VAS 4052a

# UNDERSTANDING SOILS

## 1. What Is Soil?

## 2. How Were Soils Formed?

## 3. How Do Soils Differ?

Soils differ widely in their characteristics. Soil scientists have organized their knowledge of soils in such a way that soil can be judged, just as crops and livestock are judged. The process of rating or appraising soils has been called by different names—land judging, land-use selection, and land appreciation.

Once a land's capability has been judged, it is possible to decide on sound use and management practices. The purpose of this unit is to help you examine soils, interpret their characteristics, and judge your land so that you can use and manage it wisely.

## 1. WHAT IS SOIL?

Soil is the outer portion of the earth's crust that supports the growth of plants. About half of its total volume is made up of partially decomposed rock material (mineral matter) mixed with remains of plant and animal life (organic matter). The remaining volume is made up of the pore spaces or openings of varying sizes that occur between the soil particles. These spaces are filled with either water or air. When a soil is in good condition for plant growth, air will occupy about half the pore space and water the other half (Fig. 1). In addition, the soil contains a large population of microorganisms (bacteria, fungi, etc.) together with insects and smaller animal life.

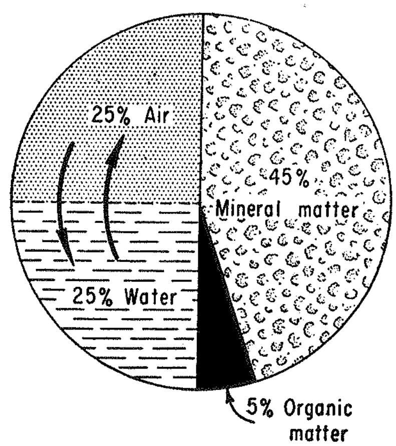



Fig. 1. Composition by volume, of a silt loam surface soil in good condition for plant growth.

### Soil profiles

Soils are composed of one or more layers or horizons, lying approximately parallel to the earth's surface. The different horizons are developed from the interaction of such soil-forming factors as -- parent material, slope, native vegetation, weathering (time), and climate. A vertical section through the horizons is called a soil profile.

Most soils have three principal horizons, which are designated by capital letters: the surface or A horizon, the subsoil or B horizon, and the substratum underlying the subsoil, or C horizon (Fig. 2). Differences within each horizon may be indicated by numbers written after the letters. For example, the A horizon might be subdivided into a surface (A1),

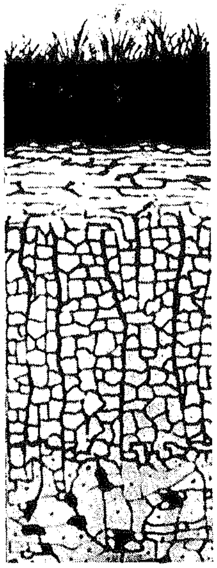



Fig. 2. This diagram of a soil profile gives an idea of the different kinds of layers that lie beneath the surface.

which is dark in color as a result of accumulation of organic matter, and a subsurface (A2) horizon which is lighter in color, lower in organic matter, and strongly leached. A third subdivision (A3) is often recognized in soils not having an A2 horizon.

To learn the physical characteristics of any soil, study its profile, usually to a depth of 3 to 5 feet. Two soils which look alike on the surface may show important differences in the horizons below the surface. You can determine these differences by sight, touch, or laboratory methods. This may mean that the soils should be managed in entirely different ways.

## 2. HOW WERE SOILS FORMED?

Soils are the product of their heredity and environment. The starting point for any soil is the parent material from which it is formed. The soil which results depends on the changes brought about in this material by four other factors — topography or lay of the land, native vegetation, amount of weathering (time), and climate.

### Parent material

The parent materials of mineral soils are formed by the disintegration and decomposition of rock. These materials, then, are classified by the way they have been moved and scattered. The list is as follows:

1. Material of glacial origin
   a. Loess
   b. Outwash, including water-deposited material in lake beds
   c. Glacial till
2. Water-borne material deposited in bottomlands
   a. Alluvium
3. Thinly covered bedrock of limestone, sandstone, shale, etc.
4. Organic deposits — peat or muck

The location and extent of these main kinds of parent materials are shown in Fig. 3. This map will be referred to as each type of soil parent material is discussed.

Most of the Illinois soils have been formed from material originally moved by great ice sheets or glaciers. During the Ice Age these glaciers, which may have been a mile or more thick, pushed southward from Canada until they covered most of the northern United States. Although Illinois was invaded by ice during several glaciations, it was the two later ones — the Illinoian and the Wisconsinan — which had the most influence on our present day soils (Fig. 4). The Illinoian glaciation covered all of the state except the seven southernmost counties and most of Calhoun and Jo Daviess counties and part of the adjoining counties. The Wisconsinan glaciation covered a little more than the northeastern third of Illinois. Thousands of years elapsed between these two glacial periods which allowed enough time for a thick highly weathered soil to be formed from the material left during the Illinoian glacial period.

