Collection and Organization of Soil Data

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ABSTRACT

The following paper briefly describes how soil documentation is collected for a progressive soil survey. The Natural Resources Conservation Service, Soil Survey Division, along with the National Cooperative Soil Survey set the standards and processes used to produce soil surveys. Soil data is collected at several levels: point data or pedon descriptions, map unit data, spatial data, and interpretative data. This data is organized and summarized to create map unit descriptions and soil maps. Collection of representative and accurate soils information will result in a meaningful and consistent soil survey that land managers and conservationists can utilize to conserve our lands.

INTRODUCTION

The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service, is the federal agency that works hand-in-hand with the American people to conserve natural resources on private lands. Utilizing scientific and technical expertise, and partnerships with conservation districts and others, NRCS helps people conserve all natural resources on private lands. Soil Survey is one of several NRCS programs. It provides national leadership and service to produce and deliver scientifically-based soils data, and provide technical assistance to help people conserve, improve, and sustain our natural resources and environment. An important part of this mission is to produce uniform, consistent, and reliable soil surveys. The National Cooperative Soil Survey (NCSS) program is a joint effort between cooperating federal agencies, land-grant universities, and other state and local agencies to map soils, collect soil data, interpret the maps and data, and promote the use of the surveys. NRCS is the lead agency for the National Cooperative Soil Survey and has a long active history, celebrating its centennial in 1999.

While the main purpose and logic of the soil survey has remained constant, the soil surveyor's ability to record, assemble, and present information has changed. Soil survey field standards and procedures have evolved during this hundred-year period. A major part of this evolution has been due to the adaptation of available technology to conduct soil survey work. Field equipment through this century has remained quite basic and the observation and relational skills of the soil surveyor remain foremost. The procedures to classify, to assemble, and to present soil information have had the most significant change. More than ever, soil survey will always be active because of the demand of the users of the information as well as the ever-developing science of soil survey. The standards established by the NCSS and the dedication of soil scientists have produced a national soils database that has no equal. This collection of data enables land managers to best manage our natural resources.

Soil scientists specialize in several areas: researchers, who work in the field and laboratories to experiment on how different soil types work and relate to other resources; resource soil scientists that relay and interpret soil information to other resource managers; and soil mappers that collect base soil information and explain soil relationships to landforms, geology, hydrology, and vegetation. Mappers provide the basic information that resource scientists, conservationists, and land managers can use.

The soil data is collected on several levels: point data, map unit data, spatial data, and interpretative data. Point data describe a pedon profile, is site specific, and should represent what is typical about a particular soil. Map unit data is the information that describes the soil forming factors and includes, where different soil types are found on the landscape, the soils range in characteristics such as color and texture, and how they relate to each other, and topography, climate, vegetation, and geology. The spatial data consists of soil delineations and special features located on georeferenced orthoquadrangle base maps. The interpretative data consists of soil ratings and estimated properties that assist conservationists and land managers in making management decisions.

Soil data is collected in many different ways, and each soil scientist organizes data in a slightly different way. It is most important to collect data that will be useful and meaningful to the end users and to organize it in a way that others can understand. The methods described below are not revolutionary or complex, but have been found to work well for organizing data.

NCSS soil scientists have several sets of documents that help guide in the process of collecting soil data. The Soil Survey Manual gives concise definitions and methods of collecting soil data. The National Soil Survey Handbook describes what and how soil properties are collected and how they are reported. Soil Taxonomy establishes a detailed system to classify soils. The Field Book for Describing and Sampling Soils lists properties and terms used to describe soils in the field with visual aids to help describe qualities, sizes, and quantities. The reference documents listed above are available on the internet at www.ncss.gov. And finally, and most important, is the Memorandum of Understanding for a specific soil survey project area. It describes the objective of the survey, identifies responsibilities, and outlines the specifications. These documents allow soil scientists throughout the United States to produce soil maps, measure soil properties, and collect documentation in a consistent manner over a wide geographic area.

Data needs to be collected in an orderly, systematic way in order to be meaningful and useful. Point data or pedon description sites must be selected so that they are representative and display a typical range of characteristics for a specific map unit in the soil survey area. Transects should be placed within soil delineations in such a way as to statistically sample the variability of the map unit. Extra care should be taken on hills and mountains so that all parts are sampled, i.e. toe slopes, side slopes, and summits. Documentation should be gathered throughout the survey area, and not limited to one geographic area. If this process is followed it will result in quality data that is significant and specific to the soil survey area.

