May 1998
Issue 3

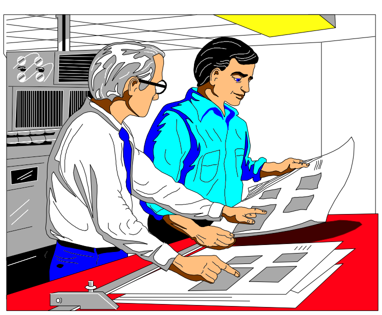
National Cooperative Soil Survey Newsletter

In This Issue—

Editor's Note

Issues of this newsletter are available on the World Wide Web (www.statlab.iastate.edu/soils/soildiv). Click on NCSS and then on the desired issue number of the NCSS Newsletter.

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—sanderson@nssc.nrcs.usda.gov.



History of the MLRA Approach to Soil Survey

By Thomas E. Calhoun, Soil Survey Division Program Manager, NRCS, Washington, D.C.

The concept of organizing soil surveys around major land resource areas (MLRA's) is not at all new. It has been on the docket for study by the Soil Survey Division and the National Cooperative Soil Survey (NCSS) since the late 1970's and early 1980's.

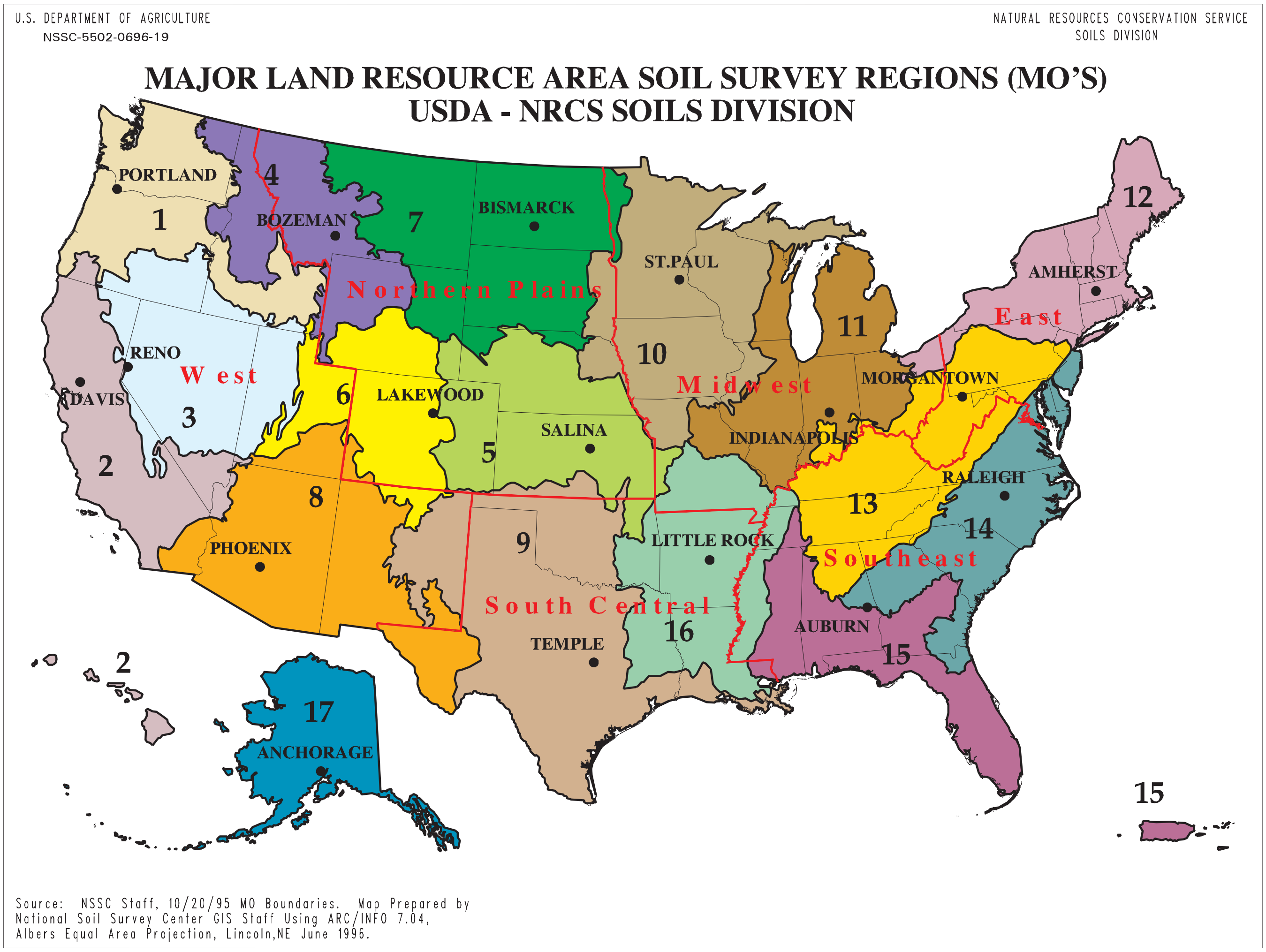
In July of 1980, Texas proposed an update of the soil surveys within MLRA-77 and held a conference to evaluate this possibility (Ratliff, 1990). It was agreed that one legend should be developed for the MLRA and that the interpretations should be updated. Wes Fuchs and Larry Ratliff at the South NTC became sponsors of the MLRA approach to updating soil surveys, and Larry carried this concept into the National Soil Survey Center in 1986.