Like giant bulldozers, the glaciers scraped and leveled the areas they touched. As they moved, they carried along large amounts of rocky material, grinding much of it into a

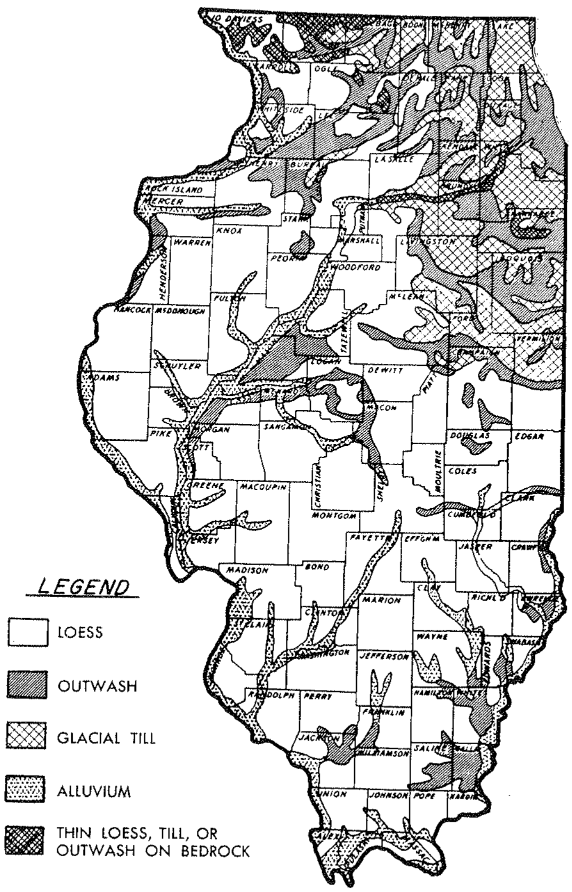



Fig. 3. The extent of the main kinds of soil parent materials in Illinois.

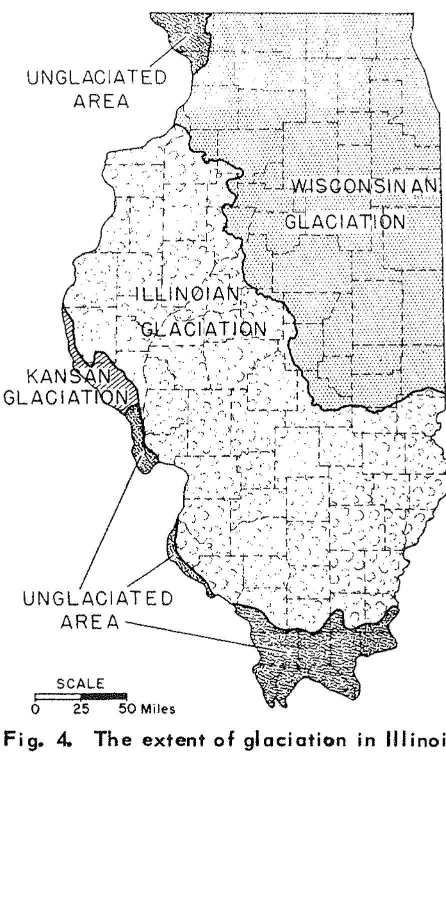



Fig. 4. The extent of glaciation in Illinois.

variable mixture of gravel, sand, silt, and clay, and redepositing it as "glacial till."

Sometimes there were warm spells when the ice melted as fast as it moved down. If these spells were prolonged, the material carried by the glacier piled up in a low ridge or "moraine" where the end of the glacier stood still. Morainal ridges are common, especially in northeastern Illinois, and often present some of our most serious erosion problems.

During the mild periods, enormous quantities of runoff water from the melting ice carried glacial material out into a flood plain below the moraines, where it was redeposited in layers as "outwash." Large amounts of finely ground rock, or "glacial flour," were deposited in the broad river valleys. During colder weather when the streams dried up, winds picked up some of this fine dust from the dry valley floors and deposited it on the uplands over a large part of the state. This silty, wind-blown material is known as "loess."

Vertical sections of three kinds of soil parent material are shown in Fig. 5. Remember that glacial till consists of rock particles varying greatly in size. Where water has picked up this material and redeposited it as outwash, definite layers of different-sized particles are noticeable. This is because particles of the same size tended to settle out at the same time, according to the speed of the running water. Loess particles were sorted by the wind so that in any one area they are fairly uniform.

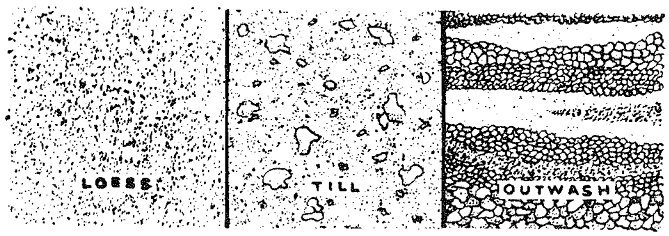



Fig. 5. Vertical section of three kinds of soil parent material.

Loess. Most of the best soils in Illinois have developed from thick loess. In fact, about 64 percent of the Illinois soils have been formed from loess. It predominates in the western, central, and southern parts (Fig. 3). Loess is the most desirable single soil parent material because of its well-balanced mineral content, its medium texture, and its excellent water-holding capacity. Because of the prevailing westernly winds, loess deposits are thickest east of the Mississippi and Illinois Rivers, although there are places where deposits reach all the way to the west bank of the Illinois River. Loess is thicker near the valley source areas and tends to get thinner with distance away from the source. The thinner loess areas are more highly weathered, more acid, and less fertile soils than those formed from deep loess. The distribution and thickness of loess is shown in Fig. 6.