Point Data

Point data or pedon descriptions are collected ideally from a soil pit. Soil pits are typically sixty to eighty inches (152 to 203 cm) deep, approximately five by six feet (1.5 to 2 m) wide, and large enough to be safe for one or two people to describe the soil profile. Point data can also be described from road cuts, auger holes, erosional cuts, or anywhere a soil profile is exposed. Caution should be used to ensure that the material you describe is naturally-occurring and not disturbed or fill material. The most important piece of information for the point data is the location coordinates. This can be in any format, but must be exact enough for other to locate. Some examples are, Township, Range and Section, latitude and longitude, or Universal Transverse Mercator (UTM), and proximity to major roads, rivers, towns, and cities. Data without a location become useless. The point data can be broken down into three categories: physical, chemical, and landscape.

Physical properties are described on site and describe the soil condition at a given time and place. Physical properties consist of texture, depth of horizons, structure, color, stickiness and plasticity, hardness, rock fragments, and depth to root restrictive layers.

Chemical properties can be described on site or later from laboratory analysis. There are several tests that can be performed onsite for pH, calcium carbonate percentage, and effervescence. More complex analyses of electrical conductivity (EC), sodium adsorption rates (SAR), and gypsum content should be completed in a laboratory. It is also advised to calibrate field measurements against laboratory analysis. This can be completed for pH, particle size, calcium carbonate percentage, and mineralogy. Not all pedon descriptions need laboratory analysis, but it is a good science to sample several representative sites throughout the survey area to calibrate field estimations.

Landscape and climatic properties are described on site. This information will establish the setting for the map unit. These properties include slope, accelerated erosion, landform, flooding potential, elevation, rainfall, air temperature, and soil temperature.

Map Unit Data

A map unit is a description of each delineation made on a soil map. It will describe where the unit is located on the landscape, the composition of the soils that are represented by the map unit, the characteristics of each soil present, and other resource information, such as ecological sites and land capability. Map unit data is collected through mapping observations, field notes, and transects. Transects are straight line traverses across soil delineations that are perpendicular to the drainages of the landscape and consist of ten evenly spaced holes/point data. For small delineations the spacing could be in feet and for large delineations in tenths of a mile. The information collected from transects is used to calculate the composition of the map unit including minor components and the range in characteristics for each soil. Field notes are used by soil scientists to record daily observations while mapping. The field notes are then incorporated into the map unit descriptions. Field notes can consist of observations for the range in characteristics, minor components (soils not named in the map unit), vegetation, erosion properties, and other unique properties of the map unit such as desert pavement, crust, and cracks. Again, all notes and transects need to have specific locations and coordinates. This can easily be done by tracking notes and transects on both aerial photos/field sheets and topographic maps. This way each field sheet (permanent record of soil delineations) will have the documentation collected recorded on the back and each document will belong to a specific field sheet.

Spatial Data

Spatial data is the information that is included on the maps including data layers and special features. Soil maps, at a minimum, should have the soil delineations and enough background features so that the user of the maps can quickly locate the areas of interest. Black and white rectified photography is commonly used for field sheets. Field sheets are the permanent hard copy record of the spatial data, which includes soil delineations, documentation, special features, acres mapped, and dates of completion. Special features can be any land or water features which are too small in extent to be easily expressed on soil maps, but are important to land management. Examples of special features could include springs, levees, major roads, stream, gravel pits, and severe erosional areas. The field sheets can be digitized either during or after a soil survey is completed.

Interpretative Data

Interpretative data can be collected from people who manage the land. An example would be crop yield information and range production. Other interpretative data are the result of estimates based on point data, such as available water content or erosion factors. The following is a list of some interpretative data: available water content, saturated hydraulic conductivity, K factor, T factor, Wind Erosion Groups, shrink-swell potential, and hydrologic group. Another set of interpretative data uses point data to rate soils for specific uses. A rating system from good to severe lets users know of potential limitations associated with a specific use. This set of data is reported in tables and includes: recreational development, building site development, sanitary facilities, construction materials, water management, soil and water features.

Before documentation begins, a filing system needs to be in place. Again this is unique to the soil scientist, but must be systematic, hopefully simple, and understandable to anyone dealing with the soil survey project. The following are simplified steps that occur in a progressive soil survey.