The first formal national level reference to the concept I could find was by Richard Duesterhaus at the National Work-Planning Conference held in Washington, D.C., in 1983. At that conference, he gave a paper called "Soil Survey Update Strategy" (Duesterhaus, 1983), in which he provided his "visions" for future soil surveys. These included 1) a generic guide to soil survey information that informs customers of the kind of soil survey information available and where it can be found, 2) digital soil survey information, 3) computerized soil survey data bases and information retrieval systems, 4) use of orthophotography as a mapping and digitizing base, 5) major land resource areas serving as a basis for technical information, and 6) user-defined soil survey products, to name just a few. Most of these "visions" are just now becoming realities.

In 1987, Kenneth Hinkley gave a summary of the "Soil Survey Productivity Improvement Study" (PIP report) at the National Cooperative Soil Survey Conference held in St. Paul, Minnesota (Hinkley, 1987). Ken had participated as a team member for that study, which reviewed the entire Soil Survey Program and made recommendations for improving its efficiency. The study recommended that soil survey technical staff be assigned responsibilities according to major land resource areas rather than political entities, such as states. It also recommended establishment of "a National Soil Survey Center (NSSC) of soils technical expertise to which scientists of the world can look for the most authoritative information on soils rather than the dispersed or segmented organization presently used."

Establishing the NSSC was an attempt to develop an "institute" mentality whereby a center of excellence could be developed that would support the National Cooperative Soil Survey Program and other agency programs. It was called a center rather than an institute because of the European institute concept, which was more academic than what was intended for the agency. The NSSC was a forerunner of the technical institutes the agency has today. Part of the justification for establishing the NSSC was the need for soil correlations that

MLRA continued on page 2



MLRA continued from page 1

are nationally consistent. This concept was another precursor to some of the current MLRA concepts. After the NSSC was established, the soil correlators were assigned MLRA responsibilities. These responsibilities have now been transferred to the MLRA Offices, but the intent of improving the quality of soil surveys and having consistent data and interpretations across political boundaries is still the focus.

At that same 1987 conference, a committee report on "Landscape Analysis and Development of Map Units" (Cunningham, 1987) made the following recommendations among others: 1) landscape management demonstration areas for a few major land resource areas should be established and 2) soil surveys that are representative of the defining soils and landscapes of major land resource areas should be selected to serve as models to be extended to other soil surveys at least within a state. The focus of this committee was to better define the soil landscape information needed for map unit descriptions.