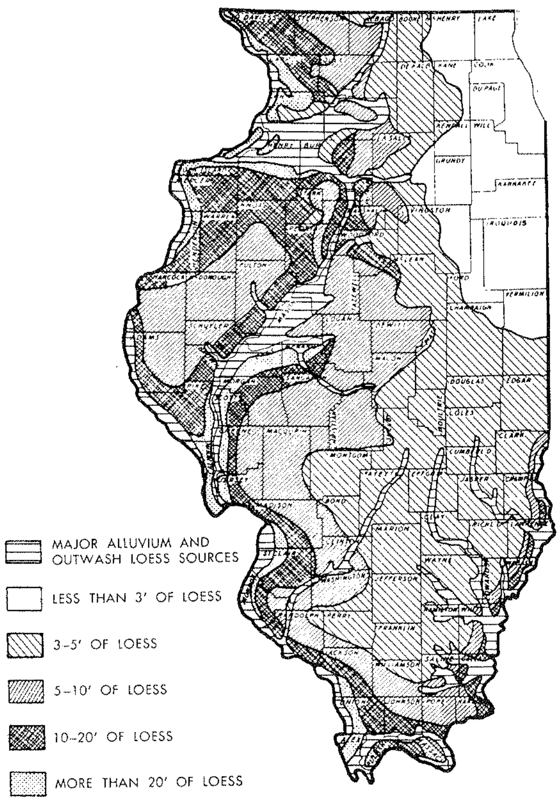



**Fig. 6. Approximate loess depths (in feet) on uneroded topography in Illinois.**

Outwash. Soils formed from outwash occupy about 16 percent of Illinois (Fig. 3). These soils are most extensive in northern Illinois on outwash plains — level areas below the glacial ridges — that received glacial melt waters. Outwash soils also occur in lakebed areas and on stream terraces along the Mississippi, Illinois, Wabash and Ohio Rivers and their tributaries. These streams carried melt waters from the glaciers. Gravelly outwash materials were deposited below the glacial ridges or in the upper reaches of the river valley. Sand was usually carried further downstream. The finer materials - silt and clay - were deposited in lakebeds or slowly moving water along streams. Medium textured outwash is more desirable as a parent material than either the coarser or finer textured outwash.

Glacial till. This is an important soil parent material in northeastern Illinois. Soils developed primarily from till occupy about 11 percent of the state (Fig. 3). In northeastern Illinois, the glacial tills are of the Wisconsinan age. A few soils have formed in till of Illinoian age, on the steeper slopes, and are present throughout much of the rest of Illinois. The Wisconsinan tills in northeastern Illinois are extremely variable in texture, ranging from loamy gravel to clay, but including sandy loam, loam and silt loam, silty clay loam, and silty clay. Pebbles and various sizes of boulders are common in till. The till textures, and the soils developed from it, often change over short distances. The medium-textured tills, especially loams and silt loams, are good soil parent materials. The other tills become progressively less desirable as soil parent materials as they become either coarser or finer in texture. The tills were calcareous and well supplied with plant nutrients, except nitrogen and possibly phosphorus, when deposited. In general, they have considerably lower available moisture-storage capacities, higher bulk densities, and are more compact than loess.

Alluvium. This includes the recent sediments deposited by streams on their floodplains. It occupies about 7 percent of the state (Fig. 3). Alluvium occurs throughout Illinois in stream valleys; however, it is most extensive in southern Illinois. Most of the small valleys or alluvial areas in the state are not shown in Fig. 3 because of its small scale.

Alluvial sediments in Illinois vary in reaction from acid to calcareous, in color from light to dark, and in texture from sands to clays. The acid alluvial sediments occur in southern Illinois and the slightly acid to neutral and the calcareous sediments occur primarily in the central and north, but are found throughout the state. Medium-textured alluvial sediments predominate. The smaller stream valleys usually have silty or loamy sediments, and the moderately fine- and fine-textured sediments are found mainly in the larger bottomlands along the Mississippi, Illinois, Wabash, and Ohio Rivers.

Bedrock. Shale, sandstone, or limestone bedrock is buried by loess, till, outwash, and alluvium in most of Illinois. However, in the unglaciated areas of northwestern and extreme southern Illinois, weathered bedrock has provided soil parent material. In some areas, soils have surface and upper subsoil horizons of loess, till, or outwash and lower horizons of weathered bedrock. The total extent of soils formed from bedrock or from thin loess, till, or outwash over bedrock is about 2 percent of the state (Fig. 3).

Organic matter. Organic deposits form parent material for peat and muck soils that occur in a few areas in extreme northern Illinois and in some of the major river valleys. These areas were formerly shallow ponds that supported swamp vegetation. The wet conditions slowed decay of the dead plants so that organic matter accumulated. This organic matter, plus small amounts of mineral matter, provided soil parent material. Muck is more decomposed than peat.

## Topography

Topography refers to the slope characteristics of a soil. It includes the degree or steepness, length, shape, and direction of a slope. These characteristics influence the amount of rainwater runoff, or the amount that enters the soil or collects in small depressions on the soil surface. Soils on steep topography often have high runoff and are likely to be subject to severe erosion. Soils on level topography have less runoff but are likely to have higher infiltration - that is, more of the water enters the soil.

The amount of moisture in the soil during its development affects the rate of weathering and the development of subsoil colors. So subsoil colors are a reflection of the moisture status during soil development. Well-drained soils have uniform brownish or yellowish-brown colors in their subsoils, and poorly drained soils have grayish subsoils. Imperfectly (or somewhat poorly) drained soils have mottled yellowish, brownish, and grayish subsoils.

Soils in depressions (concave or saucer shaped slopes) and on nearly level topography are likely to have poor or very poor natural drainage. Those on nearly level to gently sloping topography are usually somewhat poorly drained. Soils on convex ("bowl" or "ridge" shaped) or moderately sloping to steep topography are usually well drained.

## Native vegetation

Native vegetation determines the kind and amount of organic matter in the soil. In this state two types of native vegetation, deciduous-hardwood forest and tall-grass prairie, have given two distinctly different classes of soils—timber soils and prairie soils (Figs. 7 and 8).

Fig. 7. Soils along the water courses were generally developed under forest vegetation. Timber soils are usually lighter in color than prairie soils and have less organic matter.

