All Uses

Introduction to Soils

Soils 101

What is soil? (less technical)

Soil is a naturally occurring mixture of mineral and organic ingredients with a definite form, structure, and composition. The exact composition of soil changes from one location to another. The following is the average composition by volume of the major soil ingredients:

- 45% Minerals (clay, silt, sand, gravel, stones).
- 25% Water (the amount varies depending upon precipitation and the water-holding capacity of the soil).
- 25% Air (an essential ingredient for living organisms).
- 5% Organic matter or humus (both living and dead organisms).

A soil is composed primarily of minerals which are produced from parent material that is weathered or broken into small pieces. Beyond occasional stones, gravel, and other rock debris, most of the mineral particles are called sand, silt, or clay. These mineral particles give soil texture. Sand particles range in diameter from 2 mm to 0.05 mm, are easily seen with the unaided eye, and feel gritty. [One millimeter (mm) is about the thickness of a dime.] Silt particles are between 0.05 mm and 0.002 mm and feel like flour. Clay particles are smaller than 0.002 mm and cannot be seen with the unaided eye. Clay particles are the most reactive mineral ingredient in the soil. Wet clay usually feels sticky.

Water and air occupy the pore spaces—the area between the mineral particles. In these small spaces, water and air are available for use by plants. These small pore spaces are essential to the life of soil organisms, to soil productivity, and to plant growth.

The final ingredient of a soil is organic matter. It is comprised of dead plant and animal material and the billions of living organisms that inhabit the soil.

(From "Conserving Soil," NRCS)

What is soil? (more technical)

Soil is a natural body which consists of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: (1) horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or (2) the ability to support rooted plants in a natural environment. The upper limit of soil is the boundary between soil and air, shallow water, live plants, or plant materials that have not begun to decompose.

Areas are not considered to have soil if the surface is permanently covered by water too deep (typically more than 2.5 meters) for the growth of rooted plants. The lower boundary that separates soil from the nonsoil underneath is most difficult to define. Soil consists of horizons near the earth's surface that, in contrast to the underlying parent material, have been altered by the interactions of climate, relief, and living organisms over time. Commonly, soil grades at its lower boundary to hard rock or to earthy materials virtually devoid of animals, roots, or other marks of biological activity. For purposes of classification, the lower boundary of soil is arbitrarily set at 2 meters.

(From "Soil Taxonomy," second edition, 1999)

How does soil form?

Soils develop as a result of the interactions of climate, living organisms, and landscape position as they influence parent material decomposition over time. Differences in climate, parent material, landscape position, and living organisms from one location to another as well as the amount of time the material has been in place all influence the soil-forming process.

The five soil-forming factors are:

- Parent material,
- Climate,
- Living organisms,
- Landscape position, and
- Time.

Parent Material

Parent material refers to that great variety of unconsolidated organic (such as fresh peat) and mineral material in which soil formation begins. Mineral material includes partially weathered rock, ash from volcanoes, sediments moved and deposited by wind and water, or ground-up rock deposited by glaciers. The material has a strong effect on the type of soil developed as well as the rate at which development takes place. Soil development may take place quicker in materials that are more permeable to water. Dense, massive, clayey materials can be resistant to soil formation processes. In soils developed from sandy parent material, the A horizon may be a little darker than its parent material, but the B horizon tends to have a similar color, texture, and chemical composition.

Climate

Climate is a major factor in determining the kind of plant and animal life on and in the soil. It determines the amount of water available for weathering minerals and transporting the minerals and elements released. Climate through its influence on soil temperature, determines the rate of chemical weathering.

Warm, moist climates encourage rapid plant growth and thus high organic matter production. The opposite is true for cold, dry climates. Organic matter decomposition is also accelerated in warm, moist climates. Under the control of climate, freezing and thawing or wetting and drying break parent material apart.

Rainfall causes leaching. Rain dissolves some minerals, such as carbonates, and transports them deeper into the soil. Some acid soils have developed from parent materials that originally contained limestone. Rainfall can also be acid, especially downwind from industrial production.

Living organisms

Plants affect soil development by supplying upper layers with organic matter, recycling nutrients from lower to upper layers, and helping to prevent erosion. In general, deep rooted plants contribute more to soil development than shallow rooted ones because the passages they create allow greater water movement, which in turn aids in leaching. Leaves, twigs, and bark from large plants fall onto the soil and are broken down by fungi, bacteria, insects, earthworms, and burrowing animals. These organisms eat and break down organic matter releasing plant nutrients. Some change certain elements, such as sulfur and nitrogen, into usable forms for plants.

Microscopic organisms and the humus they produce also act as a kind of glue to hold soil particles together in aggregates. Well-aggregated soil is ideal for providing the right combination of air and water to plant roots.

Landscape position

Landscape position causes localized changes in moisture and temperature. When rain falls on a landscape, water begins to move downward by the force of gravity, either through the soil or across the surface to a lower elevation. Even though the landscape has the same soil-forming factors of climate, organisms, parent material, and time, drier soils at higher elevations may be quite different from the wetter soils where water accumulates. Wetter areas may have reducing conditions that will inhibit proper root growth for plants that require a balance of soil oxygen, water, and nutrients.

