National Cooperative Soil Survey

Newsletter

May 2003
Issue 23

In This Issue—

Editor's Note

Issues of this newsletter are available on the World Wide Web (http://soils.usda.gov/). Click on NCSS, then on Activities & Newsletters, and then on the desired issue number.

You are invited to submit stories for future issues of this newsletter to Stanley Anderson, National Soil Survey Center, Lincoln, Nebraska. Phone—402-437-5357; FAX—402-437-5336; email—stan.anderson@nssc.nrcs.usda.gov.

Terrestrial Ecosystem Survey Provides Ecological Information for Natural Resource Management

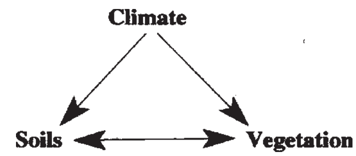
By George T. Robertson, USDA, Forest Service, Southwestern Region, Phoenix, Arizona, and Wayne A. Robbie and Steve H. Strenger, USDA, Forest Service, Southwestern Region, Albuquerque, New Mexico.

The USDA Forest Service is required to conduct comprehensive ecological surveys that analyze resource conditions and determine the existing and potential productivity of National Forest lands in the United States. To achieve this objective, the Forest Service uses the Terrestrial Ecosystem Survey (TES) to gather information about ecosystems on National Forests in Arizona and New Mexico and to apply this knowledge to ecosystem analysis, planning, and decision-making.

Definitions

Naturally occurring terrestrial ecosystems with unique sets of properties can be classified, mapped, and interpreted. The methodologies applied in describing and characterizing a terrestrial ecosystem depend on the interactions of soil, vegetation, and climate.

A *terrestrial ecosystem* is defined as the conceptual representation of the obligatory relationship between soil, vegetation, and climate. This complex relationship is depicted in the following diagram:



The diagram indicates that both soil and vegetation are directly influenced by climate; soil supports vegetation, and vegetation acts upon the soil. The product of these complex interactions defines a terrestrial ecosystem.

A *terrestrial ecosystem survey* consists of the systematic examination, description, classification (soil, vegetation, and climate), and mapping of terrestrial ecosystems. Other ecosystem components, such as landform, geology, and geomorphology, are integrated during the mapping process and modify soil or vegetation components. The unique combination of terrestrial ecosystems and appropriate phase criteria (i.e., slope, texture of the surface layer, soil depth, etc.) define an ecological map unit.

Classification

TES utilizes a component approach for classification of ecosystems (terrestrial and aquatic) and a holistic approach for the integration of components with climate through direct gradient analysis. This approach to TES is hierarchical with respect to classification levels of terrestrial ecosystem components and mapping intensities. These taxonomic systems are important as they incorporate, within class limits, diagnostic physical, chemical, and biological properties. Many nonhierarchical classification systems (rock fragment classes, texture classes, runoff classes, etc.) are also used in TES.

Direct Gradient Analysis

Direct gradient analysis is used to integrate ecosystem components (soil and vegetation) with climate. Soil moisture and soil temperature regimes provide the initial quantifiable means of separating a climatic continuum into meaningful segments, or life zones.

The correlation of indicator plants with soil moisture and temperature regimes results in further refinement of the zones. This correlation is based on the following two concepts:

1. The lower elevation limit of a given plant species on a moisture-temperature gradient is controlled by deficient moisture.
2. The upper elevation limit is controlled by deficient heat.

The final phase of direct gradient analysis consists of integrating soil taxonomic categories with plant communities to form individual terrestrial ecosystems. The resultant organized alignment of terrestrial ecosystems is a continuum of climax categories of plant communities and their edaphic environments.

Information Management

Ecological data collected from TES meet the corporate business requirements of the USDA Forest Service's Natural Resources Information System (NRIS). NRIS is an ORACLE database/Geographic Information System (GIS) application and set of analysis tools designed to implement corporate data standards for Terrestrial Ecological Unit Inventory. The Terra module of NRIS stores core terrestrial ecological data elements on climate, soils, geology, geomorphology, and potential plant communities.

The spatial component of TES is processed and edited through ARCINFO software. This is a polygon layer of ecological map units.