In 1988, at a meeting of the State Soil Scientists in Lincoln, Nebraska, a work group chaired by Larry Ratliff recommended that for the next generation of soil surveys, county boundaries could be maintained for publication purposes, but MLRA's should be the basis for the inventory (Ratliff, 1988). More definitive concepts of the MLRA approach were developed by a team at the NSSC under the guidance of Larry Ratliff. During this same period, additional memoranda of understanding (MOU's) were developed by the states for soil surveys to be conducted on an MLRA basis. The Soil Survey Program Manager in National Headquarters was asked to develop state soil survey program allowances for MLRA projects. More guidance on the development of the

MLRA continued on page 3

MLRA continued from page 2

MLRA approach was provided by a task force on the “Utility of Soil Landscape Units” at the 1989 NCSS Conference (Franzmeier, 1989). This task force, chaired by Don Franzmeier, addressed the need for a new kind of soil survey. In general, the task force suggested that the new surveys should be similar within similar large areas, or MLRA’s.

At the 1993 NCSS Conference, a committee on “Soil Survey by MLRA” chaired by Dr. McSweeney (McSweeney et al, 1993) made recommendations that included the following: 1) develop a model organizational structure for MLRA soil surveys; 2) refine OBJECTIVE/GOAL statements for MLRA soil surveys and disseminate these as soon as possible; 3) develop a soil survey marketing plan that includes a strategy for marketing or promoting the MLRA concept; 4) keep the concept of soil survey by MLRA’s flexible enough to allow for soil surveys by other geographic areas (e.g., physiographic areas, watersheds, and soil regions; and 5) finalize work on the “Soil Survey by Geographic Area” guidebook and disseminate this guidebook as soon as possible. The guidebook was issued in December of 1993 (Soil Survey Staff, 1993).

During 1994, many factors came together at the national level making the changeover to the MLRA concept a serious issue for the agency to consider. Implementation of the National Soils Information System (NASIS) was a reality, and with that came the capability of managing soil data by different geographic areas. The Soil Conservation Service (SCS) was assigned the federal responsibility for hosting digital soil surveys for the nation, and a federal standard for that data layer was being developed. Such agencies as EPA and USGS were using multi-county, multi-state, and national data sets and were pressuring SCS to develop a seamless digital coverage of detailed soil surveys (SSURGO). USDA embarked on a reorganization of SCS to the Natural Resources Conservation Service (NRCS) with an expansion of its scope of resource issues. Up-to-date, coordinated soils information was more important than ever. The soil survey data sets needed to be updated and improved to provide consistent interpretations between counties and states. SCS had soil survey coverage on 91 percent of the nation’s private lands, and a strategy for making greater use of this information was needed. With the 1985, 1990, and pending 1995 farm bills, soil information was being looked at on a national basis and the data needed to be better coordinated. The demands on soil survey information were greater than ever, and more soil scientists were needed to provide technical assistance in interpreting and using soil surveys. Customers were demanding products more tailored to meet their particular needs, and a stronger emphasis was being placed on using soil information rather than collecting it. The budgets of the states were getting tighter, and 16 State Soil Scientist positions remained vacant.

It was time for SCS not only to reassess how it conducted soil surveys and how it provided information to its clients but also to look at the way the entire soil survey program could be reorganized, in light of the current realities, to more efficiently produce soil information, to bring older soil information up to current standards, to improve the quality of the soil data, to help customers use that information, and to position the agency so that it would have a viable soil survey program in future years. Issue papers outlining the need for organizational change and change to an MLRA approach to soil surveys were presented to SCS top staff in the fall of 1994 (Soil Survey Staff, 1994). Shortly thereafter, the agency top staff gave the division approval to go forward with planning a changeover to the MLRA approach to soil surveys.

In January of 1995, a 25-member multidisciplinary team was formed at the NSSC to finalize concepts for soil survey in the reinvented NRCS. This team received input from State Conservationists, State Soil Scientists, and other key technical disciplines and formulated detailed information on the functions, organizational structure, and staffing for the reorganized soil survey (Soil Survey Staff, 1995).

