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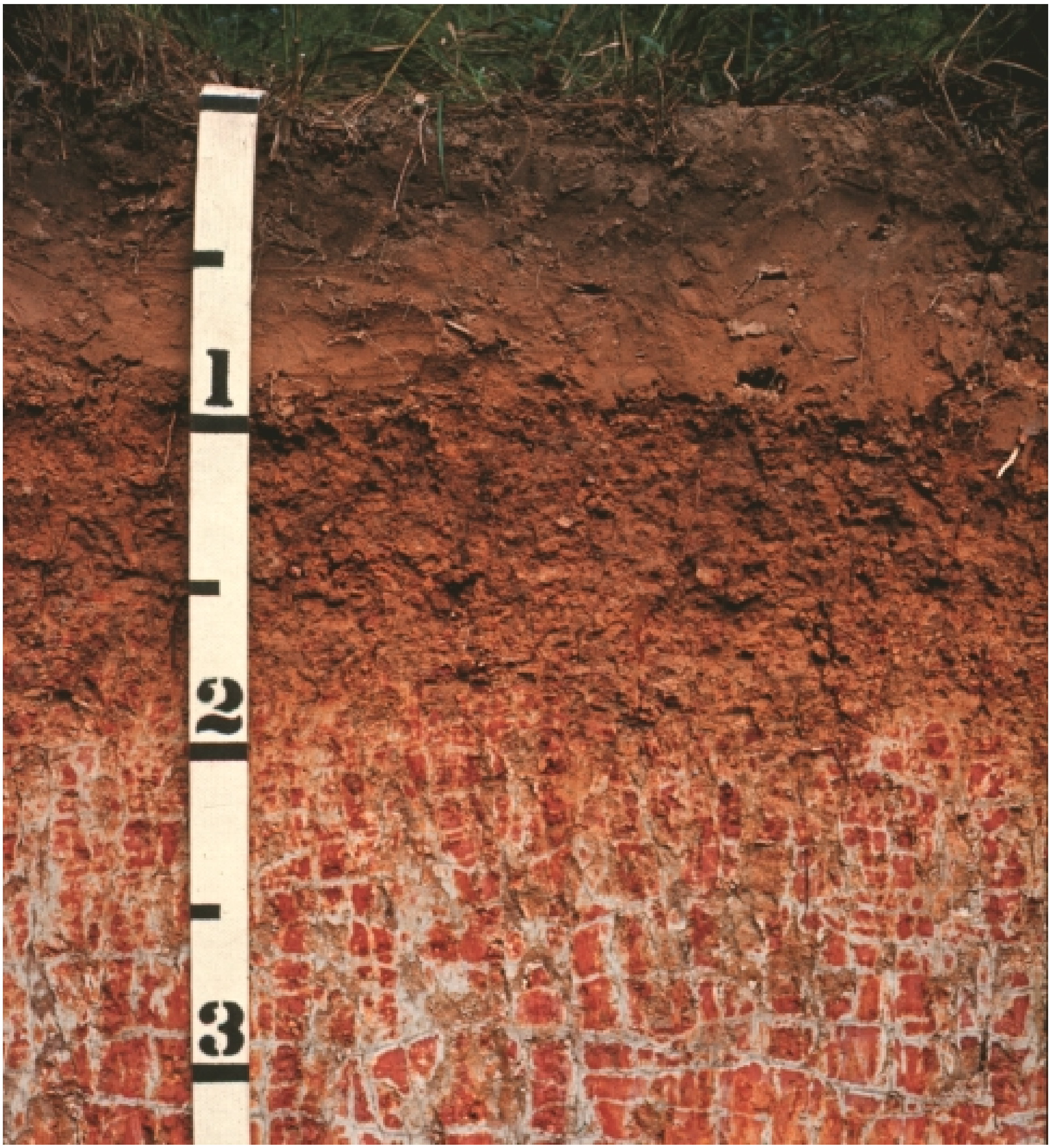
Soil Conservation Service

National Employee
Development Staff

From The Surface Down

An Introduction to Soil Surveys For Agronomic Use



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Cover: Soil profile of Segno fine sandy loam, a Plinthic Paleudalf. Note the characteristic blocks of plinthite at 30 inches. Photo by Frankie F. Wheeler, Soil Conservation Service, Temple, TX, and Larry Ratliff, Soil Conservation Service, Lincoln, NE.

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An Introduction To Soil Surveys For Agronomic Use

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Introduction

Much of our life's activities and pursuits are related and influenced by the behavior of the soil around our houses, roads, septic and sewage disposal systems, airports, parks, recreation sites, farms, forests, schools, and shopping centers. What is put on the land should be guided by the soil that is beneath it.

Like snowflakes, no two soils are exactly the same. Surface as well as below the surface soil features change across landscapes (fig. 1). A grouping of soils having similar properties and similar behavior is called a series. A series generally is named for a town or local landmark. For example, the Mexico series is named for a town in north central Missouri. More than 17,000 soil series have been named and described in the United States, and more are being defined each year.

In mapping, a soil series is further divided into a phase of a series by properties that are important to soil use, such as surface texture and slope. These phases of soil series, once identified, all have a characteristic behavior. The behavior for that kind of soil and individual phase is applicable no matter where the soil is observed.

One of the main references available to help land users determine the potentials and limitations of soils is a soil survey. Copies of a soil survey for a specific county are available from the SoilConservation Service office responsible for that county. Reference copies are also available in the county or depository libraries. A soil survey is prepared by soil scientists who determine the properties of soil and predict soil behavior for a host of uses. These predictions, often called soil interpretations, are developed to help users of soils manage the resource.

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.

The intent of this publication is to increase user understanding of soils and acquaint them with the contents of a soil survey and supplemental interpretations that are important to agronomic programs.

To be proficient in using soil survey data, a basic understanding of the concepts of soil development and of soil-landscape relationships is imperative. These topics are covered briefly in the next three sections.

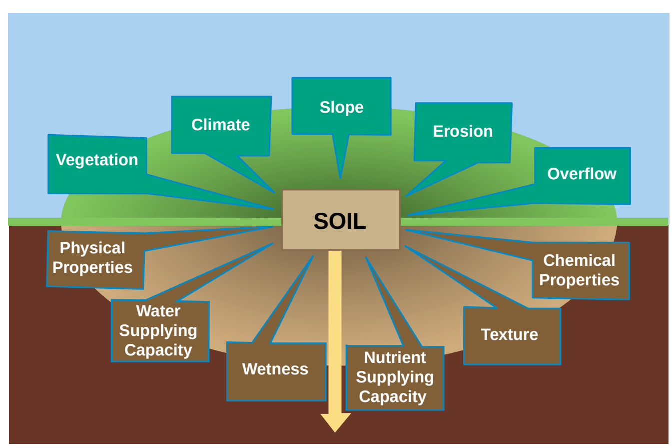

Figure1. —*Facts about soil.*

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Section 1: 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 (fig. 2). 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, such as the bottom land soil in figure 3 and the deep loess soil in plate 1.

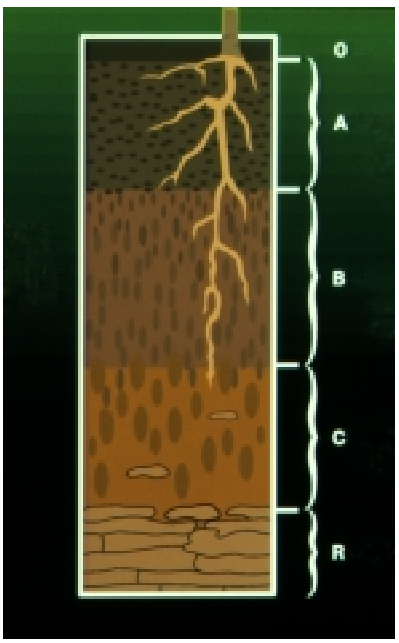


Figure 2.—*A soil profile with five major horizons.*

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 (plates 2, 3). Subdivisions of Oa, Oe, 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 (plates 4, 5). 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 an “Ab” horizon (plate 2).

The E horizon generally is bleached or whitish in appearance (plates 6, 7, 8). 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 (plates 4, 6). 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 t in the form of 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 show color or structural differences from adjacent horizons is designated Bw.

Still deeper is the C horizon or substratum (plate 1). 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 (plate 9). 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 (plate 9). 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.

Section 2: How is soil formed?

Figure 3 illustrates a few common landscapes. Soils develop as a result of the interactions of climate, living organisms, and landscape position as they influence parent material decomposition over time. Notice in this example how the soil profiles change from weakly developed to well developed with time. Older terraces, or soils on second bottom positions, usually have developed B horizons. Recent soils deposited in first bottom positions usually do not have a developed B horizon. Instead, they may have stratified layers varying in thickness, texture, and composition.