Under forest cover, the organic material is in the form of duff (the partially decayed leaves, twigs, and fallen logs which have accumulated on the surface). Since the material is on the surface, it decays rapidly and leaves only a small residue. Total build-up of organic matter is, therefore, quite low. Undisturbed forest soils have a thin, moderately dark top layer of some 2 to 4 inches (Fig. 9). When these soils are plowed, this dark material is mixed with the soil underneath to produce a lighter color.

Most prairie soils, however, have a dark surface layer that is fairly deep (Fig. 10). The wild prairie grasses and other plants, including native legumes, had abundant roots

Fig. 8. Tall prairie grass orignially covered much of the level areas of Illinois. Because of it, many soils of these areas are dark in color and high in organic matter.

## FORESTED SOIL

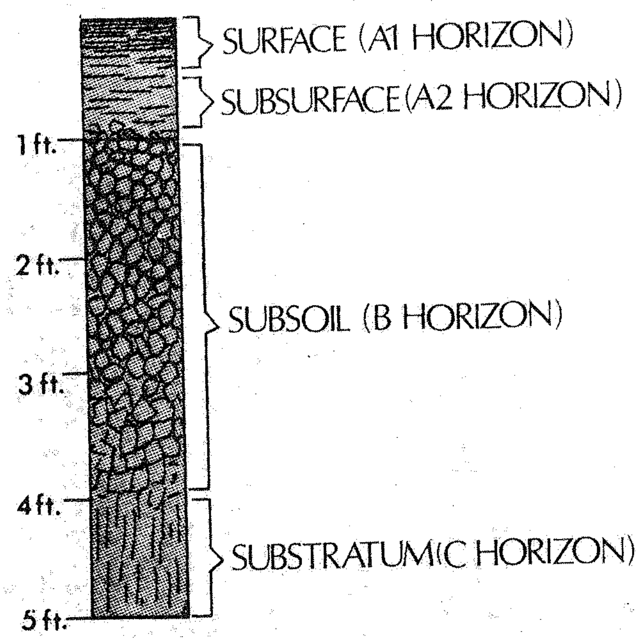



Fig. 9. This soil profile diagram gives an idea of the different kinds of layers that lie beneath the surface of a typical forest soil.

## PRAIRIE SOIL

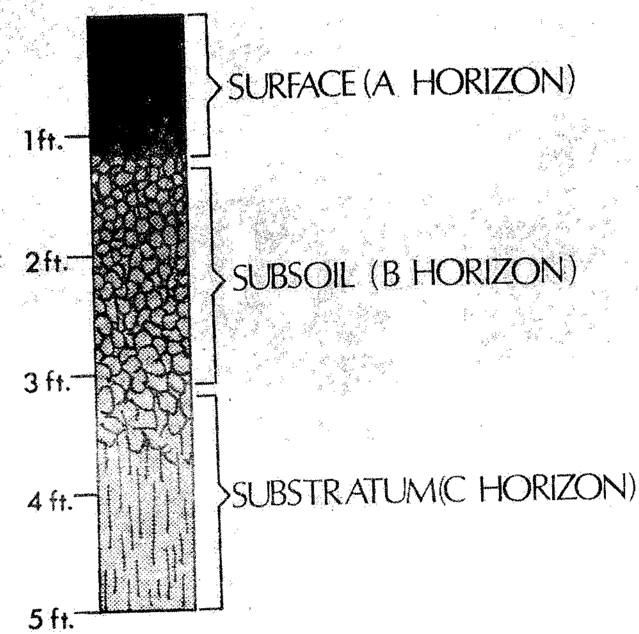



Fig. 10. Hypothetical soil profile for a prairie soil. Note that the surface horizons are usually thicker than comparable forest soil horizons.

which filled the top of the soil to a depth of 1 or 2 feet or more. Partial decay of these roots over a long period of time gave us the high organic matter or humus content of our prairie soils and, along with it, the brown to black color.

Generally, between prairie and timber soils, there is a transition zone with some of the characteristics of both soil classes.

A minor type of native vegetation in Illinois includes the freshwater swamp plants, such as reeds, rushes, and sedges, which brought about the development of our organic soils.

Other living matter besides vegetation that influences soil development includes various kinds of animal life, such as earthworms, crawfish, ground squirrels and other burrowing animals, and various insects which incorporate organic matter into the soil and mix soils to varying depths and degrees.

<u>Weathering (Time)</u>

Soils at different stages of the weathering process will differ widely. Weathering causes soils to develop, mature, and age. Soils develop rapidly during their early stages.

Plant nutrients are quickly released from the minerals, plant growth increases, and organic matter accumulates, especially where moisture is adequate. Soils, then, slowly age as they continue to weather. Eventually the available supply of nutrients is markedly decreased. Water moving through the soil leaches away many soluble portions. Many soils are now acid because the calcium originally in them has been leached away. As the supply of nutrients in the soil decreases, the amount of plant growth is reduced until the organic matter is decomposing faster than it is being produced. Soil development is more rapid in humid climates that support a good growth of vegetation than in dry climates.

As water percolates through soils, the fine clay particles commonly move downward from the surface soil into the subsoil during the weathering process. This movement, together with further breakdown of the rock material, accounts for the fact that many soil types have a higher percentage of clay in the subsoil than in the surface soil (Fig. 11).