Steepness, shape, and length of slope are important because they influence the rate at which water flows into or off the soil. If unprotected, soils on slopes may erode leaving a thinner surface layer. Eroded soils tend to be less fertile and have less available water than uneroded soils of the same series.

Aspect affects soil temperature. Generally, for most of the continental United States, soils on north-facing slopes tend to be cooler and wetter than soils on south-facing slopes. Soils on north-facing slopes tend to have thicker A and B horizons and tend to be less droughty.

Time

Time is required for horizon formation. The longer a soil surface has been exposed to soil-forming agents like rain and growing plants, the greater the development of the soil profile. Soils in recent alluvial or windblown materials, or soils on steep slopes where erosion, has been active may show very little horizon development.

Soils on older, stable surfaces generally have well-defined horizons because the rate of soil formation has exceeded the rate of geologic erosion or deposition. As soils age, many original minerals are destroyed. Many new ones are formed. Soils become more leached, more acid, and more clayey. In many well drained soils, the B horizons tend to become redder in color with time.

(Found in "From the Surface Down," NRCS)

What are soil horizons?

Soils are deposited in or developed into layers. These layers, called horizons, can be seen where roads have been cut through hills, where streams have scoured through valleys, or in other areas where the soil is exposed.

Where soil-forming factors are favorable, five or six master horizons may be in a mineral soil profile. Each master horizon is subdivided into specific layers that have a unique identity. The thickness of each layer varies with location. Under disturbed conditions, such as intensive agriculture, or where erosion is severe, not all horizons will be present. Young soils have fewer major horizons.

The uppermost layer generally is an organic horizon, or O horizon. It consists of fresh and decaying plant residue from such sources as leaves, needles, twigs, moss, lichens, and other organic material accumulations. Some organic materials were deposited under water. The subdivisions Oa, Oe, and Oi are used to identify levels of decomposition. The O horizon is dark because decomposition is producing humus.

Below the O horizon is the A horizon. The A horizon is mainly mineral material. It is generally darker than the lower horizons because of the varying amounts of humified organic matter. This horizon is where most root activity occurs and is usually the most productive layer of soil. It may be referred to as a surface layer in a soil survey. An A horizon that has been buried beneath more recent deposits is designated as Ab.

The E horizon generally is bleached or whitish in appearance. As water moves down through this horizon, soluble minerals and nutrients dissolve and some dissolved materials are washed (leached) out. The main feature of this horizon is the loss of silicate clay, iron, aluminum, humus, or some combination of these, leaving a concentration of sand and silt particles.

Below the A or E horizon is the B horizon, or subsoil. The B horizon is usually lighter colored, denser, and lower in organic matter than the A horizon. It commonly is the zone where leached materials accumulate. The B horizon is further defined by the materials that make up the accumulation, such as the letter t in the designation Bt, which identifies that clay has accumulated. Other illuvial concentrations or accumulations include iron, aluminum, humus, carbonates, gypsum, or silica. Soil not having recognizable concentrations within B horizons but showing a color or structural difference from adjacent horizons is designated Bw.

Still deeper is the C horizon or substratum. The C horizon may consist of less clay, or other less weathered sediments. Partially disintegrated parent material and mineral particles are in this horizon. Some soils have a soft bedrock horizon that is given the designation Cr. C horizons described as 2C consist of different material, usually of an older age than horizons which overlie it.

The lowest horizon, the R horizon, is bedrock. Bedrock can be within a few inches of the surface or many feet below the surface. Where bedrock is very deep and below normal depths of observation, an R horizon is not described.

(Found in "From the Surface Down," NRCS)

What is a soil scientist?

A soil scientist studies the upper few meters of the earth's crust in terms of its physical and chemical properties; distribution, genesis and morphology; and biological components. A soil scientist needs a strong background in the physical and biological sciences and mathematics.

(From "Careers in Soil Science" http://soils.usda.gov/education/facts/careers.html)

What is a soil survey?

One of the main tools available to help land users determine the potentials and limitations of soils is a soil survey. Soil surveys are available through the USDA, Natural Resources Conservation Service (NRCS). The surveys are made by NRCS in cooperation with other Federal, State, and local agencies. Our offices can provide this information, but more and more soil surveys are also available on the Internet. Web Soil Survey allows you to produce a customized soil survey for your own area of interest.

A soil survey generally contains soils data for one county, parish, or other geographic area, such as a major land resource area. During a soil survey, soil scientists walk over the landscapes, bore holes with soil augers, and examine cross sections of soil profiles. They determine the texture, color, structure, and reaction of the soil and the relationship and thickness of the different soil horizons. Some soils are sampled and tested at soil survey laboratories for certain soil property determinations, such as cation-exchange capacity and bulk density.

Like any tool, a soil survey is helpful only if you know what it can and can't do, and if you use it accordingly. The survey does not replace careful onsite investigation or analysis by a soil scientist

(Found in "From the Surface Down," NRCS)

Who uses a soil survey?

Soil surveys available from the Natural Resources Conservation Service are intended for many different users. They can help homebuyers or developers determine soil-related hazards or limitations that affect homesites. They can help land use planners determine the suitability of areas for housing or onsite sewage disposal systems. They can help farmers estimate the potential crop or forage production of his land. They can be used to determine the suitability and limitations of soils for pipelines, buildings, landfills, recreation areas, and many other uses.