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.

Five soil-forming factors
- Parent material
- Climate
- Living organisms
- Landscape position
- 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 (plate 6). Dense, massive, clayey materials can be resistant to soil formation processes (plate 5). 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 (plate 12).

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. The soil in plate 10 developed in drier regions than soil in plate 11. Climate through its influence on soil temperature, determines the rate of chemical weathering.

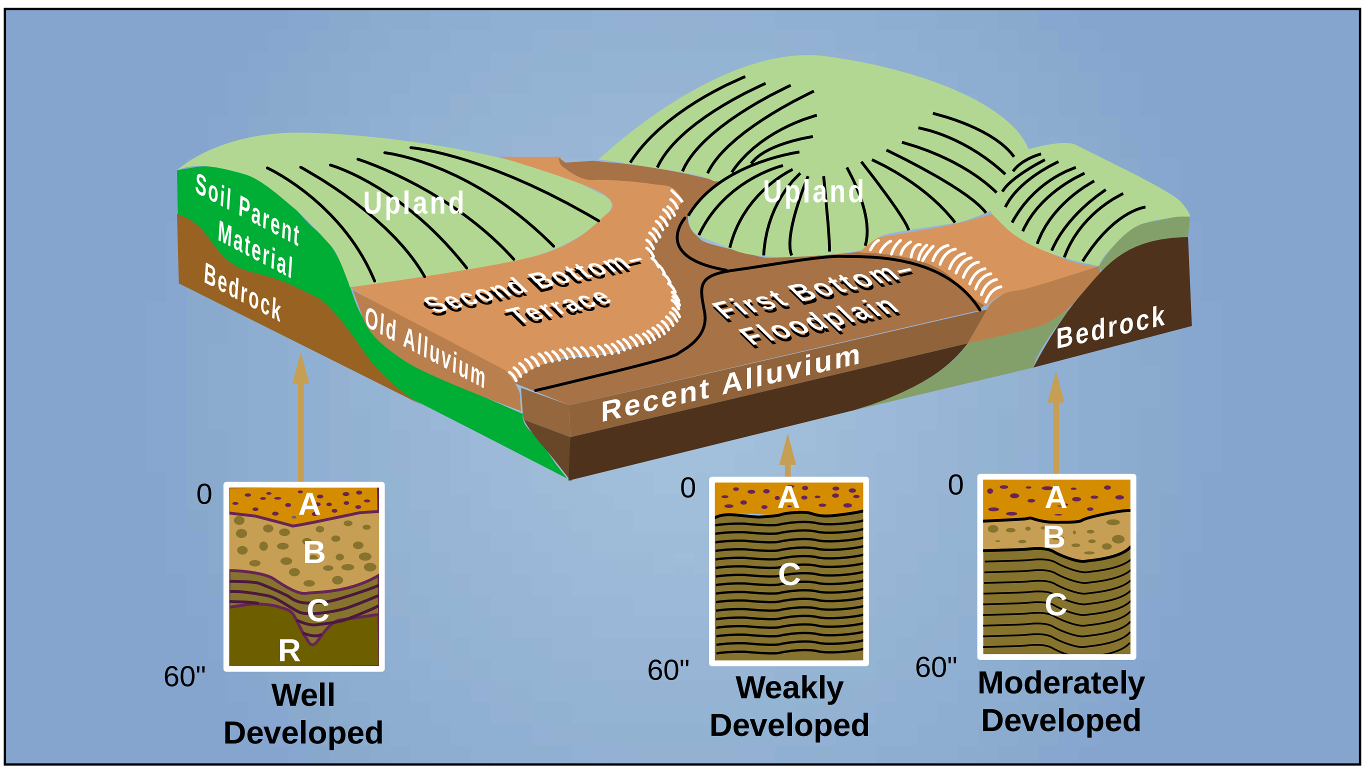


Figure 3.—*Landscape position, climate, time, organisms, and parent materials influence soil development.*

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, thawing, 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 processes.

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 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, (plate 1).

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 (plate 4). 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 with time (plates 6, 11).

Section 3: What are the soil forming processes?

The four major processes that change parent material into soil are additions, losses, transloca tions, and transformations.

Processes of soil formation
- Additions
- Losses
- Translocations
- Transformations

Additions

The most obvious addition is organic matter. As soon as plant life begins to grow in fresh parent material, organic matter begins to accumulate. Organic matter gives a black or dark brown color to surface layer (plates 4 and 5). Even young soils may have a dark surface layer (plate 1). Most organic matter additions to the surface increase the cation exchange capacity and nutrients, which also increase plant nutrient availability.

Other additions may come with rainfall or deposition by wind, such as the wind blown or eolian material (plate 12). On the average, rainfall adds about 5 pounds of nitrogen per acre per year. By causing rivers to flood, rainfall is indirectly responsible for the addition of new sediment to the soil on a flood plain.

Losses

Most losses occur by leaching. Water moving through the soil dissolves certain minerals and transports them into deeper layers. Some materials, especially sodium salts, gypsum, and calcium carbonate, are relatively soluble (plates 10, 11, and 13). They are removed early in the soil's formation. As a result, soil in humid regions generally does not have carbonates in the upper horizons. Quartz, aluminum, iron oxide, and kaolinitic clay weather slowly. They remain in the soil and become the main components of highly weathered soil.

Fertilizers are relatively soluble, and many, such as nitrogen and potassium, are readily lost by leaching, either by natural rainfall or by irrigation water. Long-term use of fertilizers based on ammonium may acidify the soil and contribute to the loss of carbonates in some areas.

Oxygen, a gas, is released into the atmosphere by growing plants. Carbon dioxide is consumed by growing plants, but lost to the soil as fresh organic matter decays. When soil is wet, nitrogen can be changed to a gas and lost to the atmosphere.

Solid mineral and organic particles are lost by erosion. Such losses can be serious because the material lost is usually the most productive part of the soil profile. On the other hand, the sediment relocated to lower slope positions or deposited on bottom lands has the potential to increase or decrease productive use of soils in those areas.

Translocations

Translocation means movement from one place to another. In low rainfall areas, leaching often is incomplete. Water starts moving down through the soil, dissolving soluble minerals as it goes. There isn't enough water, however, to move all the way through the soil. When the water stops moving, then evaporates, salts are left behind. Soil layers with calcium carbonate or other salt accumulations form this way. If this cycle occurs enough times, a calcareous hardpan can form.

Translocation upward and lateral movement is also possible. Even in dry areas, low-lying soils can have a high water table. Evaporation at the surface causes water to move upward (plate 13). Salts are dissolved on the way and are deposited on the surface as the water evaporates (plate 14).

Transformations

Transformations are changes that take place in the soil. Microorganisms that live in the soil feed on fresh organic matter and change it into humus. Chemical weathering changes parent material. Some minerals are destroyed completely. Others are changed into new minerals. Many of the clay-sized particles in soil are actually new minerals that form during soil development.

Other transformations can change the form of certain materials. Iron oxides (ferric form) usually give soils a yellowish or reddish color. In waterlogged soils, however, iron oxides lose some of their oxygen and are referred to as being reduced. The reduced form of iron (ferrous) is quite easily removed from the soil by leaching. After the iron is gone, generally the leached area has a grayish or whitish color (plate 6).

Repeated cycles of saturation and drying create a mottled soil (splotches of colored soil in a matrix of different color). Part of the soil is gray because of the loss of iron, and part is a browner color where the iron oxide is not removed (plates 15 and 16). During long periods of saturation, gray lined root channels develop. This may indicate a possible loss of iron or an addition of humus from decayed roots.

Soil Survey Information

Sections 4 through 7 describe the agronomic soil information published in soil surveys, or contained in the Soil Conservation Service, Field Office Technical Guide.

Section 4: Soil properties

Soil survey publications present a number of properties that pertain to agriculture. Some properties relate to erosion, such as slope gradient, and factors K and T. Others relate to plant growth, such as depth to layers, that restrict roots, available water capacity, salinity, and the capacity to retain and release plant nutrients. Some properties pertain to the soil's ability to retain soluble substances that may cause pollution of ground water, such as organic matter or the need for additions of lime, such as pH. Some properties, such as slope can be altered to make a site more suitable. For example, terraces can be constructed to either shorten the slope length to reduce erosion or grade for irrigation. Following is a listing of major soil properties that affect a soil's behavior for a number of specific uses:

Available water capacity

The available water capacity is an estimate of how much water a soil can hold and release for use by plants, measured in inches of water per inch of soil. It is influenced by soil texture, content of rock fragments, depth to a root-restrictive layer, organic matter, and compaction. This information is used in scheduling irrigation. The size and strength of soil structure can influence the availability and the rate of water released to plant roots.

