Soil Survey: The Foundation for Productive Natural Resource Management

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What is a soil? How does one soil differ from another? How can we use our soils to provide food and fiber for present needs and still maintain them for future generations? Soil maps and the information that accompanies them—soil survey reports—provide answers to these questions and many others.

What is a soil survey

A soil survey is an inventory of the soil resources of a county or area. It consists of a soil map, descriptions of the soils and soil map units, and predictions (interpretations) of soil behavior for different uses and management.

Soil surveys are the product of a nationwide effort known as the National Cooperative Soil Survey. Major cooperators in North Dakota are the Soil Conservation Service (SCS), North Dakota Agricultural Experiment Station, North Dakota State Soil Conservation Committee, Soil Conservation Districts (SCD), and county commissions. The SCS provides technical organization required to manage and conduct the survey. State agencies and land grant universities and many counties provide financial and technical assistance. In some counties, the Bureau of Land Management, Bureau of Indian Affairs, United States Forest Service, and various other local boards and districts provide assistance.

How soil surveys are made

Soil properties are identified on each tract of land in the survey area. Soil scientists dig holes at various locations on the landscape to examine the soil. Observations of color, texture, structure, and other characteristics of the different layers (horizons) are noted. The soil profile (a vertical section of soil through all horizons) at each hole is compared with other soil profiles in the area. Using this procedure, the soils are classified, named, and delineated on a map as bodies of soil in a landscape. Soil scientists observe and record other landscape and cultural features on the map such as slope gradient, streams, drainageways, lakes, roads, railroads, dams, and gravel pits.

Modern soil survey began about 1940 with the use of aerial photographs to study and map soils. Aerial photographs improved soil survey accuracy compared to methods used prior to 1940. Physical features of land such as drainways, hills, and depressions are easily seen on aerial photographs and related to soil properties. Cultural features such as cropping patterns, roads, farmsteads, and railroads are also shown and help orient the soil scientist when soil boundaries are drawn.

Some samples of soils are collected for laboratory analyses from sites that represent typical types of soil in the survey area.

Soil scientists can relate the results of the laboratory analyses to those types of soils anywhere in the survey area. In this way, chemical and physical properties determined in the laboratory are linked with day-to-day field observations by the soil mapper. Soil maps help the user estimate soil properties on a parcel of land without actual sampling and testing.

Information contained in soil survey reports

General Information

Information contained in soil survey reports is useful to producers, private land owners, and a wide variety of professionals that work with natural resources. Soil mapping requires the soil scientist to utilize information from many other disciplines. A blend of geology, climatology, agronomy, forestry, range science, engineering, chemistry, physics, and biology is reflected in soil maps. In addition to soils information, much of the basic information from the various disciplines needed for mapping is found within the soil survey report.

Soil Information

General Soil Map:

> A general soil map is a small-scale map which gives a broad picture of the type and distribution of soils that occur in the county or area. Maps of this scale do not show sufficient detail for comparing the soils on individual tracts or farms.

Soil Series Descriptions:

> Each soil series represents a specific kind of soil with a unique set of physical, chemical, and mineralogical characteristics. Soils of a specific soil series also have similar observable properties such as color, texture, structure, and sequence of soil horizons. The soils within each soil series have similar reactions to use and management but have uniquely different reactions compared to soils of other soil series. Soil series usually receive their names from the town or community closest to the site that represents the typical range of properties for that soil, such as **Manfred, Heimdal,** or **Fargo**. About 264 soil series currently are recognized in North Dakota.

Soil Map Unit Descriptions:

> The separations of area (delineations) on a soil map represent combinations of soil series that occur in predictable patterns in the landscape. These predictable combinations are soil map units and are identified by a unique name and symbol. Some map units represent areas dominated by a single soil series, such as Barnes loam, 3 to 6 percent slopes. However, many map units represent areas that are dominated by two or more soil series, such as Barnes - Svea loams, 1 to 6 percent slopes. All soil areas marked with the same symbol consist of the same combination of soils as identified in the soil map unit description. Soil map units are named for the one or more soil series that dominate the unit. A minor percentage of each soil map unit is other soil series that are not included in the name of the map unit. However, minor soils are discussed in the map unit description.

Interpretation:

> Soil interpretation refers to behavior and response of soils related to human activities. Interpretations are a guide to use and management of soils in the survey area. Soils with similar responses to a particular use or treatment often are grouped together. Common interpretations are land use capability classification, range site classification, woodland suitability group, engineering classification, wind and water erodibility groups, and estimated yields of commonly grown crops. Soil interpretations are generally found in tables and are organized according to map unit symbol.