Many people assume that soils are all more or less alike. They are unaware that great differences in soil properties can occur within even short distances. Soils may be seasonally wet or subject to flooding. They may be shallow to bedrock. They may be too unstable to be used as a foundation for buildings or roads. Very clayey or wet soils are poorly suited to septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These soil properties and many others that affect land use are given in soil surveys. Each soil survey describes the properties of soils in the county or area surveyed and shows the location of each kind of soil on detailed maps.

What is a map unit?

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. The contrasting components are mentioned in the map unit descriptions. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

What is a consociation, complex, association, undifferentiated group, or miscellaneous area?

A *consociation* is a kind of map unit that consists of one major soil or miscellaneous area plus any components of minor extent. The major component is identified in the map unit name. "Consociation" is a coined term.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them.

Miscellaneous areas have little or no soil material and support little or no vegetation.

What is an Official Series Description?

The Official Soil Series Descriptions (OSD) is a national collection of more than 20,000 detailed soil series descriptions, covering the United States, Territories, Commonwealths, and Island Nations served by USDA-NRCS. The descriptions, in a text format, serve as a national standard.

The soil series is the lowest category of the national soil classification system. The name of a soil series is the common reference term, used to name soil map units. Soil series are the most homogenous classes in the system of taxonomy. "Official Soil Series Descriptions" define specific soil series in the United States, Territories, Commonwealths, and Island Nations served by USDA-NRCS. They are descriptions of the taxa in the series category of the national system of soil classification. They serve mainly as specification for identifying and classifying soils. The descriptions contain soil properties that define the soil series, distinguish it from other soil series, serve as the basis for the placement of that soil series in the soil family, and provide a record of soil properties needed to prepare soil interpretations.

(From "OSD Fact Sheet" http://soils.usda.gov/technical/classification/osd/fact_sheet.html)

Information for Land Users

Homebuyers

The foundation supports the walls, the walls support the roof, and the soil holds them all. But how can you tell if the soil will be a good "home" for your house? You need to answer some important questions:

- Is the soil stable, or does it have properties that can cause the foundation or walls to crack?
- Is the soil in an area subject to flooding?
- Will storm runoff drain safely away from the house and lot? Or will it turn your yard, or basement, into a pond?
- Does the soil have a seasonal high water table that can cause a basement to flood or a septic system to fail?
- Is the soil deep enough for a basement to be dug economically? For garden and landscape plants to take root and thrive?
- Is the soil so steep that erosion may be severe?

A soil survey can help you answer these and many other questions about the soil.

Land Use Planners

Soil surveys can help planners make and substantiate the decisions that local government officials translate into zoning ordinances, building permits, authorizations for sewer extension, and other regulations that mold a growing community. Information about soil limitations for given uses helps prevent major mistakes in land use and unnecessary costs to individuals and the community.

Soil surveys help in determining the extent of floodprone areas, and they rate the hazards that affect use of soils in such areas. In many states soil surveys are used to guide municipal and other government agencies in restricting the use of flood plains for housing, septic tank absorption fields, and other forms of intensive development.

Zoning areas for housing, recreation, commercial, and other kinds of development should take account of the suitability and limitations of soils for such uses. Soil surveys describe soil properties in detail and can help planners establish general patterns of soil suitability and limitations for various land uses.

Erosion and sedimentation may increase where land is being developed. Sediment has become a major pollutant, and communities throughout the Nation spend millions of dollars every year just to remove sediment from drinking water.

Planners and other authorities can use soil maps and soil data to identify sources of sediment and to develop plans for controlling erosion and sedimentation.

Septic tank absorption fields do not work in wet or impermeable soils. Soil surveys provide detailed descriptions of soil properties that can be used to determine the suitability of areas for absorption fields. They indicate soil hazards that affect absorption fields, such as slow permeability caused by high clay content, the presence of a high water table, or excessive permeability that may allow effluent to pollute ground water. In many parts of the United States soil surveys are used as a basis for ordinances that regulate use of land for septic tank absorption fields.

Through use of soil surveys, roads and highways can be routed to avoid major soil hazards, and sources of borrow material needed in constructing highways can be located. Contractors can bid for work more accurately and can consider soil suitability and limitations in planning and designing specific structures.

Recreation uses of land should be based on suitability of soils. Soil surveys can help in identifying areas suitable for campsites, golf courses, manmade fishponds, and many other recreation facilities. They also can help in planning the construction and layout of large recreation areas that have restrooms, parking areas, outbuildings, and other structures.

Prime farmland can be identified through use of soil surveys. Other areas suited to development and not so well suited to farming may be selected for development instead.

In planning uses for specific areas, an onsite investigation by a trained professional can determine if there are any soil hazards or limitations, and whether these can be overcome by corrective measures.

Appraisers

In appraising the income potential of farmland it is essential to distinguish between income differences caused by soil properties and those caused by management. If two farms are managed in much the same way and still show differences in income, it is likely that the soils differ in inherent productivity. Likewise, two farms that have identical soil resources have the same potential productivity even if they are now managed differently.

Soil surveys available from the Natural Resources Conservation Service can help bankers, loan companies, tax assessors, farmers, and others who need to know about the productivity of farmland obtain reliable estimates of the potential productivity of soils in their area.