Bedrock

Bedrock is the solid rock under the soil and parent material (plate 9). Sometimes it is exposed at the surface, and is referred to as rock outcrop. The depth from the soil surface to bedrock influences the soil's potential for plant growth and agronomic practices. Soft bedrock indicates that the material can be ripped. A shallow depth to bedrock results in a lower available water capacity and thus drier conditions for plants. It also restricts the rooting depth. Five depth classes are defined for use in soil surveys (table 1).

Table 1.—*Depth classes*

Very shallow	Less than 10 inches to bedrock
Shallow	10 to 20 inches to bedrock
Moderately deep	20 to 40 inches to bedrock
Deep	40 to 60 inches to bedrock
Very deep	More than 60 inches to bedrock

Calcium carbonate

Calcium carbonate ($CaCO3$) influences the availability of plant nutrients, such as phosphorus and molybdenum. Iron, boron, zinc, and manganese deficiencies are common in plants grown in soils that have significant levels of calcium carbonate equivalent. Soil texture influences the levels at which these deficiencies commonly occur. Sensitive crops may show deficiencies even at low levels (0.5 to 2.0 percent).

Cation-exchange capacity (CEC)

Cation-exchange capacity is a measure of the ability of a soil to hold and exchange cations. It is one of the most important chemical properties in soil and is usually closely related to soil fertility. A few plant nutrient cations that are part of CEC include calcium, magnesium, potassium, iron, and ammonium.

Generally, as CEC levels decrease, more frequent and smaller applications of fertilizers are desirable. Smaller applications of fertilizer applied to soils that have low CEC levels may reduce fertilizer loss to surface and ground waters, lessening the impact on water quality.

Drainage class (natural)

The drainage class refers to the frequency and duration of periods of saturation or partial saturation during soil formation. Seven classes of natural drainage are used in soil surveys. They range from excessively drained to very poorly drained (plate 3).

Erosion factor (K)

The soil erodibility factor (Kf and Kw) is a relative index of the susceptibility of bare, cultivated soil to particle detachment and removal and transport by rainfall. It may be computed from soil composition, saturated hydraulic conductivity, and structure. K values range from 0.02 to 0.64 or more. Higher values indicate greater susceptibility. Soil that has more silt and very fine sand are generally more erosive because of weaker bonding. K and Kw is adjusted downward for the percent of rock fragments in each layer. Kf values are calculated values that indicate a rock fragment free K for use in the Universal Soil Loss Equation (USLE).

Erosion factor (T)

The T factor is the soil loss tolerance used in the USLE. It is defined as an estimated maximum rate of annual soil erosion that will permit crop productivity to be sustained economically and indefinitely. The five classes of T factors range from 1 ton per acre per year for very shallow soil to 5 tons per acre per year for very deep soil that can more easily sustain productivity.

Flooding

Inundation by overflowing streams (plate 17) or runoff from nearby slopes may damage crops or delay their planting and harvesting. Scouring can remove favorable soil material. Deposition of soil material can be beneficial or detrimental. Soil stratification (plate 13) is an indication of deposition by flooding. Long periods of flooding reduce crop yields. Table 2 gives the frequency and duration classes used in soil surveys.

Table 2.—*Flooding frequency and duration classes*

Flooding frequency classes	
None or rare	Less than 5 times in 100 years
Occasional	5 to 50 times in 100 years
Frequent	More than 50 times in 100 years
Flooding duration classes	
Very brief	Less than 2 days
Brief	2 to 7 days
Long	7 days to 1 month
Very long	More than 1 month

Frost potential

Potential frost action is the likelihood of upward or lateral movement of soil by formation of ice lenses. Estimates are made from soil temperature, particle size, and soil water states. Frost can break compact and clayey layers into more granular forms. It can also break large clay aggregates into smaller aggregates that are more easily transported by wind. Frost heaving can harm conservation structures if improperly designed and destroy taprooted perennial crops.

High water table

Seasonal high water table is the highest average depth of free water during the wettest season. The ground water level, or water table, may be high year round or just during heavy rains. How high the water table rises and how long it stays there affect what can be done on that soil. A soil that is ponded is indicated in the soil survey with a plus (+). A perched water table usually occurs because of the presence of a dense layer, such as a hardpan, claypan, or other dense layer that retards deeper water penetration.

Organic matter

Organic matter is estimated for each layer. One percent organic matter is equivalent to 0.6 organic carbon. It encourages granulation and good tilth, increases porosity, lowers bulk density, promotes water infiltration, reduces plasticity and cohesion and increases available water capacity. It has a high cation adsorption capacity and its decomposition releases nitrogen, phosphorus, and sulfur.

Permeability

Permeability is saturated hydraulic conductivity. Saturated hydraulic conductivity is influenced by texture, structure, bulk density, and large pores. Soil structure influences the rate of water movement through saturated soil, in part, by the size and shape of pores. Granular structure readily permits downward water movement, whereas a platy structure requires water to flow over a much longer and slower path (fig. 4). Permeability is used in drainage design, irrigation scheduling, and many conservation practices. Permeability classes are shown in table 3.

Table 3.—*Permeability classes*

Class	Rate (in/hr)
Very slow	<0.06
Slow	0.06-0.2
Moderately slow	0.2-0.6
Moderate	0.6-2.0
Moderately rapid	2.0-6.0
Rapid	6.0-20
Very rapid	>20

Reaction

Soil pH is an expression of the degree of acidity or alkalinity of a soil. It influences plant nutrient availability. A very acid soil (pH <5.0) typically has lower levels of nitrogen, phosphorus, calcium, and magnesium available for plants, and higher levels of availability for aluminum, iron, and boron than a neutral soil at pH 7.0. At the other extreme, if the pH is too high, availability of iron, manganese, copper, zinc, and especially phosphorus and boron may be low. A pH above 8.3 may indicate a significant level of exchangeable sodium.

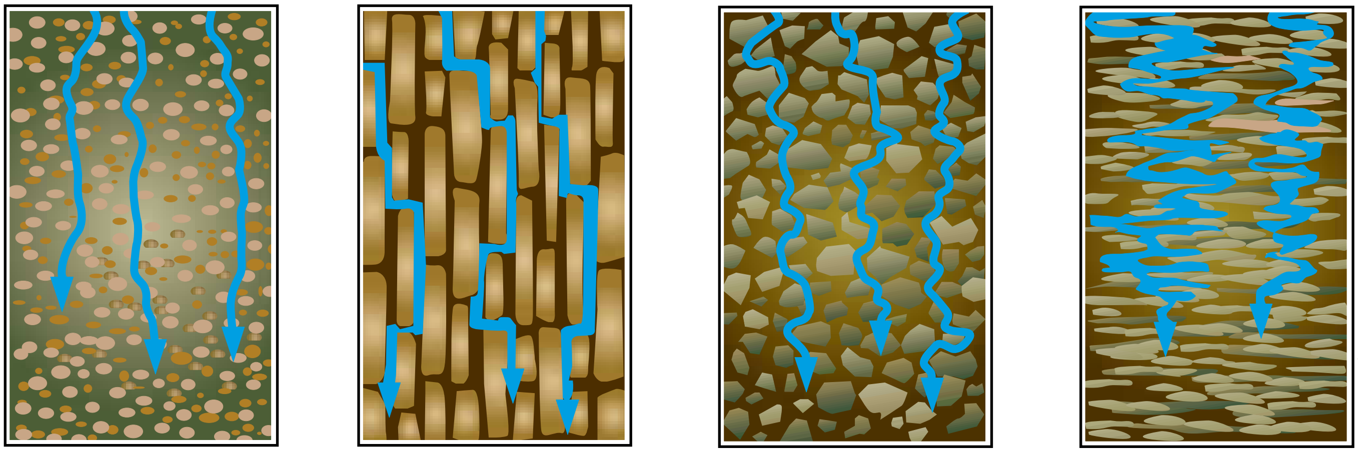


Figure 4.—Water movement through granular, prismatic, subangular blocky, and platy soils, respectively

Rock fragments

The size and percentage of rock fragments in the soil are important to land use. Rock fragments within soil layers reduce the amount of water available for plant use and may restrict some tillage operations. Particles larger than 2 millimeters in diameter are called rock fragments. Those that are 2 millimeters to 3 inches are pebbles or gravel, 3 to 10 inches are cobbles, and more than 10 inches are stones or boulders.

Root restrictive layers

Some soils have layers that roots and water cannot easily penetrate. Physical root restriction may be expected in hard or soft bedrock (plate 9) and some soil layers, such as a fragipan or cemented hardpan. Intensive management may be required to reduce the effects of poor rooting depth, a high water table, and lower available water capacity.

Some restrictive layers, such as a cemented hardpan are ripped to improve deeper root and water penetration. Physical root restrictions for many other layers usually are not improved. For example, a change from some other particle size to sand, gravel, cobbles, stones or boulders may indicate a zone of root restriction that are not improved.