At this point, armed with information developed by the team early in January, the Soil Survey Steering Team made its final draft of the proposal and concepts of the MLRA soil survey (Soil Survey Division Steering Team, 1995). A meeting was called of the National Soil Survey Center Advisory Group, made up of four State Conservationists and four Agricultural Experiment Station representatives from each of the four regions, to review this final draft, provide their comments and recommendations, and open the dialogue with other NCSS Agricultural Experiment Station cooperators. The proposal for reorganization of the soil survey to an MLRA concept was presented to this advisory group, and their recommendation was to go forward with the proposal. In retrospect, this meeting was not successful in that our discussions at the meeting were not widely distributed to the individual State Conservationists or State Agricultural Experiment Station representatives. To this day, this lack of communication with the Agricultural Experiment Station representatives

MLRA continued on page 4

MLRA continued from page 3

early in the planning process remains as a primary issue of concern. This perceived failure to openly communicate raised concerns among some partners about the validity of a "cooperative" soil survey.

After the advisory group endorsed the reorganization, the Soil Survey Program Manager presented the proposal to Regional Conservationists and State Conservationists at the Agency Business Meeting held in New Orleans in February of 1995. This presentation was followed up by presentations made by members of the Soil Survey Division Steering Team at each regional NRCS meeting in the spring and early summer of 1995. Also, teleconferences on the plan were held with the State Soil Scientists in 1995. Feedback from State Conservationists, primarily concerned the placement of the MLRA Office (MO) boundaries, was used to refine the plan.

The Soil Survey Division requested one final presentation of the MLRA concept to the top staff at their leadership meeting in March of 1995 at Beltsville, Maryland. After this presentation, Chief Paul Johnson, Associate Chief Pearlie Reed, and the six Regional Conservationists (Judy Johnson, Gene Andreuccetti, Dwight Holman, Charles Whitmore, Diane Gelburd, and Jeffrey Vonk) assured the division leadership that they understood the concept of MLRA reorganization, that they were committed to implementation of the concept, and that the Soil Survey Division was to leave the implementation of it in their hands.

It has now been 2 years since implementation of the new soil survey organization, and as an agency we are still fine-tuning it. The new organization is beginning to show some of the projected benefits. For the first time in about 12 years, the acreage mapped in one year (FY-97) showed an increase rather than a decline over the previous year, and the acreage goaled for mapping in 1998 increased rather than declined. One hundred SSURGO projects have been certified, and 650 more are currently in the works, of which 300 should be certified by the end of FY-98. Various products, such as three-ring binder publications, soil surveys on CD-ROM, soil surveys on the Internet, and new state-tailored interpretations of soil data, are being produced, and an increased number of soil survey manuscripts have been edited and submitted for publication.

Most of the 17 MLRA Offices are functioning well as far as providing quality assurance for soil surveys in their area of responsibility. They are also monitoring the scheduling and progress of the accelerated soil survey digitizing initiative. Innovative approaches to providing quality assurance for soil survey projects are being developed by the MO staffs. NASIS 3.1 has been released and is being used. An good example of how well the MLRA Offices are functioning is in Bozeman, Montana, where manuscripts are developed directly from the data base and the U.S. Forest Service has its surveys entered into NASIS and is able to connect to the NRCS server to manage their data using NASIS. Another example is Morgantown, West Virginia, which has the highest workload of manuscripts and ongoing surveys in the nation. Innovative approaches to providing quality assurance for groups of surveys allows them to meet most demands, even though they are understaffed.

State Soil Scientists are now in charge of developing a stronger technical services program and providing information to clients in a variety of formats. One example is Bob McLeese in Illinois, who has developed plans for providing state coverage of up-to-date SSURGO sponsored $^{1}/_{3}$ by local, $^{1}/_{3}$ by state, and $^{1}/_{3}$ by federal dollars and for preparing soil surveys on CD-ROM. Steve Hundley has been working closely with his customers in New Hampshire to develop order one soil survey standards and to help refine hydric soil indicators for New England. Similar successes are to be found in Maine, Tennessee, Washington, South Dakota, Missouri, and many other states. More soil scientists than ever are helping people use the information the NCSS has been in the business of producing for nearly 100 years.

We are maintaining a viable mapping program that provides information on areas that have never before been surveyed and provides updated information on areas where information has become obsolete. The regional Oversight & Evaluation Staffs have made good use of the refined STATSGO maps and data bases to support the concept of a "common resource area" for use in delivery of Field Office Technical Guide materials.