Developers and Builders

As a developer or builder, you probably know of construction projects on which time and money were lost because of unforeseen soil hazards. Soil surveys available from the Natural Resources Conservation Service (NRCS) can help you anticipate soil hazards at proposed construction areas, plan optimum development, and ensure adequate conservation during and after construction.

Soil surveys can help you determine whether tracts are suitable for development and avoid cost overruns caused by unforeseen soil hazards. By studying soil maps and supporting data in soil surveys, you can determine the soil conditions in areas where you plan to build and decide what additional investigations, if any, are needed. Soil surveys can help you avoid the unnecessary complications that attend failure of foundations, soil slippage, flooded basements, and other structural breakdowns caused by adverse soil properties. Special foundations, walls, and floor drains can be planned if soil hazards indicate that buildings of standard design would likely fail. Soil surveys describe soil properties in detail so that you can anticipate such problems and prepare alternative designs or select other areas for development.

Waste Disposal Entities

Whether you are a homeowner, land use planner, board of health official, county sanitarian, or land developer, waste management concerns you. Soil surveys available from the Natural Resources Conservation Service can help in planning the disposal of liquid and solid wastes through septic tank absorption fields, sewage lagoons, and sanitary landfills.

Septic tank absorption fields

Because of rapid suburban expansion, the number of homes that do not have access to a public sewage disposal system has increased greatly. The most common system for individual homes is one in which the sewer line from the house leads to an underground septic tank in the yard. Overflow from the tank disperses into the soil through a system of underground drains or perforated pipes.

To design a system that will work, you need to know the capacity of the soil to absorb effluent. Movement of effluent through soil is determined mainly by the porosity of the soil, the size of the soil particles, and by the kind of clay in the soil. Effluent moves faster through sandy and gravelly soils than through clayey soils. Soils high in clay content have limited pore space for holding effluent. Some kinds of clay expand when wet and close the pores entirely. Such soils are unsuitable for absorption fields. If the soil is not porous, the effluent simply builds up and seeps to the surface.

Soils that have a high water table may be saturated part of the year. A saturated soil cannot absorb additional liquid, and the unfiltered septic tank effluent discharged into the drains may seep to the surface. If there is a seasonal high water table, the septic tank absorption field may work in dry seasons but fail in wet seasons.

Soil that is shallow to rock or soil that has a cemented layer just below the bottom of the trench in which drains are laid lacks space for the effluent to be absorbed. About 4 feet of soil material between the bottom of the trench and any rock formation is necessary for absorption, filtration, and purification of septic tank effluent. More than 4 feet may be required if the underlying rock is limestone that contains water used for domestic use.

Steep slopes—15 percent or steeper—make it difficult to control the distribution of effluent. Effluent distributed into soil on a steep slope may seep onto the ground surface at a lower level. Digging drain trenches on the contour insures that the effluent flows slowly through the drains and disperses throughout the absorption field.

Soils that are subject to flooding should not be used for absorption fields. Flooding destroys the effectiveness of the field and allows unfiltered effluent to pollute the stream.

Before a septic tank absorption field or onsite sewage facility is designed for a specific area, an onsite investigation by a trained professional can determine if there are any soil hazards or limitations and whether these can be overcome by corrective measures.

Sewage lagoons

Sewage lagoons are shallow manmade ponds used to hold sewage for the time required for bacterial decomposition, after which the clarified water is released from the lagoon.

The lagoon must be capable of holding water with a minimum of seepage. The soil material in the bottom of the lagoon and in the embankment should be free of stones and boulders that interfere with compaction. Porous soils have severe limitations for sewage lagoons because water moves through the soil too rapidly.

The soil also should be low in organic-matter content to reduce the potential growth of aquatic plants. There should be no hazard of flooding, and the depth to water table should be at least 40 inches. Slope should be no more than about 7 percent.

Sanitary landfills

Sanitary landfill is one way to dispose of garbage, boxes, plastic and metal containers, and other solid wastes. Refuse is spread, compacted, and covered with soil material daily.

Landfill cannot be placed just anywhere. The properties of the soil and the kind of management determine the success of a sanitary landfill.

Soils used for landfill should not be subject to flooding or have a high water table. Flooding the landfill causes pollution of offsite areas. If the water table is seasonally high, leachate from the landfill may contaminate ground water.

Steep slopes cause an erosion hazard. More care is needed on sloping to steep soils to dispose of runoff water, including that from adjacent higher elevations. More grading is required for the roads that lead to and from a landfill on sloping to steep soils than on nearly level soils. Soils used for landfill should be easy to excavate and should hold up under heavy vehicular traffic in all kinds of weather. Most fine-textured (high clay content) soils are plastic and sticky when wet and are difficult to excavate, grade, and compact.

Water movement through the soil should be moderate to slow to retard the movement of leachate from the landfill into underlying layers where it may pollute ground water.

Cover material must be easy to dig, move, and spread over the refuse during both wet and dry periods. It must be easy to compact to reduce the rate of water intake. The area from which the cover material is taken should be suitable for revegetating in order to prevent erosion in the borrow area. Soil used for the final cover layer should be well suited to the growth of plants.