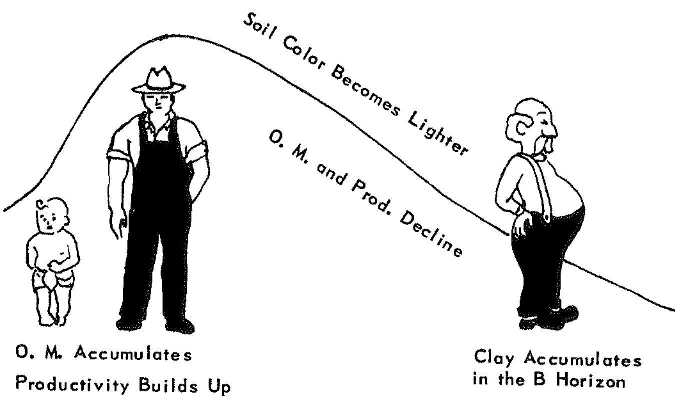



Fig. 11. Weathering causes soils to develop, mature, and age much as people do. Soils, like people, develop quickly in their youth and then gradually decline. Organic matter and productivity decline while clay accumulates in the horizon.

As soils go through the more advanced stages of weathering, they slowly decline to lower and lower levels of productivity. These soil changes involve long periods of time which run into thousands or tens of thousands of years.

## Climate

Weathering, of course, depends on climate. Rainfall, freezing, thawing, wind, and sunlight are all directly or indirectly responsible for the breakdown of rocks and minerals, the release of plant nutrients, and many processes affecting the development of soils.

The nature of the climate of Illinois during the development period of the soils of Illinois is difficult to characterize. However, best evidence seems to indicate that it was not greatly different from present-day climate, except for a rather warm, dry period some 4,000 to 6,000 years ago.

Present climate in the state is of the continental type with hot summers and cold winters. Average annual temperature ranges from about $47^{\circ}$ F. in the north to $59^{\circ}$ F. in the south (Fig. 12). January is normally the coldest month with mean temperature ranging from about $22^{\circ}$ F. in the north to $36^{\circ}$ F. in the south. Mean temperature in July (usually the hottest month) ranges from about $73^{\circ}$ F. in the north to $80^{\circ}$ F. in the south. The latitudinal extent of the state from 37 to 42.5 degrees north is largely responsible for these temperature variations.

Average annual precipitation in Illinois ranges from about 32 inches in the north to

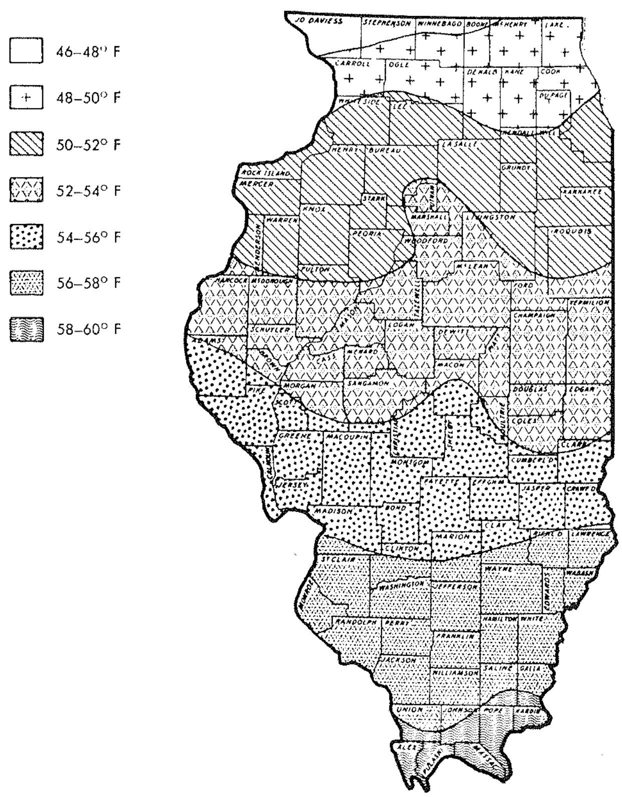



Fig. 12. Average annual temperature (degrees Fahrenheit) in Illinois, 1931 to 1960. (Data from U. S. Weather Bureau.)

47 inches in the south (Fig. 13). Although total precipitation is greatest in southern Illinois, that which falls during the growing season (April to September) is about the same throughout the state. Less distance to the Gulf of Mexico and more cyclonic activity in winter in southern Illinois are responsible for higher winter and early spring precipitation in that part of the state.

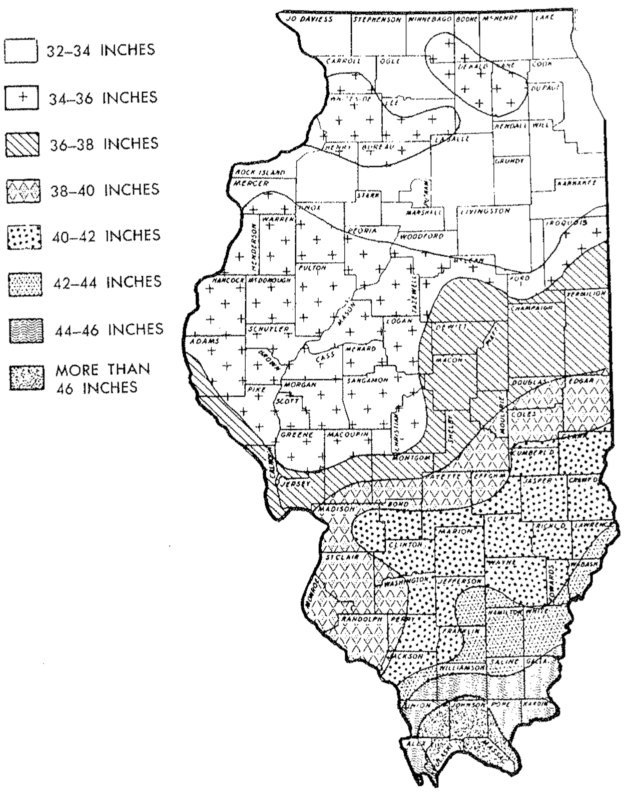



Fig. 13. Average annual precipitation (inches) in Illinois, 1931 to 1960. (Data from U. S. Weather Bureau.)