Other Soil Data:

> The soil survey report also contains information about the following:
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> Alkalinity/Acidity
> Available water capacity
> Degree of erosion
> Depth to bedrock
> Depth to water table

Horizon thickness
Permeability
Salinity and/or Sodicity
Slope gradient
Soil color
Soil lime (carbonates)
Soil organic matter
Soil structure
Soil texture
Stoniness

Finding information about the soils on your farm or ranch

Soils information about a specific parcel of land can be located in the soil survey report as follows:

1. Refer to the *Index to Map Sheets* page (usually located just before the first map sheet). The index directs you to the sheet number (map) of interest.
2. Locate the area of interest on the correct map sheet.
3. Determine the map units that represent the soils in the area of interest by comparing map unit symbols to the *Soil Legend* on the reverse side of the *Index to Map Sheets*.
4. Refer to the *Index to Map Units* at the begining of the report to find the page numbers where these soil map units are described.
5. Refer to the *Summary of Tables* at the beginning of the report to locate interpretive tables for each soil map unit.
6. Use the interpretive tables related to the type of use intended for the area of interest as a guide for successful management.

How a soil survey report can be of use to you

Agricultural Producers, Farm Managers, and Consultants

The soil survey report contains information that is the basis for conservation efforts aimed at erosion protection from wind and water. General management practices that help reduce erosion and maintain soil productivity are discussed for each soil map unit.

Estimated average yields of the principal crops suited to the soil and area are given for an above average level of management. Grass and tree species suited to the soil and area are also discussed. Soil interpretations such as available water capacity, soil texture, and soil pH can be helpful in making fertilizer recommendations.

Each map unit is assigned a productivity index for a common crop grown in the survey area (generally hard red spring wheat in North Dakota). This is a relative rating between 0 and 100. The productivity index can be converted to expected yield per acre by multiplying it by the highest yield per acre for the survey area and dividing the product by 100. Using the productivity index, the producer can refer to the soils map to determine how productive a particular parcel of land is compared to other land in the survey area.

Map units are grouped into eight land capability classes that help categorize land according to its potential for agricultural development. Each class is defined according to the severity of limitations to agricultural production. All classes, except for class I, are separated into subclasses according to the type of limitations.

Classes I - IV have increasing limitations to cultivation, respectively.

Classes V - VIII are not suitable for cultivation due to severe limitations.

Soil survey reports of areas proposed for irrigation may contain a discussion of soil management under irrigation. Irrigation suitability ratings, limitations, and management problems for each soil are given in those soil survey reports. Estimated yields under irrigation also are presented. Irrigation potential of each map unit is provided in all county soil surveys, even though irrigation may not be an immediate concern.

Sustained production of rangeland depends on proper management. Soil series are grouped in the soil survey report according to similar native plant communities and range management needs. Soil - plant community groups are called *range sites* and are used to design grazing management plans. Estimated annual rangeland production is also presented for each soil series in a good, average, and poor year.

Bankers, Investors, Land Appraisers, Credit Agencies and Directors of Tax Equalization

The soil survey report is a source of information that can be used to estimate the earning capacity of different soils in the survey area. The productivity index is an excellent system for rating relative productivity of different soils. Such information is useful to anyone interested in appraising land for investment, loan or valuation purposes.

Detailed soil maps and other soil information have been used by state and local officials in North Dakota and other states as a basis for equalizing land values for tax purposes.

Natural Resource Education

A county soil survey report is an invaluable source of natural resource information that can be incorporated into educational programs. Soil is the result of complex natural processes that are affected by climate, time, geological materials, topography, and living organisms. Identification and classification of soils during the mapping process requires accurate information about the environment that affects soil formation. The soil survey report is, therefore, an excellent inventory of local natural resources.

Windbreaks, Woodland, and Wildlife

The potential for growing trees is rated in the map unit descriptions. The preparation and maintenance of wind-break sites are discussed and species of trees suitable for windbreaks are listed. A limited discussion of native woodland that includes species and locations is included in the report.

Soil management for wildlife is presented in the report. Discussion of kinds and distribution of wildlife and methods of improving wildlife habitat in the survey area are included. Information on degree of soil salinity and occurrence of water tables is helpful in identifying areas more suited to wildlife than to crops.

Highway/Construction Engineers and Land Developers

Soil information and maps can help highway engineers with the routing and design of roadways. Soil maps show the areas where construction of road subgrades by conventional methods may be unsuitable because of unstable soil materials. Some soil areas are susceptible to frost action unless special precautions are taken during road construction. Potential sources of sand and gravel for road surfacing and soil material suitable for top dressing roadside cuts can be located on soil maps. Soil survey reports can also be used to determine suitability of soils for cross-country movement of heavy equipment.

Prior knowledge about suitability of soils for construction or buildings is valuable information to many people, including the homewowner. Land developers and construction engineers rely on soil survey information to anticipate general construction and development problems that are common to an area, such as flooding, high water table, slow permeability, shallow bedrock, soils of low bearing strength, high shrink-swell soils, or high soil corrosivity. Knowledge of general engineering problems helps them incorporate remedial measures in their overall development or construction plans. This information is also useful for planning detailed on-site investigations prior to construction. Potential construction failures or cost over-runs can be avoided by consulting a soil survey first.