Disposing of other kinds of waste

Research is being conducted on the disposal of many kinds of wastes into soils. Such wastes include animal wastes from feedlots; residues from vegetable, meat, poultry, and dairy processing plants; chemicals used for fertilizers, pesticides, and herbicides; and effluent and sludge from municipal sewage plants.

Basic factors to consider in disposing of these wastes into the soil are the ability of the soil to assimilate wastes safely, the quality of the waste, particularly its content of nutrients and heavy metals, and the ability of vegetation grown in the disposal areas to utilize the nutrients in the waste. Soil properties that affect use for landfills also affect use of soils for disposing of other kinds of wastes.

Park Boards and Recreation Area Planners

More ski resorts, dude ranches, camps, parks, picnic areas, and other private and public recreation areas are needed to meet the growing demand for recreation. But just because recreation is for fun does not mean the selection and layout of areas can be haphazard. Soil suitability and limitations should be considered in planning recreation areas.

This Web site tells how soil surveys available from the Natural Resources Conservation Service can help you select tracts suitable for recreation development and plan adequate conservation to ensure that the areas remain attractive and usable.

Why soil data are needed

It cannot be assumed that just any piece of land can be used for recreation. Some soils are as unsuitable for recreation as they are for supporting buildings or for growing oranges. Among the soil properties that affect recreation uses are the following.

Flood hazard severely limits use of soils for camps and recreation buildings, but such soils are suitable for hiking and nature study and other less intensive uses.

High water tables impose severe limitations on use of soils for campsites, roads and trails, playgrounds, and picnic areas.

Droughtiness makes it difficult to grow grass needed to prevent erosion, and droughty soils may require irrigation to maintain vegetation.

Some clayey soils swell when wet and shrink when dry. This shrinking and swelling may damage floors and foundations of recreation buildings. Such soils may fail to support roads and other structures unless special design is used.

Steep slopes limit the use of soils for playgrounds, campsites, buildings, roads, and trails, but are appropriate for hiking areas.

If bedrock is at shallow depth, it is difficult to level soils for playgrounds and campsites, to construct roads and trails, and to establish vegetation. Shallow soils are poorly suited for uses that require extensive grading.

A clayey or sandy surface layer makes some soils undesirable for playgrounds, campsites, or other uses that require heavy foot traffic.

Soils high in clay content are sticky when wet and remain wet for long periods after rains. Loose sandy soils are unstable and dusty when dry. Sandy loam and loam soils are the most suitable for recreation uses that require heavy foot traffic.

Stones, gravel, and rocks impose moderate to severe limitations on use of soils for campsites, playgrounds, trails, and other uses that require heavy foot traffic.

The absorptive capacity of soils determines whether a septic tank absorption field will work. The soil should be deep and permeable, there should be no seasonal high water table, the slope should not be steep, and there should be no danger of flooding.

Suitability for impounding water determines whether the soil can be used for manmade fishponds. Ponds are desirable for other recreation uses, such as shooting preserves, dude ranches, vacation farms, and wildlife and nature study areas. Soils suited to manmade ponds generally are deep, have low permeability when compacted, are not steep, and have a low susceptibility to piping.

Selecting recreation areas

Soil surveys can help you select areas suitable for a wide range of recreation uses, including the following:

- wetland refuges for waterfowl
- wildlife management
- open space or nature study areas
- parks
- athletic fields
- ski areas
- golf courses
- campsites, hiking trails, and picnic areas
- dude ranches
- woodlands
- hunting reserves
- manmade ponds

Maintaining recreation areas

For the manager of a ski resort, dude ranch, camp, park, picnic area, playground, or other private or public recreation area, a soil survey can provide information necessary for planning a conservation program to protect the area against erosion and other kinds of site damage. A soil survey can guide you in selecting a use for each area, based on the suitability of the soil. For example, soils that are susceptible to erosion can be planted to trees, shrubs, and grasses and used in a nonintensive way, such as for nature study. Loamy, well-drained soils can be used for play areas and other uses that require heavy foot traffic.

A soil survey also helps in determining the kind of conservation measures needed to protect the soils while in use. Soil information, which for many years has helped farmers and ranchers prepare conservation plans, can also be used by a camp operator or manager of any recreation area. Vegetation adapted to the soil can be selected and planted to protect the soil from erosion. Dams, terraces, diversions, waterways, and other mechanical measures to control water runoff can be installed in critical areas. In wet areas, if the soil and topography permit and if outlets are available, drains can be installed.

An onsite investigation of a specific site by a trained professional can determine if there are any soil hazards or limitations, and whether these can be overcome by corrective measures.

Construction Engineers

On many construction projects a major soil hazard is discovered only after the site has been selected and construction is underway. The unforeseen hazard generally leads to delays in construction and to cost overruns.

If soil hazards are known before construction begins, special compensating designs can be prepared in advance or alternate sites can be selected. Although nearly any site can be made suitable for most uses if enough money is spent, avoiding poor sites where possible helps keep construction and maintenance costs to a minimum.

Soil surveys available from the Natural Resources Conservation Service (NRCS) can help engineers anticipate soil-related hazards that affect construction of buildings, highways, pipelines, transmission lines, and similar installations.