The average number of frost-free days in Illinois ranges from less than 160 in the north to more than 200 in the south (Fig. 14). Although the growing season is shorter in northern Illinois, crop varieties and corn hybrids with shorter maturity periods are used in this part of the state, and frost damage is usually not a serious problem.

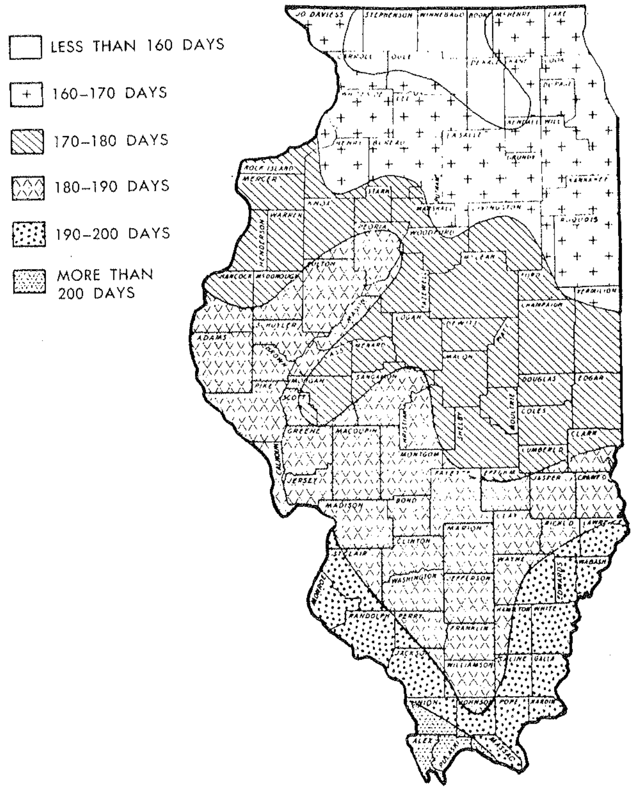



Fig. 14. Average number of frost-free days in Illinois. (Data from Ill. Bul. 532)

The effect of climate on soils is much more noticeable when you compare different broad regions of the country. In dry areas, for example, there is very little leaching and the effects of weathering are seen mostly in the physical breakdown of rock particles. In humid regions soils are subject to great leaching and chemical weathering, with a consequent decrease in fertility. Illinois is classified as having a humid, temperate climate. It is conducive to the breakdown of soil minerals, the formation of clay, and the translocation or movement of these materials downward in the soil profile. Materials, such as clay, tend to be removed from A horizons and accumulate in B horizons. This is why B horizons or subsoils are usually higher in clay than A horizons in soils developed in uniform parent materials.

## 3. HOW DO SOILS DIFFER?

### Inherent characteristics

The soil-forming agencies just discussed have interacted in various ways to produce soils with widely differing characteristics. A study of these characteristics, which are inherent in a soil, will help you to know how to use and manage the different soil types.

<u>Soil color</u>. Color is one of the most noticeable characteristics of a soil. As you examine a soil profile, you are likely to see definite changes in color from the surface through the subsoil and underlying parent material. The colors of the surface and subsoil may be classified as follows:

Surface—dark, moderately dark, light, very light.

Subsoil—dull, mottled, bright.

As a rule, the surface is darker than the subsoil because it contains more organic matter. This difference is particularly noticeable in the prairie soils of central and northern Illinois. As shown in Fig. 10, prairie soils are naturally high in organic matter to a depth of 1 or 2 feet, and are consequently brown to black in color.

Since timber soils accumulated less organic matter than prairie soils, they developed a medium- to light-brown A1 horizon only 2 to 4 inches thick. Beneath this is a light-gray A2 horizon which may vary from an inch to a foot or more in thickness. Where these soils have been farmed, the A1 and the A2 have been mixed together and the plow layer has a uniform gray color (Fig. 9).

Subsoil colors of Illinois soils are due to the status of iron compounds. Well drained soils have bright colored - brown, reddish brown, or yellowish-brown - subsoils because the iron compounds are oxidized. Soils with poor natural drainage have dull - gray or olive gray - subsoils because the iron has been reduced and removed from the soil. Sometimes small concretions of rusty colored iron compounds occur in poorly drained subsoils.

A mottled coloring with both gray and yellowish-brown indicates that the soil is saturated at certain periods of the year and is comparatively dry at other times.

To describe soil colors, soil scientists use a set of standard color chips prepared by the Munsell Color Company (Fig. 15). Each chip has a standard color name and also a "Munsell notation," which locates it precisely in relation to other colors. The color of a soil fragment is determined by matching it with one of these chips. Color can then be accurately and completely described by giving both the standard name and the Munsell notation, and also noting whether the soil is moist or dry.

<u>Texture</u>. The soil particles resulting from glacial action and weathering vary greatly in size. They are classified on the basis of size into gravel, sand, silt, and clay (Fig. 16). Gravel may range from pebbles down to particles about 1/12 inch in diameter. Sand grains feel gritty and you can see them easily. Silt is made up of particles which can only be seen with a microscope; it looks and feels like flour. Clay particles are so fine that you cannot see them even under a microscope.

Most soils are mixtures of the various-sized particles except that many contain no gravel and some very little sand. If a soil contains considerable quantities of at least two sizes of particles, it is known as a loam. It may be called a clay loam, sandy clay loam, silt loam, silty clay loam, or sandy loam, depending on the size (or sizes) of particle that predominates. If a mixture consists mostly of one size of particle, it may be clay, silt, or sand, depending on dominant particle size.