In general, resistance to root penetration is high with the following combinations of texture and bulk density if the soil layer is massive, or the structure is weak or platy (table 4).

Table 4.—*Bulk density - root restriction guide*

Texture	Average bulk density
Coarse sand, sand, loamy coarse sand loamy sand, fine sand, loamy fine sand.	>1.85
Very fine sand, loamy very fine sand, fine sandy loam, coarse sandy loam, very fine sandy loam, sandy loam, loam that has clay average <18 percent clay	>1.8
Loam, sandy clay loam, clay loam that has clay average 18 to 35 percent clay	>1.7
Silt, silt loam, silty clay loam that has clay average <35 percent	>1.6
Clay loam, sandy clay, clay, silty clay loam, silty clay that has 35 to 59 percent (Vertisols >30%)	>1.5
Clay that has average >60% clay except in Vertisols	>1.35

Salinity

Salts, mainly sodium, magnesium, calcium, and chloride or sulfate, may interfere with the absorption of water by plants. They also create a nutrient imbalance in some plants. Soils that have more than 2 mmhos/cm of electrical conductivity in soil solution are considered saline (plate 13).

Sodium adsorption ratio (SAR)

SAR is a measure of the activities of sodium relative to calcium and magnesium in the soil solution. Soil that has an SAR value of as low as 6, where salinity is low, may have increased dispersion of clay, resulting in reduced aeration and permeability and increased susceptibility for erosion. Higher values may have surface conditions that take on a puddled appearance. Amendments, such as gypsum ($CaSO_4$), along with irrigation and drainage can improve the unfavorable soil condition in many cases.

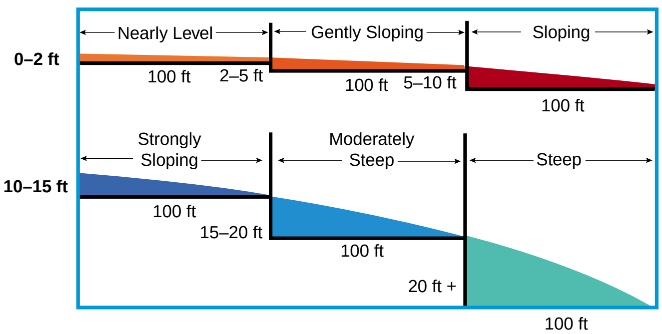


Figure 5.—*Slope diagram.*

Slope

Slope is the gradient of the elevation change. A 10 foot rise in 100 feet is a slope of 10 percent. Ranges of slope assigned to map units represent practical breaks on the landscape that are important for the use and management of the area (fig. 5). Terraces, irrigation, and tillage practices are all considered. For example, terraces for erosion control are a concern in some areas that have more than about 1 or 2 percent slope; thus a separation of 0 to 2 percent and more than 2 percent for the same kind of soil may be used in mapping. However, they are not site specific, and for conservation planning, site investigation is necessary to determine the slope.

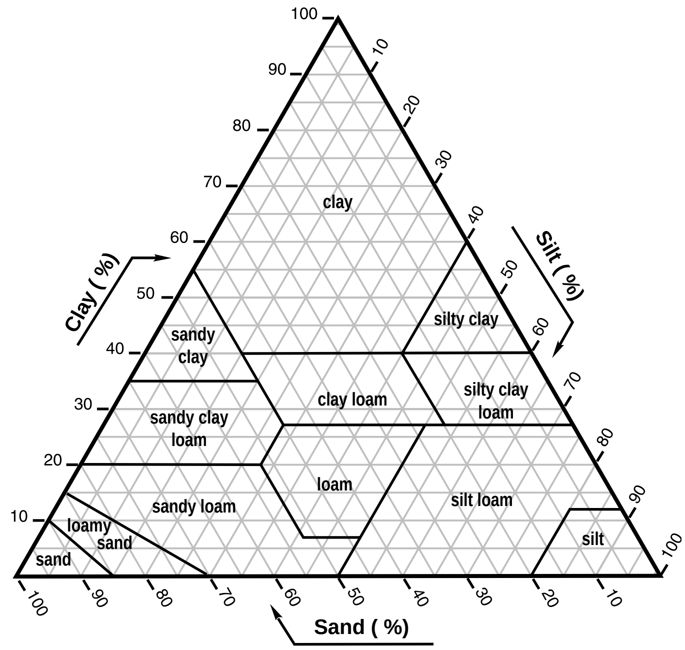


Figure 6.—*Soil textural class.*

Soil texture (USDA)

Texture is determined by the relative proportion of sand, silt, and clay (fig. 6). Figure 7 illustrates the relative sizes between the three major particles. Soils that are sandy tend to have low strength, greater susceptibility to wind erosion, and less water available for plants than soils of other textures. In addition, trenches and banks are highly susceptible to caving, which may pose a safety hazard (plate 17). Water may pipe through terraces and other water impoundments.

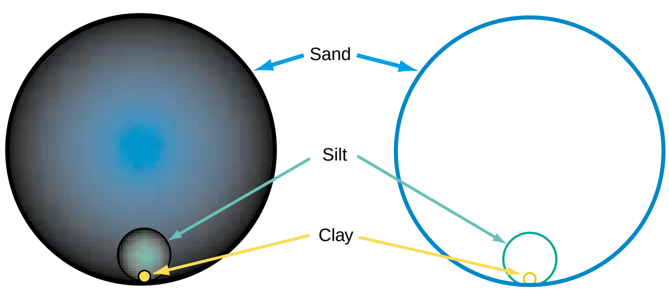


Figure 7.—*The relative sizes of sand, silt, and clay.*

Clayey soils have more available water than sandy soils. Generally, as clay and organic matter increase, soils have higher cation-exchange capacity. Soils that have large amounts of clay will fix more phosphorus than the same kind of soils that contain less clay. Clayey soils high in montmorillonite tend to have the greatest capacity to shrink and swell (plates 5 and 18). They retain large quantities of water, which affects tillage practices and can contribute to soil creep or landslides in sloping areas. Montmorillonitic or other smectitic clays also have strong adhesive properties that bond particles together.

Soils that are silty have a higher available water capacity than those that are sandy. In the absence of clay particles, silty soils have lower adhesive properties. Piping through terraces, levees and pond embankments can be a problem. Trenches may cave, particularly in saturated soils.

Muck or peat is used in place of textural class names in organic soils (plate 2). Muck is designated for well decomposed organic soil, and peat for raw undecomposed material. The word “mucky” is used as an adjective to modify a textural class, such as “mucky loam”. Rock fragments are also used as an adjective to modify a texture. Plate 9 shows a soil that is very cobbly.

Subsidence

Organic soils often subside when drained because of shrinkage from drying; loss of ground water, which physically floats the organic material; soil compaction; and oxidation of the material. This creates an uneven surface that can require periodic surface smoothing or grading to maintain adequate irrigation systems.

Some mineral soils also subside because of lowering of ground water tables; removal of zones of soluble salts, such as gypsum or calcium carbonate through leaching; or melting of ice lenses in frozen soils.

Wind erodibility group (WEG) and wind erodibility index (I)

WEG is a general grouping of soils with similar properties affecting their resistance to soil blowing. Soil texture, size of soil aggregates, presence of carbonates, and the degree of decomposition in organic soils are the major soil blowing criteria. The groups are numbered 1 through 8 with 1 representing sandy soils that are the most susceptible to wind erosion (plate 19) and 8 for gravelly or wet soils that do not have a wind erosion problem. The wind erodibility index (I) is an estimate of soil loss in tons per acre per year.

Plate 1. Somewhat excessively drained Colby soil formed in loess. Grayish brown silt loam A horizon, 0 to 8 inches thick; pale brown silt loam AC horizon, 8 to 16 inches; and below 16 inches a pale brown silt loam C horizon. Ustic Torriorthent. Western Nebraska, eastern Colorado, Kansas, South Dakota, and Wyoming. (Scale F in feet)

Plate 2. Poorly drained Cathro soil. Thick layers of organic material developed from a continuous high water table identified as Oa and Oe horizons, 0 to 37 inches. A (2Ab horizon) buried layer of black mineral materials that has a loam texture 37 to 45 inches. Terric Borosaprist. Northeast Minnesota, northern Wisconsin, northern Michigan and upper New England. (Scale F in feet)

Plate 3. Surface of very poorly drained soil that has numerous depressional areas.

Plate 4. Moderately well drained Pawnee soil formed in till. It has an A horizon 0 to 14 inches, underlain by a dark brown clay Bt horizon that has prismatic structure 14 to 32 inches. White soft lime pockets at 53 inches. Aquic Argiudoll. Nebraska, and northeast Kansas. (Scale F in feet)

Plate 1.