Determining soil hazards

Soil surveys show the location of and describe each kind of soil in the county or area and describe the soil properties. These data can help engineers anticipate soil-related problems and plan onsite inspection. Failure to investigate adequately may lead to expensive delays in construction or eventual structural breakdown.

How soil surveys can help engineers

Construction engineers are particularly interested in soil properties that may require special structural measures to overcome or special maintenance once construction is completed. Soil surveys describe important soil properties that affect construction, including the following:

Shrink-swell potential: Certain kinds of clay soils expand when wet and shrink when dry, and special foundations are required to compensate for this movement. Soil surveys identify soils that have large shrink-swell potential.

Wetness: Soil surveys provide data on natural soil drainage, permeability, depth to seasonal water table, and suitability for winter grading for various kinds of soils. They can help engineers anticipate seasonal limitations on the use of heavy machinery for earthmoving and compacting and estimate the hazard of flooding or damage to underground structures caused by soil wetness.

Depth to bedrock: Soil surveys show areas where bedrock is at a depth of less than 5 or 6 feet and indicate the kind of bedrock.

Erodibility: Soil surveys provide information on how susceptible each soil is to erosion. Slope is only one factor contributing to erodibility. Other soil properties are also important, especially those properties that determine the cohesiveness of soil particles. These properties commonly vary within different layers of the same soil and cause different degrees of erodibility in different soil layers.

Flood hazard: The hazards of flooding and ponding are rated in soil surveys, and flood-prone areas are shown on soil maps. Such information does not take the place of hydrologic studies to determine the severest flood expected once in 10, 25, 50, or 100 years, but it does provide reliable estimates of areas where floods are most likely.

Slope: Slope gradient is a determining factor in establishing the final grade of a construction site and the amount of cut and fill needed to achieve the final grade. Ranges in slope are recorded in soil surveys, and areas where cuts and fills may be needed can be identified by studying soil maps. Slope particularly affects the installation of underground conduits and the construction of roads and highways.

Bearing capacity: Soil surveys give estimates of the particle size and plasticity of soils, and each soil layer is classified according to the Unified and the AASTHO systems. These classifications help in evaluating soils for shallow foundations and determining ease of compaction, ease of winter grading, trafficability, density, moisture relationships, susceptibility to frost action, and other properties.

Corrosion potential: Standard concrete deteriorates rapidly in very acid soils, and steel corrodes in soils that are highly saline or acid. The corrosion potential of each kind of soil is rated in soil surveys.

Organic layers: Muck and peat are very soft and unstable, and if drained, they subside. Areas of organic soils are shown in soil surveys, and the thickness of organic layers is indicated.

Ease of excavation: Excavating friable soils may cost half as much as excavating soils that are hard and compact. Sticky, clayey soils are difficult to spread in thin layers. Some soils are very susceptible to sloughing in trenches; others are stable. All these properties may differ from layer to layer in the same soil. Data presented in soil surveys can be used by engineers to anticipate earthmoving problems and to prepare more accurate bids for earth-moving.

Soil surveys also provide interpretations of the effect of soil properties on many kinds of land use. These interpretations and other data can be used to determine soil suitability as a source of topsoil, sand and gravel, roadfill for highway subgrade, and impermeable material. The interpretations also show the degree and kind of limitations of soils if used for septic tank absorption fields, foundations for low buildings, underground utility lines, pipelines, highways, roads, streets, and parking lots.

Farmers and Ranchers

As farmer or rancher you don't have time or capital to spend on elaborate agricultural research and experiments or on mapping and studying soils. But you are interested in the results of such studies if they can help you to manage more profitably.

Soil surveys contain detailed maps and descriptions of soils in your area. This information can contribute to the management of your farm or ranch. For specific sites and uses, an onsite investigation of the soils by a trained professional can determine if there are any soil hazards or limitations, and whether these can be overcome by corrective measures.

How soil surveys can help farmers

To stay in business, farmers have to evaluate important developments in agricultural management. A soil survey can play a major part in this aspect of managing a farm.

Management practices: Farm production depends largely on fitting soil management practices to the soil properties as accurately as possible. It is the right combination of a number of practices that gets optimum results. Researchers try various combinations of fertilizers, tillage methods, water management, and conservation measures. Combinations that produce the greatest yields at the least cost on soils at experiment stations can be expected to give equally good results on similar soils elsewhere. Soil descriptions presented in the soil survey of your area can help you evaluate prospective changes in management of your soils.

New practices also are constantly on trial at state and other agricultural experiment stations. By comparing soils at such stations with those described in the soil survey of your area, you can estimate the likely success of new practices on your farm.

Special crops: You may want to know if new or special crops will work for you. The soil survey of your area describes soil properties that affect crop growth and provides information that could save you costly experiments in determining the best way to manage your land for unfamiliar crops.

Crop yields: Estimated yields of major crops under a high level of management are included in published soil surveys. The estimated yields can help you calculate approximately what returns to expect on your soils and determine whether a high level of management would increase yields enough to pay the extra cost.

Conservation plan: A soil survey can help you determine how intensively you can use your soils without damage. It also helps in determining what conservation measures are needed to control erosion and maintain or increase the productivity of your farm.