Planning Boards, Health Officials and Municipal Officials

Soil data on permeability, depth to ground water, flooding, slope gradient, soil texture, and depth to bedrock can be useful in determining soil suitability for septic waste filter fields. Septic waste systems will back up and overflow when the soil does not allow fast enough movement of waste effluent through the filtration field. Other types of soils allow waste effluent to move too rapidly through the filtration field, resulting in groundwater contamination. Soil survey information identifies those soils that may cause serious contamination and health problems due to inadequate filtration of waste.

Knowledge of local soil capabilities and limitations is useful when zoning land for various uses. It can help zoning boards prepare land use plans and zoning maps by evaluating soil suitability for agriculture, private homes, industry, transportation, and recreation. For example, land areas subject to flooding might be zoned to prohibit the erection of permanent structures. Soil survey information can also be used to help officials evaluate proposed building development plans or landfill sites.

New uses and applications of soil survey information

Geographical Information Systems (GIS)

Every scientific discipline must be progressive to meet society's needs. Soil survey is not an exception. The advent of computers and demand for accurate, timely soils information have led to the use of geographical information systems (GIS). Computers allow rapid access to soil maps and interpretive tables. Soil survey information is just one of many geographical data sets that are part of a GIS. Common data sets used in a GIS include topography, land use, and hydrology. The different data sets can be combined, manipulated, and analyzed in many ways. For example, a township board might be interested in knowing the locations of township roads occurring on soils poorly suited to road construction. A GIS would allow board members to overlay the township roadmap on the soil map. Problem areas could be located in a matter of seconds with a GIS. The potential for GIS as a management tool is limited only by the accuracy of the various data sets and the imagination of the user.

The National Cooperative Soil Survey is committed to developing a GIS to meet the growing demand for soils information. The SCS in cooperation with the State Soil Conservation Committee and North Dakota State University has four GIS work stations in North Dakota.

Water Resource Vulnerability

Contamination of soils and water resources with industrial, municipal, and private wastes is a growing concern. Soil acts as a natural filter and deactivator of many types of contaminants. Filtering efficiency within an area can be quite variable due to differences in soil properties. Recently, soil scientists have begun to use information from soil surveys to identify areas of water resource vulnerability. A general groundwater vulnerabilty map is available for most counties in North Dakota.

Soil interpretations that rate soils series in regard to contamination from nitrate and different pesticides are being tested. Eventually these interpretations will be used to provide detailed maps of contamination potential to assist in managing land to protect water resources. At this time, interpretations for water resource vulnerability are not in the county soil survey reports.

High Efficiency Application of Agricultural Chemicals

The need for efficient use of agricultural chemicals will continue to increase due to economic and environmental factors. Recent advances in computer and control equipment technology are helping to improve efficiency of fertilizer application.

Actual utilization of fertilizer by the plant varies with changes in soil properties. Computerized application equipment has been tested that uses soil survey maps to adjust the application rate of fertilizer. As the equipment moves across a field, the rate of fertilizer application is automatically adjusted at soil boundaries. The most advanced application equipment locates itself with respect to soil boundaries by communicating with a Global Positioning Satelite. Accuracy of location varys with expense of the positioning system.

Do soil maps have limitations?

Regardless of the purpose and scale of mapping, all map unit delineations contain small areas of dissimilar soils that cannot be delineated. Most county soil surveys in North Dakota have been mapped and published at a scale of 1:20,000 or 3.17 inches per mile. Soil maps of this scale can be used to evaluate tracts of land for most resource planning needs. Soil areas smaller than about five acres cannot be shown on these maps, even though they differ significantly from the adjacent soils.

On-site investigation is necessary to determine soil suitability for intensive use of small areas. The capacity of soils on a residential lot to absorb septic waste effluent or to support the weight of a large building can be estimated only in a general way from a county soil survey report. **On-site** soil examination and testing are required to accurately determine soil suitability for these and other uses.

For some purposes it is essential that contrasting soil areas of less than one acre be delineated. The soils of agronomic

research sites, for instance, must be mapped in great detail so that soil conditions can be related to crop performance. Large-scale maps (8 inches per mile or larger) provide for the delineation of smaller soil areas.

New information will require periodic updates to all soil survey reports and maps. Soil mapping is a continual process similar to research in other scientific disciplines. As soil survey reports age, some parts may rapidly lose their utility, while other parts may accurately reflect our knowledge for years to come. Updated soil interpretations can be found at local SCS offices in the Technical Guide.

Soil surveys can help you manage your resources for sustained productivity

SOIL SURVEYS CAN HELP YOU. They are an inventory of the soils that affect your basic needs; food, water, and shelter. Soil survey reports provide information that can be used for agricultural production, environmental protection, highway and building construction, recreation and wildlife management, and land use planning and zoning for healthy city and rural environments.

Where to obtain soil survey information

Published county soil survey reports are available at the respective Soil Conservation Service offices or the Department of Soil Science, North Dakota State University. For counties with unpublished soil surveys, the local Soil Conservation Service office should be contacted.

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