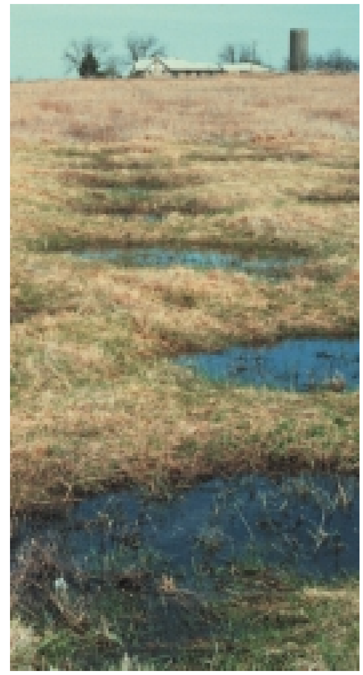


Plate 3.

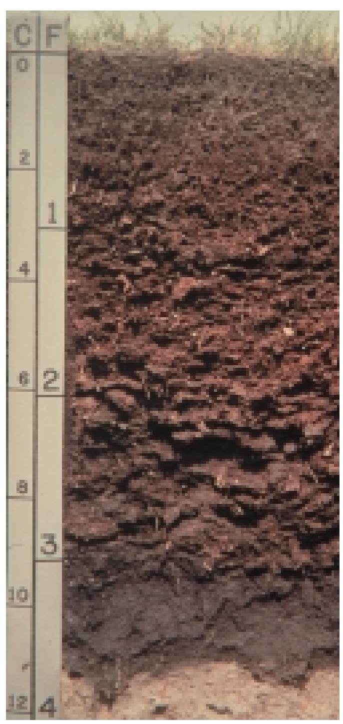


Plate 2.

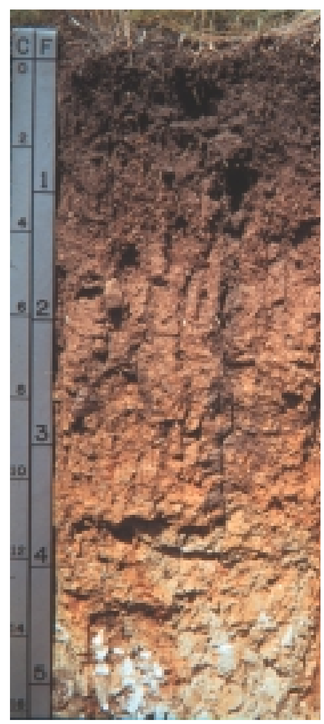


Plate 4.

Plate 5.

Plate 7.

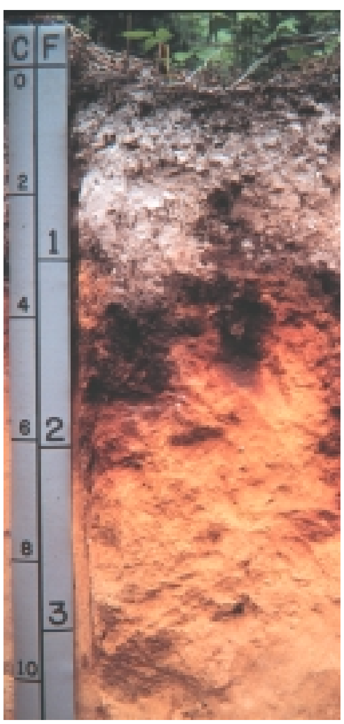


Plate 6.

Plate 8.

Plate 5. Well drained Ferris soil. Olive clay A horizon, 0 to about 6 inches, and pale olive clay, 6 to 60 inches. Cracks filled with surface soil material to 24 inches. Chromic Udic Haplustert. Texas and Oklahoma. (Scale F in feet)

Plate 6. Well drained Wallace soil formed in sandy deposits on old sand dunes, lake benches and outwash plains. Dark grayish brown sand A horizon, 0 to about 2 inches; white, sand, E horizon, 2 to 10 inches; and dark reddish brown, brown, and yellowish brown B2hsm massive and cemented (ortstein) horizon, 10 to 26 inches. The B2 horizon has illuvial concentrations of organic matter, aluminum, and iron. Typic Haplorthod. Northern Michigan and New York. (Scale F in feet)

Plate 7. Moderately well drained Exum soil formed in loamy Coastal Plain sediments. Grayish brown A horizon, 0 to 6 inches; light brownish gray E horizon, 6 to 10 inches; and thick, yellowish brown, very strongly acid, Bt horizons to a depth of 6 feet. Aquic Paleudult. Maryland, North Carolina, South Carolina, and Virginia. (Scale in feet)

Plate 8. Poorly drained Felda soil formed in marine sands. Grayish brown and light gray E horizon, 5 to 24 inches. An irregular boundary is between the E and Bt horizons at 24 inches. Arenic Ochraqualf. Florida.

Plate 9. Well drained Hambright soil formed in amorphous material from basic igneous rocks. Rock fragment content is about 50 percent to the Cr horizon at 15 inches. Fractured basalt (R horizon) is at 19 inches. Lithic Haploxeroll. California. (Scale in feet)

Plate 10. Well drained Clovis soil formed in deep loamy sediments on fans and plains of old alluvium. The accumulation of calcium carbonate increases with depth beginning at a light brown loam Bk horizon at 10 inches. Ustollic Haplargid. New Mexico, east-central Arizona, and southwest Utah. (Scale F in feet)

Plate 11. Well drained Olton soil formed in mixed alluvial and eolian material. Brown loam Ap horizon, 0 to 6 inches; reddish brown clay loam Bt horizon, 6 to 32 inches; and below that whitish calcium carbonate is present. Aridic Paleustoll. Texas and New Mexico high plains. (Scale F in feet)

Plate 12. Well drained Brownfield soil formed in old eolian material. Light brown fine sand 0 to 30 inches, over a red and yellowish red sandy clay loam, 30 to 60 inches. Arenic Aridic Paleustalf. New Mexico and Texas. (Scale F in feet)

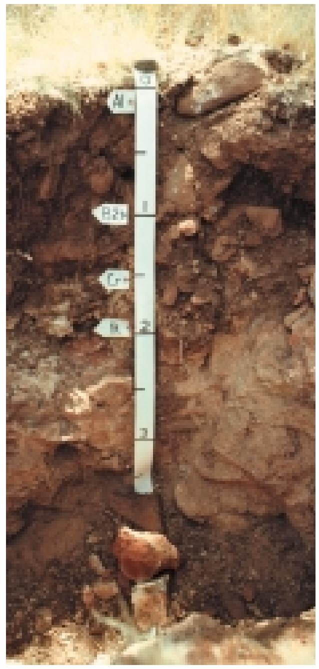


Plate 9.

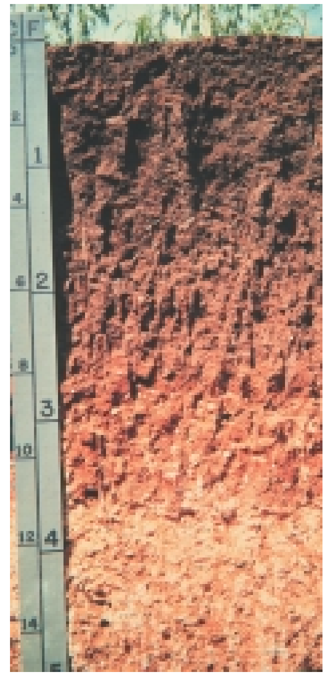


Plate 11.

Plate 10.

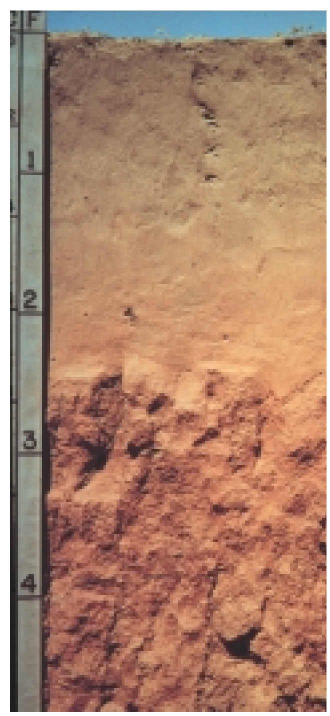


Plate 12.

Plate 13.

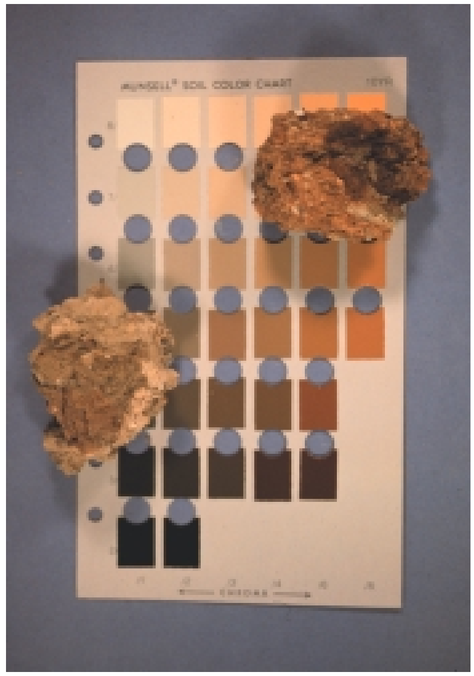


Plate 15.