System-generated analysis and interpretations are processed by an E-Tools application. E-Tools is a nationally accessible, comprehensive set of data analysis and reporting tools that enables one to work efficiently with data contained in a given database. It is specifically designed to assist in analyzing compiled data through application of a standard set of sampling protocols.

E-Tools enables specialists to access basic ecological data and create taxonomic unit description and map unit description summaries. It assists in performing analyses and resource characterizations and facilitates sharing of information about ecological units and interpretations on a National level.

Use and Application of Terrestrial Ecosystem Survey

TES provides ecological information that assists land managers in determining desired resource conditions and management activities that conform to the physical and biological capabilities of ecosystems. Ecological map units consist of terrestrial ecosystems and phases from which ecological structure, function, capabilities, responses, and management opportunities and limitations are determined. The ecological information also includes data on both natural and anthropogenic disturbances (fire, floods, wind, grazing, use of off-highway vehicles, etc.).

This information provides vital basic land capability information for environmental analysis (NEPA) and decision-making; habitat data used to predict the effects on threatened and endangered species (ESA); soil, climate, and landscape information for watershed assessments (CWA); and interpretations for management activities outlined in forest plans (NFMA).

Protocols

Terrestrial ecosystem surveys are necessary to meet the requirements of the Forest and Rangelands Resource Planning Act of 1974 as amended by the National Forest Management Act of 1976 implementing regulations in 36 CFR Part 219 of the National Environmental Policy Act. The objectives, policy, and responsibility for conducting terrestrial ecosystem surveys are contained in FSM 2060 and FSH 2090.

TES meets the requirements of the National Hierarchal Framework of Ecological Units, which is a land classification hierarchy that provides the framework for developing terrestrial ecological units at multi-scales. The framework is a classification and mapping system for stratifying the Earth into progressively smaller areas of increasingly uniform ecological potentials. TES provides information useful in landscape ecology analysis at the land type association, land type, and land type phase hierarchal levels within the framework.

Identification of the soil component meets the standards and follows the policies and procedures outlined in the National Cooperative Soil Survey program. The description and classification of soils meets the criteria established in *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys* (2nd edition, 1999), the *Soil Survey*

Manual, and the "National Soil Survey Handbook."

The "Terrestrial Ecosystem Survey Handbook" of USDA, Forest Service, Southwestern Region, describes the basic concepts, standards, and procedures for conducting and interpreting terrestrial ecosystem surveys. This handbook requires a systematic (cause/effect) evaluation of the relationship among the components of terrestrial ecosystems.

Literature Cited

Carleton, J.O., D. Shaw, J. Gass, H.G. Brown, C. Spann, G. Robertson, W. Robbie, T. Robinson, W. Moir, D. Potter, R. Fletcher, R. Galeano-Popp, and G. Miller. 1991. General ecosystem survey. USDA, Forest Service, Southwestern Region, Albuquerque, New Mexico.

USDA, Forest Service. 1986. Terrestrial ecosystem survey handbook. USDA, Forest Service, Southwestern Region, Albuquerque, New Mexico.

USDA, Forest Service. 1999. GIS data dictionary. USDA, Forest Service, Southwestern Region, Albuquerque, New Mexico

USDA, Forest Service. 2000. E-Tools information. Web site—http://fsweb.sandy.wo.fs.fed.us/terra_web/etools.html. USDA, Forest Service, Sandy, Oregon.

USDA, Forest Service. 2000. NRIS: The Forest Service natural resources information system. Web site—http://www.fs.fed.us/emc/nris/facts/terra_fact_sheet_23mar01.htm. USDA, Forest Service, Sandy, Oregon.

Winthers, E., D. Fallon, J. Haglund, T. DeMeo, D. Tart, M. Ferwerda, G. Robertson, A. Gallegos, A. Rorick, and D. Shadis. 2002. Terrestrial ecological unit inventory technical guide. [Draft.] USDA, Forest Service, Washington Office, Ecosystem Management Coordination Staff, Technical Guide xx. ■

The Lewis and Clark Expedition at Council Bluff

By Stanley P. Anderson, Editor, NRCS, National Soil Survey Center, Lincoln, Nebraska.

The Lewis and Clark Expedition held its first official council with Native Americans on August 3, 1804, at a site in what is now Washington County, Nebraska. Clark's map of the Missouri River in this area identifies this site as "Councell Bluff."