Reclaiming land: Some severely eroded soils respond readily to soil treatments, such as fertilizer, lime, and green manure, but other soils respond very poorly. A soil survey can help you decide whether added treatment to reclaim soils is likely to succeed.

Waste disposal: Feedlots, poultry and broiler plants, and dairy farms dispose of manure and other wastes into soils. A soil survey helps in determining how much waste the soils can absorb and in what form.

Recreation: A soil survey can help in selecting areas suitable for manmade ponds. It also can help in planning development of land for fee fishing, hunting, camping, and other recreation facilities used to supplement income.

How soil surveys can help ranchers

As a rancher, you want the greatest amount of high-quality forage from your range. Because forage yields depend in large part on soil properties, detailed knowledge of the soils on your ranch can help you manage your range more effectively.

Range potential: A soil survey provides detailed soil descriptions that can help you relate the kinds of soil on your ranch to the distinctive kind and amount of vegetation each soil can support. Soil texture, depth, wetness, available water, slope, and topographic position are among the important soil properties that affect range potential. Deep loamy soils on bottom lands may produce the most desirable range plants. On uplands where rainfall is moderate, medium-textured soils that take in water readily may produce desirable plants if grazing is controlled. In some dry areas sandy soils are more productive than clayey soils. Grouping the soils on your range according to their potential productivity helps you plan the kind of management needed to increase forage yields.

Range management: A soil survey can help you estimate the likely benefits of management practices. For example, the soil in an area of brush or mesquite may have such low potential productivity that the cost of chaining or chemical removal may not be worth the ultimate yield in forage. On the other hand, there may be rocky areas or hillsides where the soils are capable of producing more forage if properly managed. A soil survey can help you determine such natural differences in productivity.

Grazing management: If range is overgrazed, desirable plants decrease and less desirable plants may take over the site. A soil survey can help you identify soils that are producing at less than their potential. Each soil survey names the main species of desirable and undesirable range plants that grow on the soils and provide estimates of forage yields than can be expected under favorable and unfavorable conditions.

Pasture, hay, and silage: You may need to grow more winter feed or establish more pasture. A soil survey rates soil suitability for hay and pasture plants so that you can determine which areas will be most productive for this use.

Wildlife and recreation: To supplement income, many ranchers use their land for fee hunting or other kinds of recreation. A soil survey provides information that can help you manage your land for wildlife habitat or identify areas suitable for recreation development.

Conservation plan: A soil survey can help you plan conservation management of your range. Soil maps and soil descriptions help you identify problem areas, select suitable areas for stock ponds, and establish schedules for grazing and proper use of the soils on your range.

What soil data are available?

Soil surveys contain detailed maps and descriptions of soils and they provide interpretations of soil properties for farming and ranching where such land use is practiced. Among the soil properties that affect use of soils for farming and ranching are the content of sand, silt, and clay, acidity and alkalinity, flood hazard, depth to water table, natural drainage, erodibility, organic-matter content, and fertility. These and many other properties described in soil surveys provide basic information for managing soils on a farm or ranch.

To determine whether a soil survey of your area is available, call the local office of the Natural Resources Conservation Service. The soil conservationist or soil scientist will welcome an opportunity to discuss conservation management of your soils with you.

Cropland

Land capability classification

Determinations of land capability involve consideration of the risks of land damage from erosion and other causes and the difficulties in land use resulting from physical land characteristics and from climate. Land capability, as used in the USA, is an expression of the effect of physical land characteristics and climate on the suitability of soils for crops that require regular tillage, for grazing, for woodland, and for wildlife habitat.

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, forestland, or engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit.

Capability classes, the broadest groups, are designated by the numbers 1 through 8. Capability classes are determined for both irrigated and nonirrigated land. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class 1 soils have slight limitations that restrict their use.

Class 2 soils have moderate limitations that restrict the choice of plants or require moderate conservation practices.

Class 3 soils have severe limitations that restrict the choice of plants or require special conservation practices, or both.

Class 4 soils have very severe limitations that restrict the choice of plants or require very careful management, or both.

Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, 2e. In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w*, *s*, or *c* because the soils in class 5 are subject to little or no erosion. These soils have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation. The significance of each subclass letter is described as follows:

Subclass letter e shows that the main problem is the hazard of erosion unless close-growing plant cover is maintained. The susceptibility to erosion and past erosion damage are the major soil-related factors affecting the soils that are assigned this subclass letter.

Subclass letter w shows that water in or on the soil interferes with plant growth or cultivation. In some soils the wetness can be partly corrected by artificial drainage. Ponding, a high water table, and/or flooding affect the soils that are assigned this subclass letter.

Subclass letter s shows that the soil has limitations within the root zone, such as shallowness of the root zone, a high content of stones, a low available water capacity, low fertility, and excessive salinity or sodicity. Overcoming these limitations is difficult.

Subclass letter c shows that the chief hazard or limitation is climate that is very cold or very dry. This subclass letter is used only in some parts of the United States.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. The use of this category of the land capability classification is a state option. This category of the system is not stored in the soil survey database. For information about capability units, please contact the local NRCS State Soil Scientist. For locations of the offices of the State Soil Scientists, click on the State Contacts link in the upper portion of this window.