Plate 14.

Plate 16.

Plate 13. Stratification of alluvial material that has textures of fine sandy loam and silt loam, 0 to 18 inches, and an accumulation of soluble salts at a depth of 24 inches in somewhat poorly drained Salmo soil. Cumulic Haplaquoll. South Dakota and Nebraska. (Scale in feet)

Plate 14. Salinity-alkalinity problem caused by poor internal soil drainage. California.

Plate 15. Munsell soil color. Soil block on left has gray reduced colors. Block on right has reddish oxidized colors.

Plate 16. Moderately well drained Mattapex, wet phase soil formed in marine sediments. Dark grayish brown A horizon, 0 to 6 inches; brown BE horizon, 6 to 12 inches; yellowish brown, strongly acid, Bt horizon, 12 to 36 inches with common light brownish gray mottles 21 to 36 inches. Below 36 inches is a C horizon. Aquic Hapludult. Maryland, Delaware, Virginia, and New Jersey. (Scale in feet)

Plate 17. Flooding along the Missouri River.

Plate 18. Deep wide cracks are common during dry periods in Vertisols. Maxwell soils. Typic Pelloxerert. California.

Plate 19. Evidence of erosion on a sandy textured soil partially protected by surface gravel.

Plate 17.

Plate 19.

Plate 18.

Section 5: Management interpretations

Soil surveys commonly identify the more important soil characteristics that determine the limitations and qualities of soil for farming. Interpretations for farming include soil productivity, placement of the soil in management groups, and presentation and evaluation of a number of soil properties affecting use. The interpretations are designed to warn of possible soil-related hazards in an area. Table 5 displays important soil property information related to agronomic interpretations. The following discussion includes some of the major agricultural interpretations.

Soil productivity

Productivity of the soil is the output or yield per acre of a specified crop or pasture under a defined set of management practices. If the land is irrigated, yields are provided for irrigated and nonirrigated conditions. Management practices are usually defined for each class.

A “high” level of management provides necessary drainage, erosion control, protection from flooding, proper planting rates, suitable high yielding varieties, appropriate and timely tillage, and control of weeds, plant diseases and harmful insects. This management method also includes favorable pH and levels of nitrogen, phosphorous, potassium and trace elements; appropriate use of crop residue, barnyard manure, and green manure crops; and harvesting methods that incur low loss. For irrigated crops the irrigation system is adapted to the soil and crops, and good quality irrigation water is uniformly applied as needed.

Irrigation

For most crops, the most favorable soils for irrigation are deep, nearly level, and well drained. They have good surface soil permeability and a high available water capacity. Important considerations for the design of irrigation systems are feasible water application rates, ease of land leveling and its affect on the soil, erosion potential, equipment limitations caused by steep slopes or rock fragments, and flooding.

Slope affects the performance of an irrigation system. Flood or furrow irrigation is mainly used on soils having slopes of less than 3 percent. Wheel lines and center pivots work well on slopes of up to 7 percent but with increasing difficulty. Drip systems work well even on steep slopes.

Most irrigated crops do well if the rooting depth exceeds about 40 inches. A shallower root zone lowers the available water, thus requiring more care in crop management and irrigation. Shallow soils, sandy soils, or soils that have rock fragments require more frequent irrigation than deep and finer textured soils. Frequent light irrigations on fine textured soils prevents cracking which reduces the evaporative loss of water (plate 17).

Chemical characteristics can be important. Salinity is particularly a problem where drainage conditions are unfavorable for the removal of soluble salts by flushing. In areas that have only small differences in slope and elevation, salt-laden water can lead to accumulation of salinity-alkalinity in low places (plate 14).

Drainage

Drainage is the removal of excess water from soil. Determinations of soil that meets “hydric soil” criteria need to be made to avoid draining wetlands.

Soils that have intermediate saturated hydraulic conductivity (permeability) respond well to subsurface drainage, open ditches, or a combination of these. In areas that have large amounts of excess water, drainage can be improved by smoothing or shaping the surface of the soil. This increases runoff and reduces the amount of water to be disposed of by internal water movement.

Stoniness, slope, silty soil low in clay, and the presence of physical soil barriers affects installation and functioning of the drainage system. Caution is needed in areas of unstable soils. Silty soil material low in clay tends to move into and clog subsurface drains that have inadequate filter protection. Coarse textured soils are unstable and may be droughty after drainage. Some wet soils have sulfides that oxidize on exposure to air, causing extreme acidity after drainage. Drainage water high in anaerobic iron may precipitate a “slime” that plugs drainage lines. Wet organic soils subside after drainage.

The effective rooting depth is an indicator of the depth that soils can be drained. In deep soils without root-restrictive layers, depth is not a limitation. If a massive clayey layer or other root-restrictive layer is in the soil, then effective drainage is more difficult.

Erosion control practices

The need for erosion control practices depends on the potential for erosion and the cultivars grown. Some crops, such as hay and pasture, protect against soil erosion. For others, such as row crops, specific management practices are needed. The practices to be used should be selected only after onsite soil inspection. Sometimes adequate erosion control can be achieved by simple application of one of the general practices. In other cases, two or three different practices may be needed. In addition to using cover crops, strip cropping, conservation tillage, terraces and diversions, and grassed waterways, other measures may be appropriate.

Other management interpretations

Some soil surveys, or addenda to the surveys, have special tables on important agronomic soil interpretations. A few tables may be in the form of a soil's potential for a specified use, such as its potential for cropland. Table 5 shows the soil property information that influence the behavior of a soil for agronomic use.

Other tables group soils for specific programs, such as prime or unique farmland, land capability classification, highly erodible lands, and hydric soils.

Hydric soils are wet soils defined as a group for the purpose of implementation of legislation for preserving wetlands and for assessing the potential habitat for wildlife. The soils considered to be hydric were selected on the basis of flooding, water table, and drainage class criteria. Hydric soils developed under wet conditions (anaerobic within 12 inches) and can support the growth and regeneration of hydrophytic vegetation (plates 2 and 8).

Table 5.—*Soil survey information that influences agronomic use*

	Soil Properties																
Agronomic Use	Organic matter	Flooding	Texture	Bedrock or pan	pH	Subsid-ence	Cation-exchange Capacity	$CaCO_3$	Slpoe	Bulk density	Preme-ability	Frost Potential	Available water	Salinity – alkalinity	Water table	Wind erosion group	Erosion factors K–T
Tillage suitability	●	●	●	●					●	●	●				●		
Plant adaptability	●	●	●	●	●		●	●	●	●	●	●	●	●	●		
Erodibility — wind — water	●		●					●	●	●	●				●	●	●
Irrigation		●	●	●	●	●		●	●	●	●		●	●	●	●	●
Drainage		●	●	●		●			●	●	●			●	●		
Crop yield productivity	●	●	●	●	●		●	●	●	●		●	●	●	●		
Conserva-tion practices	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●
Land use capability		●	●	●	●			●	●		●		●	●	●	●	●