Clark's journal entry for July 30 identifies the various levels of the landscape at Council Bluff. It also identifies the kind of vegetation, including grasses that are 10 to 12 inches tall on a "high Prarie" above their camp and 5 to 8 feet tall on a prairie below the camp. The journal indicates that the soil is "of good quality" (Moulton, 1987, vol. 2, pp. 430 and 434).

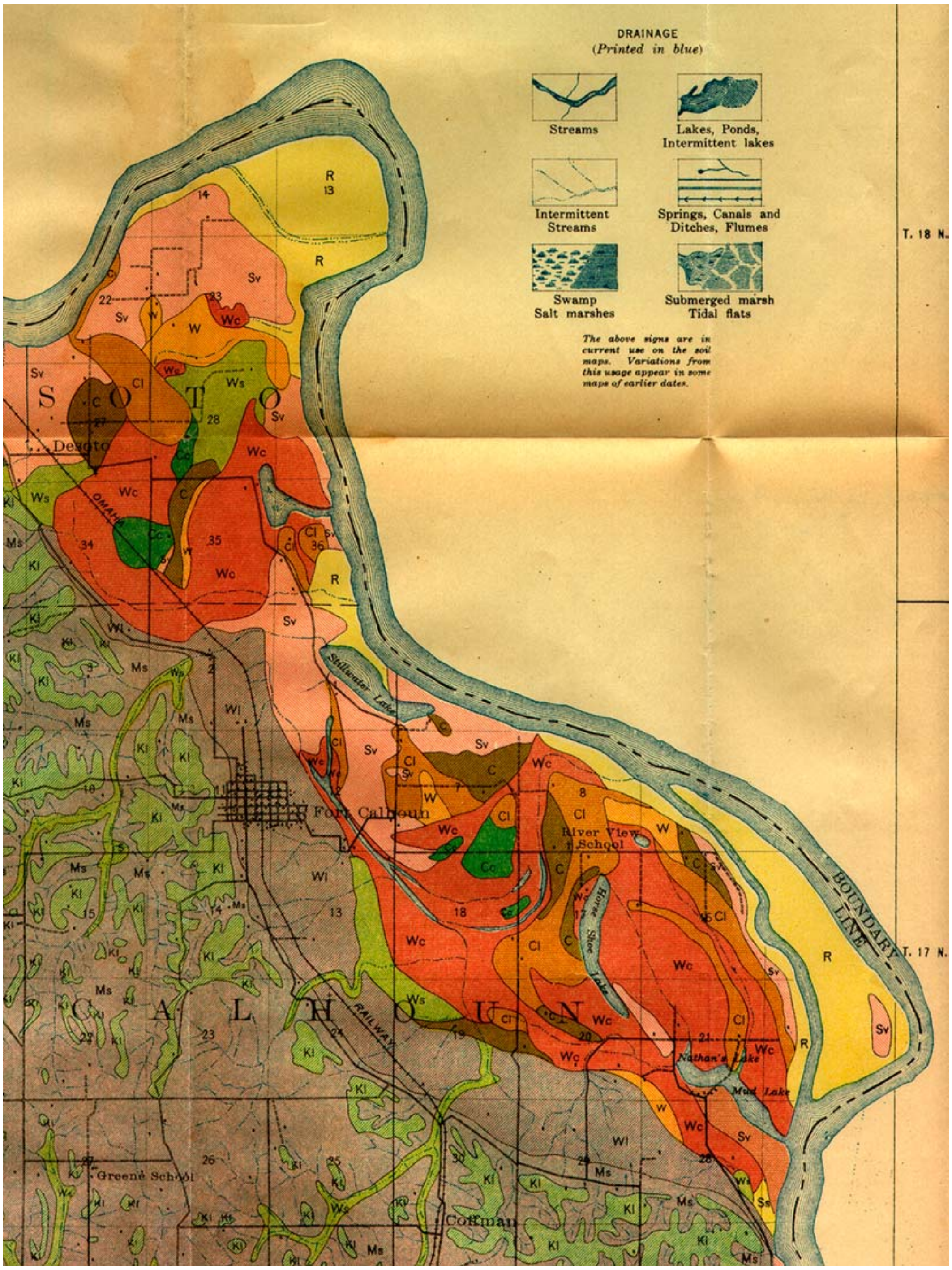
After walking to one of the highest points on the landscape, Clark observed the "Countrey" as "one Continual Plain as fur as Can be Seen, from the *Bluff* on the 2d rise imediately above our Camp the most butifull prospect of the River up & Down and the Countrey opsd. prosented it Self which I ever beheld" (Moulton, 1987, vol. 2, p. 430). This description shows the enthusiasm with which members of the expedition responded to the vast, nearly treeless prairies of the Great Plains. An earlier example of this enthusiasm is recorded in Clark's journal for July 19, 1804. As Clark was pursuing elk in an area near what is now Nebraska City, he was enchanted by a view of the prairie:

> Came Suddenly into an open and bound less Prarie, I Say bound less because I could not See the extent of the plain in any Derection, the timber appeared to be confined to the River Creeks & Small branches, this Prarie was covered with grass about 18 Inches or 2 feat high and contained little of any thing else, except as before mentioned on the River Creeks &c, This prospect was So Sudden & entertaining that I forgot the object of my prosute and turned my attention to the Variety which presented themselves to my view (Moulton, 1987, vol. 2, p. 394).

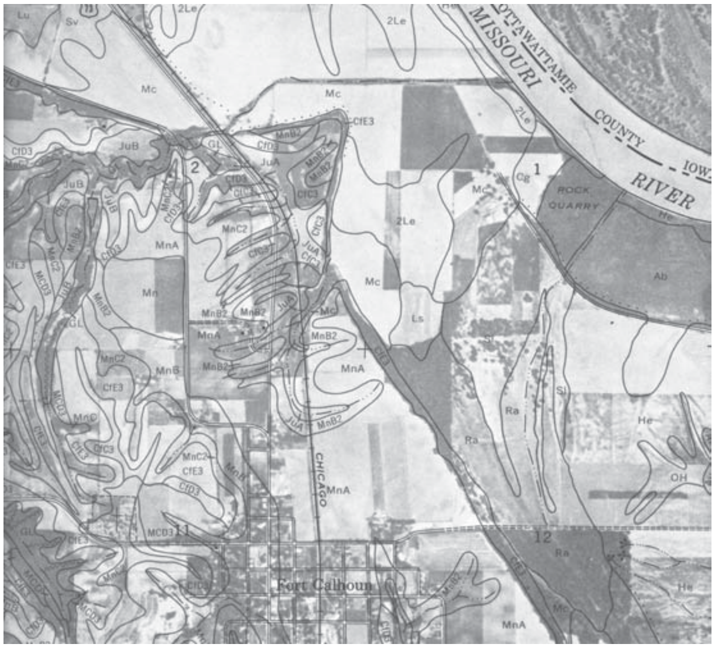
As he looked out over the river at Council Bluff on July 30, Clark was afforded a panoramic view of "Two ranges of High Land parrelel to each other and from 4 to 10 miles Distant between which the river and its bottoms are Contained. (from 70 to 300 feet high)" (Moulton, 1987, vol. 2, p. 430). This view is sketched on his map.

In a document written the following winter at Fort Mandan, Meriwether Lewis describes Council Bluff. He

Council Bluff as drawn on Clark's map (from *The Journals of the Lewis and Clark Expedition*, vol. 1). At the time of the expedition, the Missouri River touched the bluff.



Council Bluff as it appears in the *Soil Survey of Washington County, Nebraska*, published in 1917. The date of the map is 1915. Council Bluff is just east of Fort Calhoun. The long and narrow body of water between the words "Fort" and "Calhoun" on the map may indicate the old course of the river and may be the approximate landing site for the Lewis and Clark Expedition more than 100 years earlier. A flood plain separates the Missouri River from the bluff where the expedition landed.



Council Bluff as it appears on map sheet 24 in the *Soil Survey of Washington County, Nebraska*, published in 1964. The map was compiled in 1962. The long and narrow area of water in the 1919 survey is now a soil—CfE3 (Crofton silt loam, 18 to 30 percent slopes, eroded).