Altogether, Illinois soils can be grouped into 12 main classes on the basis of texture as shown in Fig. 17). The corners of this texture triangle represent 100 percent sand, clay, or silt, as indicated. Gravel and organic soils are not included. The triangle is divided into 10-percent portions of clay, silt, and sand. Heavy lines show the divisions between 12 basic soil textural classes. The triangle can be used only when the percentages of clay, silt, and sand have been determined in the laboratory. If you know that a soil is 20 percent clay and 40 percent silt, you can follow the 20-percent line from the left-hand (clay) side of the triangle to the point where it meets the 40-percent line from the right-hand (silt) side of the triangle. You will see, then, that the soil is a loam.

Sometimes a modifier is added to the name of the textural class to describe the dominant particle size — for example, fine sandy loam. The word "gravelly" may be added if the sample contains a large proportion of gravel. Soil types are named by combining proper names (usually geographical) with the textural designation of the surface soil, as "Ridgeville sandy loam."

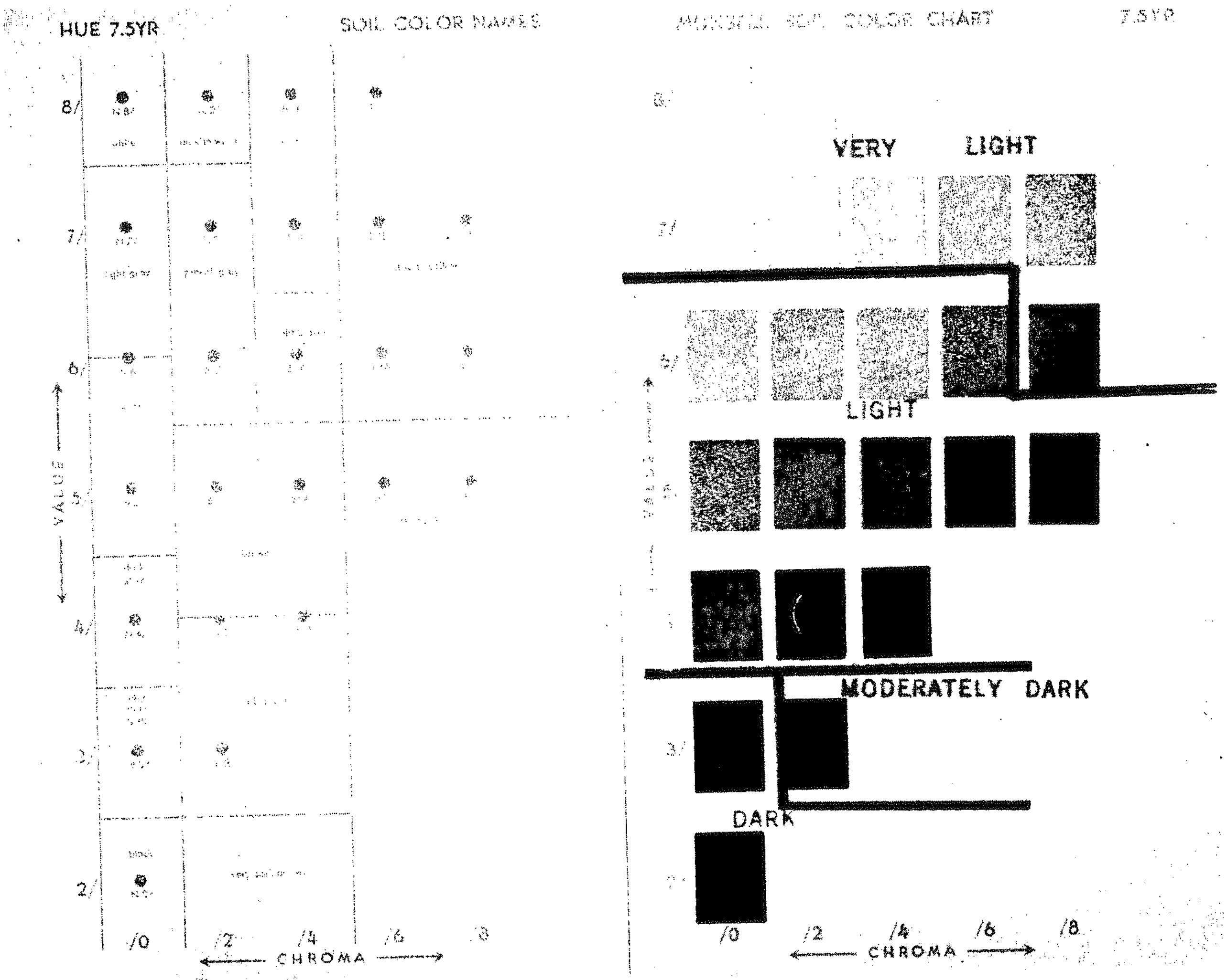



**Fig. 15. Soil color charts are helpful in determining the color of soil.**

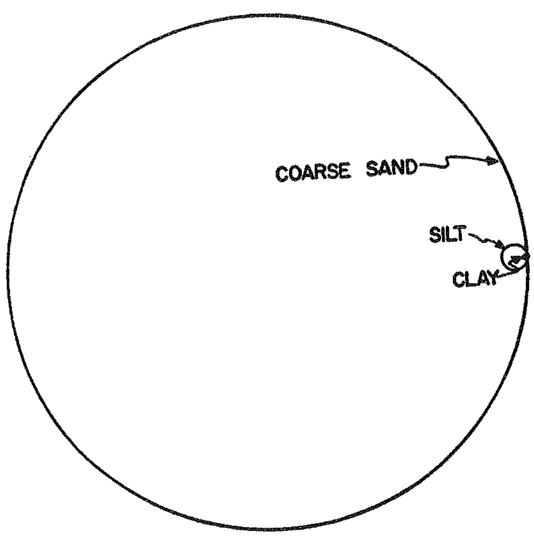



**Fig. 16. This diagram shows the relative sizes of three kinds of soil particles. Even though they have been enlarged about 60 times, the clay particles can barely be seen.**