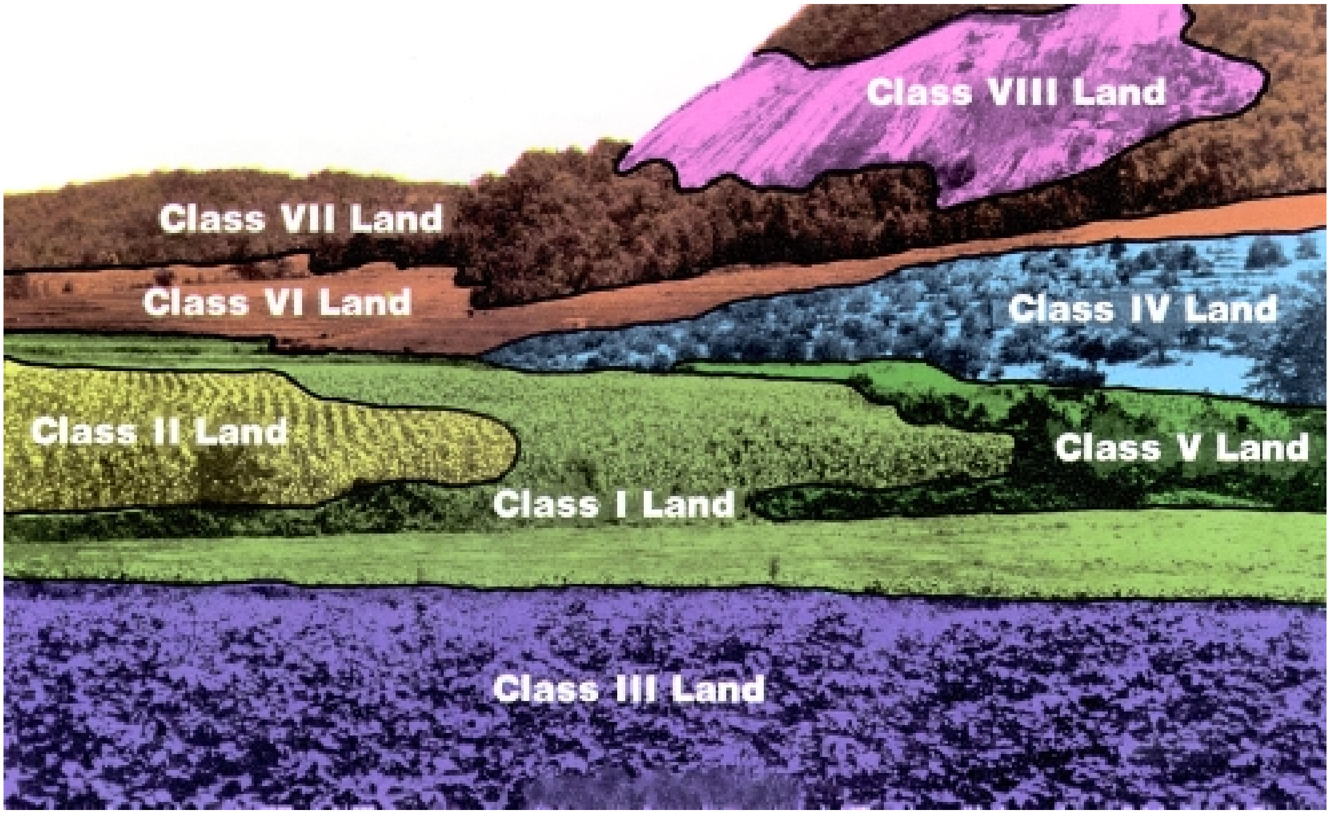


Figure 8.—*Landscape with land capbility classes outlined.*

The hydric soils list, developed for the 1982 Farm Bill, is included in the SoilConservation Service Field Office Technical Guide, Section II. Some map units that have inclusions of soils that meet the hydric soil criteria are added to the field office listing.

Highly erodible soil and potentially highly erodible soil are also listed in Section II of the Soil Conservation Service Field Office Technical Guide. The criteria used to group highly erodible soils were formulated using the Universal Soil Loss Equation and the wind erosion equation. The criteria are in the National Food Security Act Manual. Soil use, including tillage practices, is not a consideration.

Areas defined as highly erodible can be held to an acceptable level of erosion by following approved practices in a conservation plan. Various conservation practices, such as residue management, reseeding to grasses, contour farming, and terraces, are used in conservation planning to reduce soil loss, maintain productivity, and improve water quality.

Land capability classes and in most cases, subclasses are assigned to each soil. They suggest the suitability of the soil for field crops or pasture and provide a general indication of the need for conservation treatment and management. Capability classes are designated by either Arabic or Roman numerals (I through VIII), which represent progressively greater limitations and narrower choices for practical land use. Capability subclasses are noted with an e, w, s, or c following the capability class; for example, IIe. The “e” indicates that the soil is erosive. A “w” signifies a wetness limitation. An “s” denotes a shallow, droughty, or stony soil. A “c” indicates a climatic limitation. No subclasses are shown for capability class I because these soils have few limitations. Figure 8 illustrates some of the capability classes on a landscape.

Prime farmland soils are listed by map unit name in the tables or the “Prime Farmland” section of the soil survey. These soils have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oil seed crops. Unique farmland is land other than prime farmland that is used for the production of specific high value crops, such as citrus, tree nuts, olives, cranberries, fruit, and vegetables.

Section 6: General soil information

The general soil map is near the back of the soil survey publication. This generalized map of the soils for the soil survey area is color coded to show major soil associations (or groupings) of the major soils. Soils within a soil association may vary greatly in slope, depth, drainage, and other characteristics that affect management. Descriptions of each of the soil associations are near the front of the soil survey report immediately following the short introductions to cultural and natural features of the area. This section is labeled “General soil map units” in the Contents.

The general soil map can be used to compare the suitability of large areas for general land uses. Because of the scale, it is not intended to be used to make management decisions on specific sites. Each color-coded area on the map has a corresponding description. For example, on the general soil map illustrated by figure 9 areas coded 1 and shaded light yellow designate the Lamoni-Shelby soil association. As the name of the unit implies, Lamoni and Shelby soils are the major soils that occupy the landscape in this area. Likewise, the description of association 1 gives general information about this section of the county.

Some soil surveys include three-dimensional drawings depicting the relationships of soils, parent material, and landscape position for the major soils. Figure 10 illustrates the dominant Lamoni and Shelby soils and the minor Colo soils as they occur in association 1. Note the relationship of parent material and landscape positions to the different soils. Please refer to Section 2 “How is soil formed?” and to figure 3 for additional insights on these relationships.