Council Bluff as it appears on the latest soil map (1988). This map is from a new soil survey of Washington County that is being prepared for publication.

apparently had Clark's map of the site in front of him as he wrote:

> the base of the Bluff is washed by the river about a mile; it is about 60 feet high & nearly perpendicular; as it's lower extremity it leaves the river nearly at right angles, descending with a handsome and regular declivity on it's lower side about forty feet to a high, level, fertile and extensive bottom, lying between itself and the river. the top of the bluff is a level plain from one to two miles in width, and about five miles in length (Moulton, 1987, vol. 3, p. 353).

Both Lewis and Clark thought that Council Bluff would be a suitable site for a fort and trading post, partly because of the panoramic view of the river that the site provided at that time. Lewis thought that the main problem with building a fort at this site would be the scarcity of timber, but he noted that the soils in the area appeared to be good sources of clay for bricks. Fort Atkinson was later built at the site (mainly from timber in the immediate vicinity). It was in operation from 1819 to 1827. It has been restored and is open to visitors. Today, a good view of the Missouri is not possible from this spot because the river has shifted its course. ■

Snotel Site Installation

By Brad Duncan, Resource Soil Scientist, NRCS, Idaho Falls, Idaho.

As a Resource Soil Scientist, I spend most of my time providing technical soil information for conservation planning, animal waste management, soil surveys, and interpretation maps. I spend most of my time on the arid and semiarid landscapes of eastern Idaho.

Recently, the Snow Survey section of our State Office in Boise asked me to help install equipment and instruments at a new Snotel site. They told me it would take about 2 1/2 days to install all the equipment and instruments. I was kind of excited by this opportunity because I knew that the Snotel sites are usually high in the mountains and usually in remote locations. I was told we would be camping for two nights and the site was accessible only by four wheelers, trail bikes, or helicopters. This particular site was at the head of Lake Creek, south of the Copper Basin area, in the Challis National Forest.

I met the project coordinator and other workers who were going to help install the equipment and instruments at the loading zone about 6 miles below the actual site. All the equipment, food, water, and camping gear had to be sling-loaded by helicopter up to the site. There were about 12 loads all together, and it took quite a while for the helicopter to make all the trips. Another person and myself rode in ATVs up to the site, two others rode trail bikes, and two others got to ride in the helicopter on the last trip. The helicopter pilot said he would be back in 2 days to sling-load materials and equipment back down. The project coordinator told me that I could ride the helicopter back down and that he would ride in the ATV.

The installation work at a Snotel site is more involved than I imagined. Concrete had to be mixed with water for the base of the electronic equipment shack and for the bases of two towers. The snow pillow area had to be leveled and raked and a layer of sand put down for a smooth surface for the pillow. The snow pillow was filled with a mixture of antifreeze and water. All the electronic equipment had to be installed and wires run through conduit to every instrument. My particular job was to excavate a soil pit and do a full soil profile description. We were in a lodgepole pine-whitebark pine habitat type, and the soil had quite a bit of volcanic ash in the upper part. My job also involved installing moisture sensors at three different depths in the soil, and these will be read electronically by the Snotel equipment.

We worked a couple of long days, and we spent the evenings by the camp stoves listening to the elk bugle all around us.

The last day was spent cleaning up the site and waiting for the helicopter to come and haul the garbage and empty barrels back down. The helicopter arrived at about 1:00 p.m. and took about four sling loads back down to the staging area. The other workers took the ATVs and trail bikes down, and another person and myself rode in the helicopter. The pilot took us over the site, and it was pretty impressive to see the work that we had done.

This was quite an experience for me, and I quickly volunteered my services for the next Snotel site installation. ■

The Ohio Soil Survey: Cooperative for 50 Years

By Tim Gerber, Ohio Department of Natural Resources, and Jon Gerken, Natural Resources Conservation Service. Reprinted from *News & views*, January/February/March 2003, Vol. 38, No. 1, a newsletter published by the Ohio Department of Natural Resources, Division of Soil and Water Conservation.

If you know any of the 26 NRCS or ODNR soil scientists who are a part of the Ohio Soil Survey, chances are you may not know which of the two agencies employs them. This lack of apparent distinction between agencies is a testament to the effectiveness of the Ohio Soil Inventory Board, which was created by a memorandum of understanding signed in May 1953.