It is now easier to evaluate maps and data for national concerns. For example, the RCA appraisal process and the districts have made good use of the improved coordination of soil information across county and state lines with the soil productivity rating process.

The system of providing soil survey information on a geographic basis to support programs that are delivered on a political basis works. Many of the discrepancies in the soil survey data set between states and counties have already been eliminated, and that effort continues as surveys are updated and digitized. Quality soil data have been provided in support of FSA and EQIP. There are still challenges in some areas to eliminate other inconsistencies and to maintain and improve communications

MLRA continued on page 5

MLRA continued from page 4

with partners, but the structure and communications necessary first to recognize the issues, then to identify the problems, and finally to resolve them are in place and are working.

Bibliography

Cunningham, Bob, chairman of committee 2. 1987. Landscape Analysis and Development of Map Units. *In* 1987 NCSS Conference Proceedings, pp. 104-131. NRCS, Washington, D.C.

Duesterhaus, Richard. 1983. Soil Survey Update Strategy. *In* 1983 NCSS Proceedings, pp. 30-32. NRCS, Washington D.C.

Franzmeier, Don, task force chairman. 1989. Utility of Soil Landscape Units to the National Cooperative Soil Survey. *In* 1989 NCSS Conference Proceedings, pp. 55-62. NRCS, Washington, D.C.

Hinkley, Kenneth. 1987. USDA-SCS Soil Survey Productivity Improvement Study. *In* 1987 NCSS Conference Proceedings, pp. 73-75. NRCS, Washington, D.C.

McSweeney, K., J. Bell, R. McLeese, and C. Love. 1993. Soil Survey by MLRA: Positioning the NCSS for the 21st Century. *In* 1993 NCSS Conference Proceedings, pp. 195-201. NRCS, Washington, D.C.

Ratliff, Larry F, session chairman, work group session number 4. October 1988. Next Generation of Soil Surveys. *In* National Workshop for State Soil Scientists Proceedings, pp. 191- 197. National Soil Survey Center, NRCS, Lincoln, Nebraska.

Ratliff, Larry F. March 26, 1990. MLRA-77 Update and Evaluation Correspondence 1980-1990. National Soil Survey Quality Assurance Staff, NSSC, NRCS, Lincoln, Nebraska.

Soil Survey Division Steering Team. 1995. Soil Survey in the Reinvented NRCS. A presentation including overheads for the NRCS Agency Business Meeting, February 1995, and Regional Business Meeting in 1995. NRCS, Washington, D.C.

Soil Survey Staff. December 1993. Soil Survey by Geographic Area. NSSC, NRCS, Lincoln, Nebraska.

Soil Survey Staff. August 1994. Issue Paper on MLRA Approach in Soil Survey, and Decision Memo for the Chief, NRCS on Soil Survey Program Reinvention. NRCS, Washington, D.C.

Soil Survey Staff. January 1995. Soil Survey in the Reinvented Natural Resources Conservation Service. NSSC, NRCS. Lincoln, Nebraska.

Keys to Soil Taxonomy for Finland

By Dr. Delbert L. Mokma, Department of Crop and Soil Sciences, Michigan State University.

Dr. Delbert L. Mokma, Professor in the Department of Crop and Soil Sciences at Michigan State University, has recently been working with Henry Mount and Dr. Robert Ahrens at the National Soil Survey Center, Lincoln, Nebraska, to complete the "Keys to Soil Taxonomy for Finland." This 19-page document contains the keys to only the orders, suborders, great groups, and subgroups that occur in Finland. The keys are based on those in the revised edition of *Soil Taxonomy*, the taxa of which were listed in the February 1998 issue of the *NCSS Newsletter*. Finnish soil scientists are in the process of reviewing the keys. During recent trips to Finland by Del Mokma and Henry Mount, 46 pedons were described and sampled. Data from these pedons will be used to substantiate or change the keys.