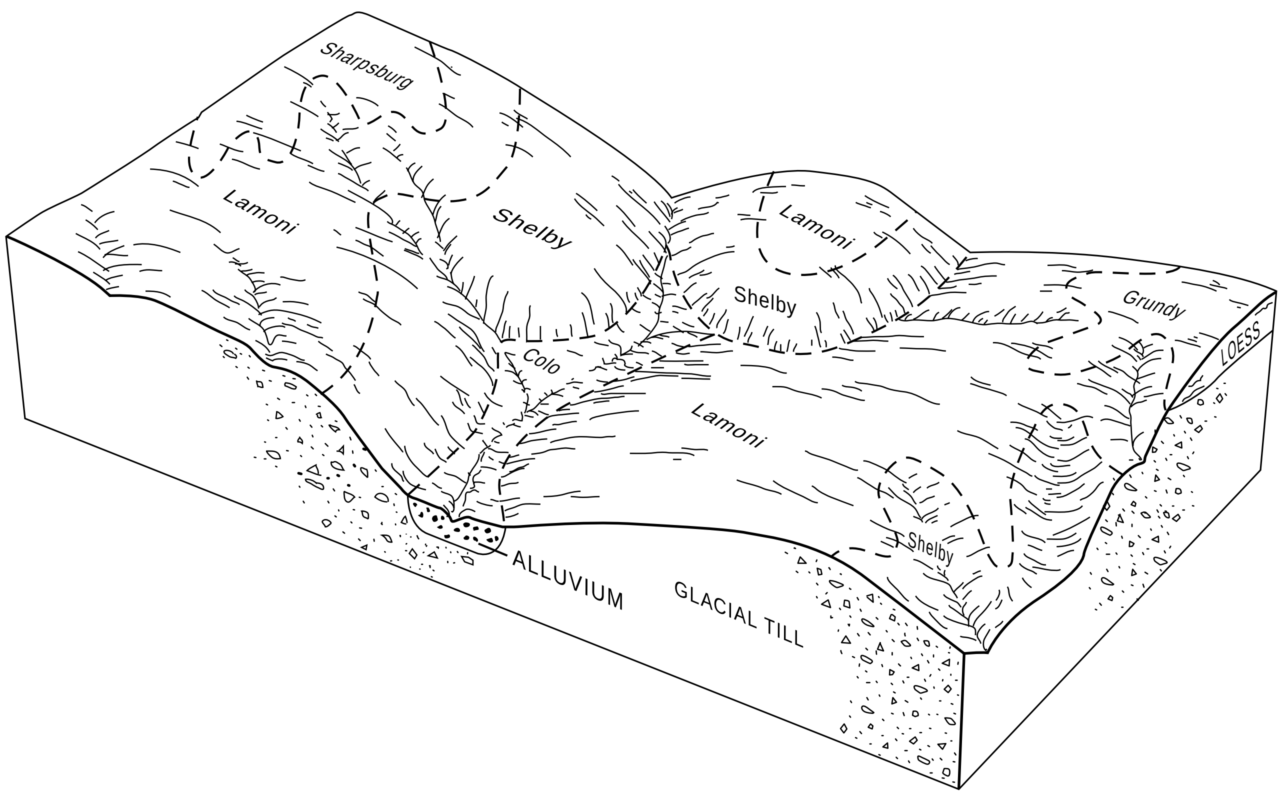
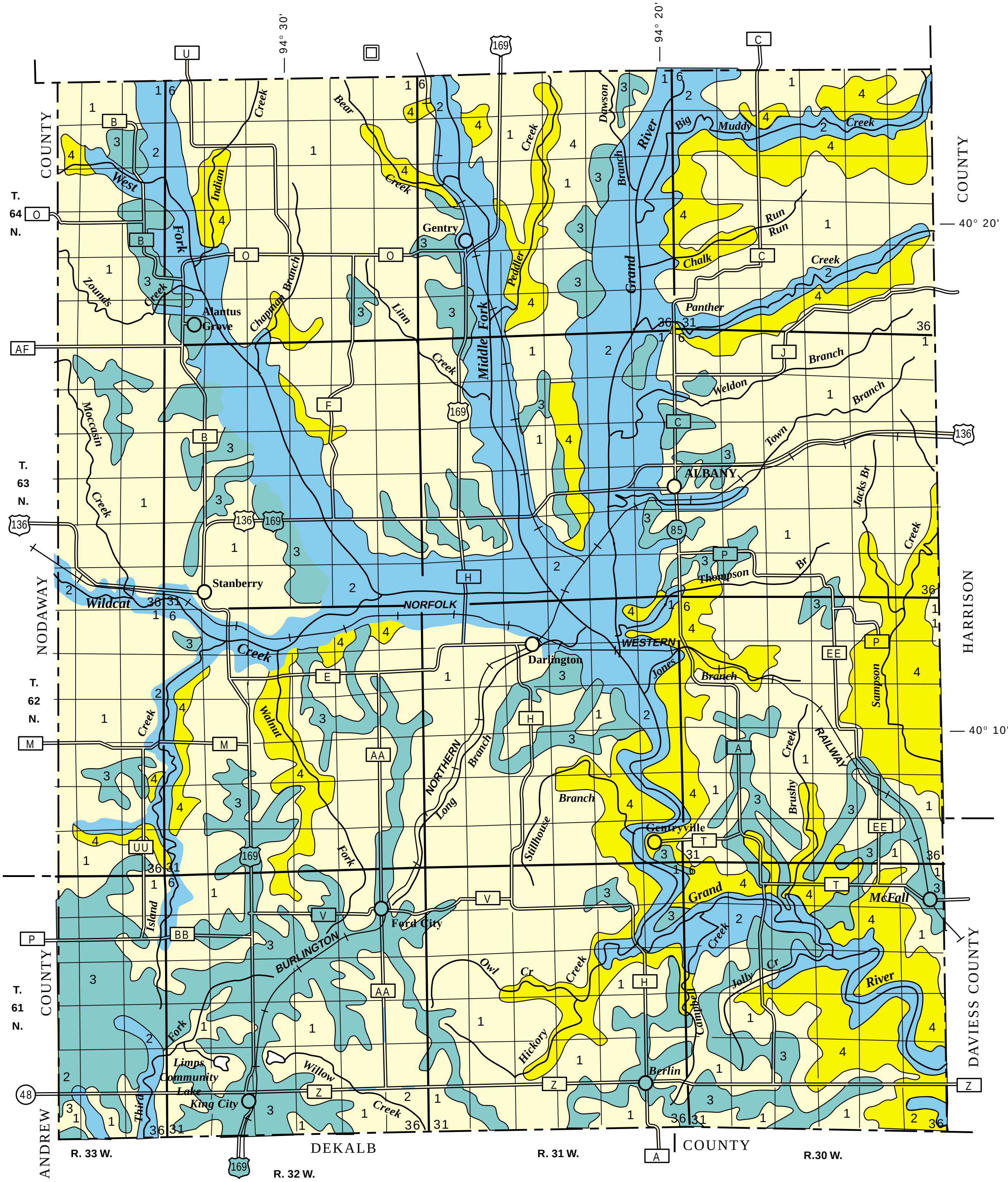


Figure 10.—*Relationship of soils, topography, and underlying material in the Lamoni-Shelby-Colo soils.*



Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

Figure 9.—*General Soil Map*

General Soil Map

Legend

1	LAGMONI-SHELBY association: Deep, moderately sloping to moderately steep, somewhat poorly drained and moderately well drained soils that formed in glacial till; on uplands.
2	NODAWAY-ZOOK association: Deep, nearly level, moderately well drained and poorly drained soils that formed in alluvium; on flood plains.
3	GRUNDY association: Deep, gently sloping and moderately sloping, somewhat poorly drained soils that formed loess; on uplands
4	GARA-ARMSTRONG-VANMETER association: Deep and moderately deep, moderately sloping to very steep, moderately well drained and somewhat poorly drained soils that formed in glacial till or residuum of shale; on uplands.

Compiled 1983

U.S. Department of Agriculture
Natural Resources Conservation Service
Missouri Agricultural Experiment Station

GENERAL SOIL MAP
GENTRY COUNTY
MISSOURI

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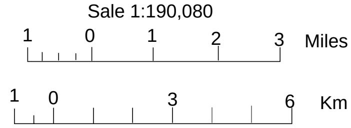

SECTIONALIZED
TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Section 7: Detailed soil information

To obtain information about a particular plot of land from a soil survey, locate the general area on the "Index to Map Sheets," and select the appropriate map sheet number. The sheets are in numerical order in the soil survey. After selecting the correct sheet, a specific parcel of land is located on the aerial map by using section numbers, roads, streams and drainage ways, towns, or the imagery on the map sheet. Areas on the aerial photograph are delineated for individual soil map units and each contains a unique map unit symbol.

The symbols on the detailed maps are listed on the back of the "Index to Map Sheets" with the names of each soil they represent. Some soil names include terms for the surface texture, slope range, and erosion. Detailed information can be obtained about each unit by referring to the map unit description or soil interpretive tables. Each unit is easily located by using the Index to Map Units or Summary of Tables in the front of the publication. Both the map unit descriptions and soil survey interpretive tables have information about the soils.

In each map unit description, soil information is given for the common uses. Major limitations or hazards affecting these uses are stated. Also listed are possible alternatives to help overcome each major limitation or hazard.

Areas delineated on the soil maps are not necessarily made up of just one soil, but include smaller areas of similar or different soils. The composition of soils in the map unit is explained in each map unit description.

Soil surveys provide sufficient information for the development of resource plans, but onsite investigation is needed to plan intensive uses in small areas. Some useful information is not published, but it is contained in section II of the NRCS Field Office Technical Guide.

Location of information

Section 8 describes where soil information can be located.

Section 8: Location of soil properties and interpretations

Specific soil properties or interpretations are sometimes difficult to locate within a soil survey. Following is a ready reference of commonly sought after items for agronomic use. Some of the data elements were not collected during earlier surveys and are not in the published soil survey. In addition, some information may not be included in recent soil surveys because it simply was not needed. For example, some soil surveys do not have information about salinity because saline soils were not mapped.

Immediately following the listing of items is a code indicating the location of that item. The location codes correspond to a listing in the box at right.

Soil properties

Available water capacity — B, 16
Bedrock or layer depth — B, D, 14, 16, 17
Bulk density — B, 16
Calcium carbonate ($CaCO_3$) — B, D, 16
Cation exchange capacity (CEC) — 16
Cemented pan — B, D, 17
Clay — B, D, 16
Drainage class — A, B, D
Erosion factors (K),(T) — 16
Flooding — B, 17
Landscape position — A, B, D
Organic matter — B, D, 16
Permeability — B, 16
Potential frost action — 17
Rock fragments — B, 15
Salinity, alkalinity (SAR) — B, D, 16
Soil reaction (pH) —B, 17
Soil texture (USDA) — A, B, D, 15
Subsidence — B, 17
Water table — B, 17
Wind erodibility group (WEG) — 16
Wind erodibility index (I) — 16

Soil interpretations

Adapted trees — C, 7, 8
Capability classification — B, 5, 6
Drainage — C, 14
Grassed waterways — 14
Highly erodible land — *
Hydric soil list — *
Irrigation — C, 14
Predicted yields — C, 5
Terraces and diversions — 14
Topsoil — 13

Soil Survey Report

Sections[1]

A. General soil map unit descriptions
B. Detailed soil map unit descriptions (nontechnical soil descriptions)
C. Use and management of the soils (crops and pasture)
D. Soil series and their morphology (technical soil descriptions)

Tables[1]

1. Temperature and precipitation
2. Freeze dates in spring and fall
3. Growing season
4. Acreage and proportionate extent of the soils
5. Land capability classes and yields per acre of crops and pasture
6. Capability classes and subclasses
7. Woodland management and productivity
8. Windbreak and environmental plantings
9. Recreational development
10. Wildlife habitat
11. Building site development
12. Sanitary facilities
13. Construction materials
14. Water management
15. Engineering index properties
16. Physical and chemical properties of the soils
17. Soil and water features
18. Classification of the soils

1 All sections and tables can be located in the Contents, Index to Map Units, or Summary of Tables in the front of published soil surveys.

* Field Office Technical Guide, Section II contains soil and site information.

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