle@agctr.lsu.edu
Puckett, William E	State Soil Scientist	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4517	334-887-4551	bill.puckett@al.usda.gov
Ragus, Jerry	Regional Soil Scientist	USDA-Forest Service 1720 Peachtree Rd. NW Atlanta, GA 30309	404-347-7211	404-347-6197	ragus@fs.fed.us
Roberts, David C.	Resource Soil Scientist	1 Fen Oak Ct Madison, WI 53718	608-224-3752	608-224-3745	roberts, dave@co.dave.si.us
Rutledge, E. Moye	Professor of Pedology	115 Plant Science Bldg University of Arkansas Fayetteville, AR 72701	501-575-5737	501-575-7465	erutledg@comp.uark.edu

Sample, Chuck	Assistant State Soil Scientist	100 USDA Suite 208 Stillwater, OK 74074-2655	405-742-1249	405-742-1288	chuck.sample@ok.usda.gov
Santiago, Carmen	Soil Scientist Liaison	USDA-NRCS PO Box 364868 San Juan, PR 00936-4868	787-766-5206, ext. 240	787-766-5987	carmen@pr.nrcs.usda.gov
Schuster, Joe		Ecological Resource Consultants, Inc. 2209 Joan Avenue Panama City, FL 32408	850-230-1882		
Shaw, Joey	Asst. Professor	Dept of Agronomy & Soils 202 Funchess Hall Auburn, AL 36849	334-844-3957	334-844-3945	jnshaw@acesag.auburn.edu
Smith, Bill R.	Professor of Soils	Dept of Crop & Soil Env. Sci. Box 340359 Clemson, SC 27634	864-656-3526	864-656-3443	brsmith@clemson.edu
Spratling, Larry	Carto Technician	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4589	334-887-4551	larry.spratling@al.usda.gov
Steptoe, Levi	Project Leader	4613 NW Stalling Drive Nacagdoches, TX 73964	936-462-8184	936-560-4840	levi.steptoe@tx.usda.gov
Stubbs, Cleo	Soil Scientist	PO Box 2356 Decatur, AL 35602	256-637-7255	256-637-7214	clmistubbs@aol.com
Stuckey, Ben	State Soil Scientist	1835 Assembly St Rm 950 Columbia, SC 29201	803-253-3856	803-253-3776	ben.stuckey@sc. usda.gov
Torbert, John	Soil Productivity Manager	Mead Coated Board 1000 Broad Street Phenix City, AL 36867	334-448-6328	334-448-6476	jtorbert@mindspring.com

Ward, Larry B.	Soil Data Quality Specialist	USDA-NRCS Fed Bldg Rm 3411 700 West Capitol Ave Little Rock, AR 32201-3225	501-301-3163	501-301-3989	larry.ward@ar.usda.gov
West, Larry	Professor	Dept of Crop & Soil Sci 3111 Plant Sciences University of Georgia Athens, GA	706-542-0906	706-542-0914	west@uga.edu
White, Christy	Professional Soil Classifier	The RSA Tower Suite 1250 201 Monroe St Montgomery, AL 36130	334-206-5375	334-206-5788	
Zellmer, Rick	GIS Specialist	USDA-NRCS PO Box 311 Auburn, AL 36830	334-887-4576	334-887-4551	richard.zellmer@al.usda.gov
Zhu, A-Xing	Assistant Professor	Depart of Geography University of Wisconsin Madison, WI 53706	608-262-0272	608-265-3991	axing@geography,wisc.edu

Last Updated on 7/25/00
By Julie A. Best
Email: julie.best@al.usda.gov