Until recently, Finnish soil scientists have not used an international soil classification system. They used a national system that was designed for soil management. Observations below a depth of 50 cm were seldom made. As the soil scientists explored the potential of the system described in *Soil Taxonomy* as a soil classification system for Finland, they found the seventh edition of the *Keys to Soil Taxonomy* (644 pages) somewhat formidable. The 19-page "Keys to Soil Taxonomy for Finland" will remove that obstacle. Because the *Keys to Soil Taxonomy* is computerized, it was easy to select the orders and then delete the portions that do not apply to Finland. This process of selection could be used in other countries where soil scientists are reluctant to adopt the system described in *Soil Taxonomy* as their national soil classification system. A state or MO might wish to prepare similar keys for its state or area. This technique could be used in teaching soil classification to students who are interested only in the soils of a limited area.

The criteria for diagnostic horizons, diagnostic soil characteristics, soil moisture regimes, and soil temperature regimes were not included in the "Keys to Soil Taxonomy for Finland." These criteria could easily be added if including them is considered desirable in the future. If Finnish soil scientists encounter soils or characteristics that are not included in the Finnish keys, they should first consult the *Keys to Soil Taxonomy*. Also, they should have one or more persons in the country who follow accepted changes in the classification system described in *Soil Taxonomy* and evaluate their application to classification of the soils of Finland. The "Keys to Soil Taxonomy for Finland" and the keys for any other area must be dynamic just as the system of soil taxonomy is dynamic.

The Soil Survey of New York City as Part of the NRCS Urban Initiative

Those contributing to this article include Tyrone Goddard, Steve Carlisle, Luis Hernandez, and Steve Indrick, Natural Resources Conservation Service, New York; Ray Bryant and John Galbraith, Cornell University; and Eugenia Flatow and Robert Alpern, New York City Soil and Water Conservation District.

Just as forest soils are strongly affected by the presence of a high concentration of trees per unit area, so are urban soils highly influenced by the presence of a dense human population. All soil on earth has been influenced by humans to some degree, but only in urbanized areas has technology allowed such wholesale alteration of the natural soil condition.

In cities, much of what is termed "soil" is derived from sources other than mother nature. Urban parent material may consist of earthy fill material that may be similar to or vastly different from the natural soil material below, fill from garbage material and construction debris, dredgings from watercourses; composite material of asphalt and concrete in various stages of deterioration and decay; and huge areas having an artificial hard surface. The soils in many areas, even those derived from natural parent material, have been subject to special stresses, often for long periods of time. These stresses include compaction, vibration, and exposure to urban pollution.

In New York City, the Soil and Water Conservation District Board identified the following concerns for a city soil survey early in the planning discussions:

- Aquifer recharge, where ground water under the city itself is a major source of water, as in the federally designated "sole source aquifer" in Brooklyn and Queens;
- Leachate control, where active and inactive landfills have been used for dumping of toxic materials, as in the inactive landfills adjoining Jamaica Bay and Pelham Bay;
- Habitat protection, especially in threatened freshwater wetlands and salt marshes and on restricted sites where pockets of nature survive despite neglect and development;
- Sediment control, where waterfront erosion and soil carried by combined sewer overflows are significant sources of polluted near-shore sediment;
- Park landscaping and management, in soils of varied origins and qualities, in areas more or less subject to urban stress and pollution;
- Development of nature-based alternative infrastructure for storm-water management ("bluebelts") in an urbanized drainage area and for bio-remediation of landfills;
- Construction siting and design, where proposed projects test the carrying capacity and seismic stability of land and infrastructure.

For the Natural Resources Conservation Service (NRCS), addressing these concerns was the challenge as it embarked on the first serious urban soil survey in two decades.

Before the NRCS selected New York City as a pilot for the agency's urban initiative, the questions "Where to begin?" and "What services to provide?" had to be addressed. Representatives from the NRCS began by meeting and talking with community leaders, nonprofit organizations, city agencies, and elected officials. From these initial meetings, the agency ascertained what the local needs, issues, and concerns were. Throughout the process, the agency stayed focused on its commitment to build a strong and lasting local partnership through effective communication. A consensus was reached by all partners that a comprehensive urban soil survey that addressed the unique characteristics of urban soils as well as the specialized demands of urban customers was needed. A soil survey project area was selected in South Latourette Park to demonstrate NRCS soil survey products for park land and open land in urban settings.