During the past 50 years, NRCS, ODNR, and Ohio State institutions (School of Natural Resources, Ohio Agricultural Research and Development Center, and OSU Extension) have undergone name changes, re-organizations, re-locations, expansions and reductions in staffing, and changes in leadership and priorities. These changes have certainly impacted the state's soil survey program, but Board coordination of these three agencies has maintained a level of stability that otherwise could not have been achieved here.

To encourage similar cooperative benefits at the national level, last year Division Chief David Hanselmann began encouraging his colleagues in the National Association of State Conservation Agencies (NASCA) to seek direct representation for NASCA in the National Cooperative Soil Survey Conference. With the signing of a memorandum of understanding between NRCS and NASCA recently, NASCA officially became part of the National Cooperative Soil Survey.

Ohio Soil Inventory Board members Jon Gerken (NRCS), Tim Gerber (ODNR), and Neil Smeck (OARDC) meet monthly to plan and coordinate various aspects of the state's soil survey program, and schedule a two-day Work Planning Conference each summer to develop a business plan for the upcoming federal fiscal year. The first part of this year's conference is scheduled for late June.

The Ohio Soil Survey Business Plan for the current fiscal year can be accessed on NRCS' Ohio website, at http://www.oh.nrcs.usda.gov. It documents the status of manuscript and map development for 12 counties and field activities in two other counties. Information on the scheduling of

NASCA President Steve Cauthen (left) and NRCS Chief Bruce Knight signed a memorandum of understanding establishing NASCA as a member of the National Cooperative Soil Survey Conference during the 2003 NACD annual meeting.

digitizing work for 70 counties is included, along with plans for editing the National Soil Information System (NASIS) database for 28 counties during this fiscal year. Some aspects of the state's soil survey are more glamorous than others, but all are critical to delivering important soils information to landowners and units of government.

The Statewide Digital Soils Information (SDSI) Project, which is a part of a national SSURGO Initiative, and the Soil Information Delivery Program are probably the most visible parts of the Ohio Soil Survey now. Both are excellent examples of how NRCS, ODNR, and the OSU institutions have tackled tasks that could not be completed independently. Although the three entities are funded separately and have missions that differ at least slightly, they share many objectives. And, with only 30 soil scientists available to contribute, coordinating their activities is well worth the Soil Inventory Board's efforts. ■

Version 5.01 of *Field Indicators of Hydric Soils in the United States* Available on CD

By Karl W. Hipple, National Leader for Interpretations, NRCS, National Soil Survey Center, Lincoln, Nebraska

Field Indicators of Hydric Soils in the United States, version 5.01, 2003, is now available on a CD from the National Soil Survey Center (NSSC). A pdf version is available at http://soils.usda.gov/soil_use/hydric/main.htm or from the Soils Web page, http://soils.usda.gov (select "Soil Use" and then "Hydric Soils"). This version was created after the 2003 annual meeting of the National Technical Committee for Hydric Soils (NTCHS), which was held at the NSSC.

At the meeting, the NTCHS approved several changes to version 5.0, issued in 2002. For example, it approved changes in the procedure for adding new hydric soil test indicators and/or modifying existing test indicators.

The committee also adopted a definition of "biological zero" to further clarify the hydric soil indicator criteria. Alaska research data show that plant respiration in cold environments (an indicator of plant growth and function) was measured at temperatures well below 5 degrees C. The biological zero issue was clarified for possible use within the hydric soil criteria.

An errata sheet listing the changes approved by the NTCHS will be included in the printed copies of version 5.0 that have not yet been distrubuted. ■

A Day in the Field

By Emily Rose Seifferlein, Chemical Analysis Section, National Soil Survey Laboratory, National Soil Survey Center, NRCS, Lincoln, Nebraska.

I started at the National Soil Survey Laboratory (NSSL), National Soil Survey Center (NSSC), a year ago, and I've enjoyed ever widening exposure to the broader mission of NRCS, in part through such activities as the Lancaster County Field Trip on May 15th, 2003. Dewayne Mays (head, NSSL, NSSC) organized the field trip to illustrate field practices and highlight environmental issues and research. Participants included technicians, support staff, student workers, and soil scientists—a group of about 30 individuals. There were five stops around Lancaster County, Nebraska, and at each stop we participated in lectures given by specialists in soil science, soil conservation, and water quality.