1. Collect all related resources including: topography maps, geology maps, historical mapping, precipitation and temperature information, stream flows, and, most important, good quality aerial photography.
2. Become familiar with the Memorandum of Understanding, the soil survey area, and begin mapping.
3. Create map units and add to the developmental legend.
4. Collect documentation.
    a. Log completed transects, field notes, and pedon descriptions on a spreadsheet format by map unit number and date and on field sheets or topographic maps.
    b. Place documentation in map unit folder; summarize range of characteristics.
    c. Establish type location.
    d. Complete database input sheets.
    e. Input data.
    f. Generate map unit descriptions and tables.
    g. Build descriptive legend of developmental map units, tables and soil maps.
    h. Test map units by soil staff and other resource specialists.
5. Map units must be approved by quality control and assurance staff before being added to the approved legend.
6. Repeat. The above steps are a continual process until mapping is completed. Remember to keep the descriptive legend and soil maps updated.

The above steps are the process of a progressive soil survey. Before the process begins, you must know who and what information the end users will need, as specified in the Memorandum of Understanding. As a soil scientist begins to map, a legend begins to develop. A legend is simply a list of map units, that includes soil names, phases, and slopes. In the early days of mapping a new survey area, the legend may exist only as numbers with generalized soil names or properties. As more and more time is spent mapping and data is collected, the legend evolves. Each piece of documentation is recorded on a spreadsheet by both map unit and date. It is sometimes helpful to color code documentation by year. Then, each piece of documentation is placed in a folder that represents that map unit; this is where the range in characteristics are built. A summary sheet for each soil collects the individual range in characteristics accumulated from the documentation for each map unit. When sufficient documentation has been collected, a type location is selected. A type location or typical pedon is the site data that best represents the soil for a particular map unit. The typical pedon will have the most typical characteristics of the named soil. The map unit can be written using the typical pedon and incorporating all of the data collected. The map unit description represents all areas where the unit occurs and is unique for the soil survey area. Information may vary due to the land managers' and conservationists' need for the soil survey.

The following information is generally included in a soil map unit description: Setting - landform, slope range, elevation, mean annual precipitation, mean annual air and soil temperature, and frost-free period; Composition - including minor components; Typical Profile with location and coordinates - detailed description of each soil by horizon; Soil Properties and Qualities - classification, parent material, depth class, drainage class, permeability, available water capacity, runoff class, shrink-swell potential, seasonal water table depth, hydrologic group, land capability, ecological site, present vegetation, land resource unit, and major land resource area. The soil survey area is best represented if all the data collected is processed and included in the map unit descriptions.

From the folders that contain this information, summary data spreadsheets pull the information together to consolidate the ranges. Map unit descriptions are computer-generated from databases or complied in word documents. Map unit descriptions need to be very consistent in both context and format. Format needs to be consistent so users can easily compare different map units and quickly find the information they need. NRCS, soil scientists enter all data into a national database known as the National Soil Information System (NASIS). NASIS allows field soil scientists (mappers) to input point data, map unit data, and estimated data, along with legends and correlation and map unit notes. NASIS is then able to run complex programming which generate reports and interpretations; including map unit descriptions. NASIS has the ability to generate interpretations for a specific set of map units and for a specific land use. Common interpretative tables include ratings on the following: Recreational Development - camp areas, picnic areas, playgrounds, paths and trails; Building Site Development - shallow excavations, small commercial buildings, dwelling with or without basements, local roads and streets, lawns and landscaping; Sanitary Facilities - septic tank absorption fields, sewage lagoon areas, trench sanitary landfills, daily cover for landfill; Construction Materials - road fill, gravel, sand, topsoil; Water Management - pond reservoir area, dikes and levees, irrigation, terraces and diversion; Soil and Water Features - flooding, depth to bedrock, depth to hardpans, risk of corrosion. NASIS is programmed in such a way as it can be modified to include local and state reports or calculations as needed.

The completed map unit descriptions, legends, and field sheets combine to create the descriptive legend. The descriptive legend is a working draft document of the soil survey manuscript. The descriptive legend is used to test the validity of the map units and soil maps and will be corrected and updated throughout the life of the soil survey. After all of the map units are approved and correlated, the descriptive legend becomes the rough draft of the soil survey manuscript, ready for technical and English edits. The field sheets will go through the process of map finishing, which includes digitizing and then formatting for publication. The manuscript and the finished maps come together to form the completed soil survey.

Producing a soil survey is more than just data collection. The documentation must connect to spatial data and the soil scientist must be able to “draw a picture in the air” for the user. Organization of data starts before the soil scientist leaves the office. Keeping track of legends, map unit descriptions, transects, field notes, and pedon descriptions is a tedious task, but necessary for a successful and smooth running survey. If the process is started before mapping begins, the result will be a smooth running, progressive soil survey that will build upon itself. At its completion, the progressive soil survey will have approved map unit descriptions, interpretations, and soil maps ready for land managers and conservationists to utilize.

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