The soil survey of South Latourette Park represents a milestone in the classification of human-influenced soils. *Soil Taxonomy* (Soil Survey Staff, 1975), the USDA system of soil classification for making soil surveys, was developed under the concept that soils form by forces of nature over thousands of years, and drastic modifications of soil characteristics by human activities were considered atypical, of limited extent, and of minor importance. Soils that are drastically altered by human activity were classed at the great group level as Udorthents but were not identified at the more specific soil series level, as other soils have been. For the purpose of soil survey, the soils covered with a high amount (more than 85 percent) of pavement or buildings were grouped into map units under the broad

NYC continued on page 7

NYC continued from page 6

designations of "miscellaneous land types" called Urban land, with only broad reference to the material underneath. Neither of these broad designations carried information specific enough to allow interpretations relative to use and management, as was provided by soil series and phases and their Interpretation Records.

In South Latourette Park, human-influenced soils are extensive and are of major importance to the use and management of the park. The park itself represents an important and limited land resource for tens of thousands of Staten Island residents. Reflecting this importance and the need for more soil specific information, several new soil series were established for drastically human-influenced soils, which carry relatively narrowly defined ranges of characteristics and soil interpretations for urban land use. In all map unit descriptions that accompany the soil survey of South Latourette Park, narrow ranges of properties derived from soil series are given and the interpretations that most apply to urban users are specifically targeted.

Soil quality can be considered the character of the soil that makes it suitable for various functions in the environment. In the urban ecosystem, soil quality is especially important and fragile. Nowhere else is soil managed so intensively and intimately as in the urban environment, where large populations of humans live in a confined area. The soils in these environments are buffeted by innumerable foot strikes. They act as a storehouse for the enormous amounts of solid wastes that humans generate. The soils absorb some of the poisonous exhaust gases emitted from the many cars, buses, and trucks. The strength of the soils is taxed as the soils provide foundations for multitudes of structures. Beyond all else, the soils are counted on to contribute to a healthy, high-quality living environment. In urban areas soil properties that influence rooting, the water-holding capacity, and the availability of nutrients are important measures of soil quality for plant communities. Likewise, the content of organic matter, organisms, other factors that influence runoff and infiltration, soil compaction, structure, and texture are important in measuring soil quality for hydrologic cycles. Another part of the issue of soil quality is the ability of the soil to store and recycle contaminants, and the impact of these contaminants on the soil and the environment. Unfortunately, monitoring or managing urban soil quality is at best poorly understood. The soil survey of Latourette Park, which includes new urban soil series and a heavy metals study, is a first step towards a more complete understanding of this profoundly important topic.

The soil survey of New York City is designed to help urban dwellers to better use and manage their soil resources. The first part of the program is what we have called a reconnaissance survey of the city at a mapping scale of 1:62,500. This will be followed by detailed soil surveys of open areas and intermediate soil surveys of the more built-up areas. The scale for this detailed mapping will vary but will often be at 1:4,800. The soil survey of South Latourette Park has been completed at this mapping intensity.

New soil series for anthropogenic soils are being proposed and evaluated during field mapping in some parts of the city. Percent of human artifacts, kind of human artifacts, and thickness of transported fill or truncated soil and its effect on other soil properties were used to characterize new soil series. Other soil properties, such as bulk density, compaction, organic carbon, and pH, are being evaluated as characteristics of urban soils.

In addition to the ongoing special studies of physical soil properties significant to soil quality, other special studies unique to soils in an urban environment will be undertaken. Already completed is a study of soil quality in the North Meadow Area of Central Park for use in developing a renovation plan. This project is an intensive study that measures water infiltration and movement in the upper part of the soil. Similar studies are anticipated during the course of the survey. A study is underway to determine the level of soil contamination by heavy metals. This study is part of a research project intended to measure the level of contamination, determine area distribution, and develop protocols for future studies. A ground-penetrating radar study was successful in identifying soil composition in landfills.