At our first stop, near the airport west of Lincoln, Warren Lynn (Research Soil Scientist, NSSL, NSSC) illustrated how soil samples are collected in the field (fig. 1). He showed how horizons can be designated based on physical properties in the soil, performed the tricky task of collecting soil from a particular horizon for characterization, and demonstrated how clods are prepared. Doug Wysocki (Research Soil Scientist, NSSC) spoke about the age and development of soils at that site. We learned that we were standing on over 500,000 years of soil development!

Roger's Memorial farm, northeast of Lincoln, was the second stop. John Gilley, Agricultural Engineer, Agriculture Research Service/ University of Nebraska, and Cliff Hunter, the farm manager, led us through sites where research was being conducted. We learned about conservation practices and observed an alternative wastewater treatment system which used a constructed wetland to filter the wastewater. We saw a riparian buffer system and grassed waterways, which prevent runoff and digest excess nutrients, as well as a rainfall simulation station. We heard lectures on the effects of early season planting and on a comparison between till and no-till farming. Bob Grossman (Research Soil Scientist, NSSC) demonstrated a technique to simulate infiltration of rainwater into the soil (fig. 2).

At the third stop, southwest of Lincoln, Dennis Shroder (District Conservationist, NRCS, Lincoln Field Office), Jim Harder (Soil Conservationist, NRCS, Lincoln Field Office), and Moustafa Elrashidi (Soil Scientist, NSSL, NSSC) talked about flood-control structures, excessive nutrients in runoff which promote algae blooms in ponds, and other conservation issues concerning watersheds in Lancaster County.

Our fourth stop was Wagon Train Lake, a reservoir in southern Lancaster County. Dennis and Jim continued the discussion about conservation issues in

Figure 1.—Warren Lynn demonstrates the art of sampling soils.

Figure 2.—Robert Grossman illustrates the infiltration process.

Figure 3.—Observing native prairie at Spring Creek are from left to right Arnold Mendenhall, Warren Lynn, Valarie Murray, Amber Kunc, Cathy Seybold, James Harder, Robert Grossman, and Suzie Riedel.

the county, including soil fertility, crop rotations, and compensation to farmers who practice conservation. Steve Peaslee (GIS Specialist, NSSC) spoke about Geographic Information System (GIS) techniques in mapping using global positioning satellite (GPS) units. He demonstrated military-based technology, which determines position to within 20 feet at the push of a button! We had an impromptu birthday celebration for Bob Grossman (NSSC) and enjoyed some cake under beautiful blue skies.

Our final stop was the Audubon Nebraska Spring Creek Prairie near Denton (fig. 3). Arnold Mandenhall (NRCS retiree) guided us through the prairie. This 500-acre reserve was established to promote the conservation of original tall-grass prairie that once covered vast areas of the Great Plains States. Less than 2 percent of the original tall-grass prairie remains. This site is unique to our area because it has never been plowed and represents native prairie. Arnold is working hard to remove alien plant species that compete with the native species, using techniques such as rotational grazing of cattle, prescribed burning, and tree removal. He is also working to restore water and woodland habitats within the prairie that support the diverse wildlife that live around Spring Creek.

Feedback from participants was as varied as the group:

What was your favorite spot/ moment?

"Audubon Prairie...neat to see the virgin prairie."

"The soil profile...when Warren cut out the potato (clod)."

"Audubon Prairie because of all the new conservation practices they are using."

"Roger's Farm where we learned about the Riparian Buffer system."

"Roger's Farm; the new septic system was really cool. It was neat to see how it would work on farms."

"... having lunch under the old cotton wood tree at Wagon Train Lake!"

What were your thoughts about the field trip?

"It was wonderful, I had a great time, there were a good mix of stops, and it helps us to be proud of what we do."

"It was good for morale; it made me feel like I'm part of something."

"The walk through the prairie was lots of exercise; my legs were really stiff the next day."

"...I would have liked to spend more time at some of the stops."

"It would be worth going again."

