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.


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] )