The soil survey of New York City is a cooperative project. Among the participants are the New York City Soil and Water Conservation District, Cornell University, and the NRCS. Other major cooperators are the Environmental Protection Agency (EPA), the New York City Department of Environmental Protection, the New York City Department of Transportation, the New York City Department of General Services, and the New York City Department of Parks and Recreation. It is hoped that this project will serve as an example of interagency collaboration and innovative design and project methods. Formation of the Technical Advisory Committee (TAC), made up of representatives of all of the cooperating Urban Initiative partners, provides a monthly forum for discussion and feedback among the interested parties.

First Subaqueous Soil Survey Completed

By Dr. George P. Demas, Soil Scientist, NRCS, Snow Hill, Maryland.

The Maryland Soil Survey Program has completed what may be the first ever soil survey of underwater (or subaqueous) soils. The project, a Subaqueous Soil Survey of Sinepuxent Bay, Maryland, was completed in early 1998 as part of Dr. George P. Demas' Ph.D. program under the direction of Dr. Martin C. Rabenhorst, Professor of Pedology at the University of Maryland, College Park. The research resulted in a significant change in the pedological definition of soil contained in *Soil Taxonomy* to include pedogenically altered materials in permanently submersed estuarine areas that support rooted, flowering, submersed aquatic vegetation.

Up until the completion of the project, permanently submersed areas were referred to as "sediment" and were commonly mapped by state geological agencies and the U.S. Geological Survey. The research showed that these materials have undergone pedogenic alteration and therefore fall within the scope of USDA-NRCS soil survey activities. The approach developed by Drs. Demas and Rabenhorst combined terrestrial concepts of soil survey (including terrain analysis and the soil-landscape paradigm) with estuarine processes of subaquatic landform development. Soil morphological descriptions and taxonomic placement of the soils indicated that subaqueous soil characteristics and distribution are related to the underwater landform type (e.g., shoals and overwash fans) and position on the subaqueous landscape. In addition, chemical and physical analyses of the soils indicate that the four processes of the generalized theory of soil genesis (described by Roy W. Simonson in "Outline of a Generalized Theory of Soil Genesis," *Soil Science Society of America Proceedings* 23: 152-156, 1959) were active in shallow water environments.

The project also employed an interdisciplinary approach to determine if subaqueous soil attributes are significant to the growth and survival of submersed aquatic vegetation (SAV). With the help of Dr. J. Court Stevenson, SAV researcher and Professor at the Center for Environmental Studies at Horn Point, Maryland, the study examined SAV biomass production in relation to water quality and subaqueous soil characteristics. The results of study indicate that subaqueous soil attributes, such as organic-carbon content, sulfide content, bulk density, and subaqueous soil fertility, are controlling factors in SAV distribution.

The project, funded by the USDA-NRCS and the Maryland Agricultural Experiment Station, has the potential to enhance estuarine restoration efforts underway in such areas as the Chesapeake Bay; Delaware Inland Bays; Pamlico-Albermarle Sounds, North Carolina; and Naragansett Bay, Rhode Island. For example, in areas where water quality has improved enough for SAV growth in the Chesapeake Bay, restocking efforts have not been successful, probably as a result of subaqueous soil attributes. SAV consists of rooted, flowering plants that rely on root uptake of nutrients, such as nitrogen and phosphorus. Some subaqueous soil attributes have a deleterious effect on SAV root survival. Subaqueous soil maps could provide a means to identify potential successful SAV restocking sites. Other environmental applications include the identification of areas that, when dredged, may have a serious acid-sulfate weathering potential if placed on upland sites, identification of potential clam and oyster restocking sites, and identification of areas that should be protected for future benthic organism colonization.

For more information about the study or mapping protocol, contact Dr. Demas or James Brown, State Soil Scientist, Maryland Soil Survey Staff. The results of the study should be published in a series of articles during the next year. The concepts underlying the study are described in an article entitled "Subaqueous Soils: A Pedological Approach to the Study of Shallow Water Habitats" in the June 1996 issue of *Estuaries* (37: 229-237).