Everyone was excited to see how their jobs tied in with the mission of the NRCS. Some said it made them feel good to know that the soil properties they determine in the lab help contribute to the welfare of farmers and the planet. Many participants had never seen soil collected before and now can more fully appreciate the care and thought that go into conserving one of our valuable natural resources. ■

National Soil Survey Center Participates in Infrared Spectroscopy Study

By M. Dewayne Mays, USDA, NRCS, Lincoln, Nebraska, and David Brown, Montana State University, Bozeman, Montana.

The Soil Survey Laboratory (SSL) at the National Soil Survey Center is participating in a research study with Dr. David Brown, Assistant Professor at Montana State University. Thousands of soil samples in the Soil Survey Laboratory archive will be scanned with a high-resolution visual and near-infrared (VNIR, 350-2500 nm) spectrometer. The reflectance spectra thus obtained can be statistically related to chemical and physical soil properties (McCarty and Reeves, 2001; Shepherd and Walsh, 2002). Using the models and the VNIR Spectroradiometric technology, scientists can rapidly and nondestructively characterize soils in the laboratory and in situ.

The objective of this study is to compile the first comprehensive soil spectral library with a diverse sample-set (geographically dispersed, all horizons) and with complete characterization comparing reflectance to chemical and physical properties.

By using <2 mm archived samples, the researchers expect to minimize efforts to create a robust model that may prove useful to field personnel using this technology. If such technology proves successful, NRCS will be able to rapidly estimate chemical and physical properties of soils under field conditions, thus improving the quality of soil surveys and field investigation studies. The investigation studies that will benefit from this research will include field environmental studies.

The spectral absorption features of soil materials are related to functional groups, such as OH, SO_4, and CO_3 (Hunt and Salisbury, 1970). While much of the research on reflectance spectroscopy has been related to organic carbon in soils (McCarty and Reeves, 2001), other researchers have found strong relationships for clay content, organic carbon, total N, $CaCO_3$, surface area, cation-exchange capacity, and 1500 kPa water (Ben-Dor and Banin, 1989; Reeves et al., 2002; Shepherd and Walsh, 2003). The best results were obtained from homogeneous samples, such as the <2 mm processed samples we decided to use.

We look forward to working with Dr. Brown and other researchers who are seeking to improve field methods relating to rapid estimates of soil analyses. These kinds of technology will improve the quality of soil surveys and environmental assessments.

This study will add to an earlier pilot study conducted in Eastern and Southern Africa by Shepherd and Walsh (2002) and is expected to add to the spectral library of over 1,000 African topsoils. Samples from the SSL archive will add further validation to samples in the spectral library and will add new dimensions, making the overall model more robust (Shepherd and Walsh, 2003).

In summary, there are several major applications of this technology to soil survey. The technology can:

--Serve as a rapid means of quantifying information needed to make predictions;
--Apply to risk-based evaluation of soils;
--Possibly be a substitute for some of the more complex analyses;
--Significantly increase the number of soil profiles that can be characterized;
--Provide a method for more vigorously ground-truthing GIS-based landscape models, such as SoLIM;
--Monitor soil change and/or degradation, such as the loss of organic matter and soil erosion.

References

Ben-Dor, E., and A. Banin. 1989. Determination of organic matter content in arid-zone soils using simple "loss-on ignition" method. Commun. Soil Sci. Plant Anal. 20: 1675-1695.

Hunt, G.R., and J.W. Salisbury. 1970. Visible and near infrared spectra of minerals and rock: Silicate minerals. Mod. Geol. 1: 283-300.

McCarty, G.W., and J.B. Reeves III. 2001. Development of rapid instrumental methods for measuring soil organic carbon. *In*: Lai, R., J.M. Kimble, R.F. Follett, and B.A. Stewart (eds.). Assessment methods for soil carbon. Lewis Publishers, Washington, DC, pp. 371-380.

Reeves, J. III, G. McCarty, and J. Mimmo. 2002. The potential of diffuse reflectance spectroscopy for the determination of carbon inventories in soils. Env. Pollution 116: S277-S284. Elsevier Sci. Ltd.

Shepherd, K.D., and M. Walsh. 2002. Development of reflectance spectral libraries for characterization of soil properties. Soil Sci. Soc. Am. J., 66: 988-998.

Shepherd, K.D., and M. Walsh. 2003. Diffuse reflectance spectroscopy for rapid soil analysis. Submitted for publication in Encyclopedia of Soil Sci. ■