Reference:
"National Soil Survey Handbook," Part 622 (00-Exhibit 1), USDA, NRCS

Soil erosion and crop production

Soil erosion has long been considered detrimental to soil productivity. It is the basis for soil loss tolerance values. Considerable loss in productivity is likely to occur on most soils if they are eroded for several centuries at present soil loss tolerance levels. The cost of annual erosion-caused losses in productivity on cropland and pastureland in the United States approaches $27 billion. There is an additional cost of $17 billion for off-site environmental damage. Worldwide costs for erosion-caused losses and off-site environmental damage are estimated at $400 billion per year.

Soil erosion can significantly reduce crop yields, especially in years when weather conditions are unfavorable. As soil erosion continues, the soil is further degraded. Poor soil quality is reflected in decreases in the content of organic matter, aggregate stability, phosphorus levels, and the potential for providing plant-available water. The net result is a decrease in soil productivity.

Soil erosion occurs through either water or wind action. Erosion by water includes sheet, rill, ephemeral gully, classical gully, and streambank erosion. Each succeeding type is associated with the progressive concentration of runoff water into channels as it moves downslope.

Sheet erosion, sometimes referred to as "interrill erosion," is the detachment of soil particles by the impact of raindrops and the removal of thin layers of soil from the land surface by the action of rainfall and runoff.

Severe sheet and rill erosion on highly erodible soils in northwest Iowa after heavy rains. The spring rains fell on the surface when the soils were not protected against erosion. (NRCS Photo Gallery NRCSIA99126)

Rill erosion is the formation of small, generally parallel channels caused by runoff water. It usually does not recur in the same place.

Rill erosion on highly erodible soils in Cass County, Iowa, after heavy rains. The field was not protected against erosion. (NRCS Photo Gallery NRCSIA99128)

Ephemeral gully erosion is the formation of shallow, concentrated flow channels in areas where rills converge. The channels are filled with soil by tillage and form again through subsequent runoff in the same general location.

A central Iowa field where ephemeral gully erosion has washed young corn plants from the ground and has removed topsoil and plant nutrients. (NRCS Photo Gallery NRCSIA99140)

Classical gully erosion is the formation of permanent, well defined, incised, concentrated flow channels in areas where rills converge. The gullies cannot be crossed by ordinary farm equipment.

Gully erosion caused by uncontrolled runoff in an area in Kansas. (NRCS Photo Gallery NRCSKS02008)

Streambank erosion is the removal of soil from streambanks by the direct action of streamflow. It typically occurs during periods of high streamflow.

The greatest deterrent to soil erosion by water is a vegetative cover, living or dead, on the surface. Supplemental erosion-control practices include contour farming, contour stripcropping, and terraces or diversions.

Wind erosion is generally the most common form of soil erosion on the Great Plains. Other major regions that are subject to damaging wind erosion are the Columbia River plains; some parts of the Southwest and the Colorado Basin; areas of muck and sandy soils in the Great Lakes region; and areas of sand on the Gulf, Pacific, and Atlantic seaboards. Wherever the soil surface is loose and dry, vegetation is sparse or does not occur, and the wind is sufficiently strong, wind erosion will occur unless erosion-control measures are applied.

Wind is an erosive agent. It detaches and transports soil particles, sorts the finer from the coarser particles, and deposits the particles unevenly. Loss of the fertile topsoil in eroded areas reduces the rooting depth and, in many places, reduces crop yields. Abrasion by airborne soil particles damages plants and manmade structures. Drifting soil also causes extensive damage. Sand and dust in the air can harm animals, humans, and equipment.

A "black roller" moving across the plains, carrying soil blown from unprotected farmland during the Dust Bowl. (NRCS Photo Gallery NRCSDC01019)

Wind erosion in an area of unprotected fields in north-central Iowa. (NRCS Photo Gallery NRCSIA99158)

Wind erosion in an unprotected cultivated field near Manhattan, Kansas. (NRCS Photo Gallery NRCSKS02050)

References:
1957 Yearbook of Agriculture, USDA, NRCS.
"National Agronomy Handbook," USDA, NRCS, 2002
Natural Resources Conservation Service Photo Gallery, USDA, NRCS "Soil Quality-Agronomy Technical Note 7," Soil Quality Institute, USDA, NRCS, 1998

Cropland management

Because of the impacts of both wind and water erosion on yields and soil quality, good cropland management is necessary to conserve and protect our soil, water, and air. Following is a discussion of several different kinds of cropland management practices. Generally, cropland management involves crop rotation, tillage or planting techniques, crop residue management, nutrient management, and pest management. Additional practices or treatments, where applicable, include irrigation water management (IWM), surface and subsurface water management, contour farming, buffer strips, filter strips, cover crops, cross wind strips, subsoiling, terraces and water- and sediment-control basins, and grassed waterways.

Crop rotation

How this practice works: A planned sequence of two or more different crops grown on the same land in successive years or seasons helps to replenish the soil; reduces the damaging effects of insects, weeds, and disease; and provides adequate feed for livestock. Crop rotations add diversity to an operation and often reduce economic and environmental risks. They are low-cost practices that often form the basis for other conservation practices. Crop rotations are common on sloping soils because of their potential for conserving soil. They can reduce the need for fertilizer when legumes, such as alfalfa or soybeans, replace some of the nitrogen that corn and other grain crops remove.