The 12 textural classes (plus gravel, gravelly loam, muck, and peat) may be grouped as follows:

Fine-textured — clay, silty clay, sandy clay

Moderately fine-textured — silty clay loam, clay loam, sandy clay loam

Medium-textured — loam, silt loam, silt, very fine sandy loam

Moderately coarse-textured — sandy loam, fine sandy loam

Coarse-textured — loamy sand, sand, gravel

Organic — muck, peat

A soil's productivity and the management practices that it requires depend a great deal

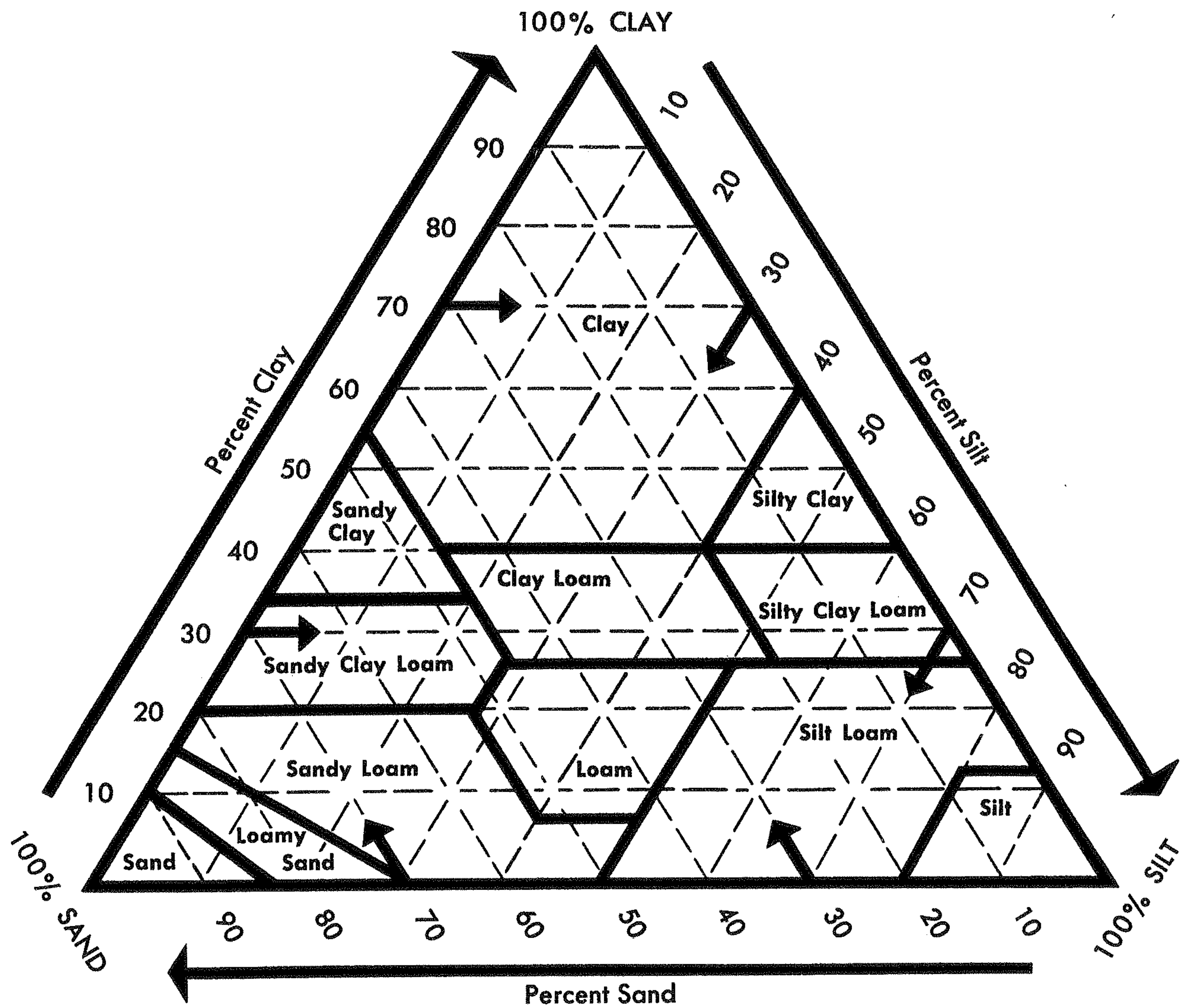



Fig. 17. The texture triangle shows the percentage of sand, silt, and clay in each of the textural classes.

on its texture. Texture influences the water intake of a soil, water-holding ability, drainage, tillage, erosion, and the ease with which organic matter and fertility can be maintained.

As a rule, both gravelly and sandy soils drain readily and work easily, although the coarse texture may cause slippage which may cause trouble in the use of power machinery. If soils contain too much sand or gravel, however, the water drains away too fast and plants suffer from drought during a dry spell. In soils of this kind, organic matter decays rapidly after it is plowed down. The plant food which is released, particularly the nitrogen, leaches out readily and is carried away in the soil drainage water.

Since silt is much finer than sand, soils made up largely of this material retain moisture well. At the same time they are open enough that air and water move freely through them. These soils usually work well.

The very fine particles in clay soils help to hold water in the soil. However, the clay particles may hold the water so tightly that plants cannot utilize it. Clay also serves as a storehouse for minerals upon which plant roots can draw. Too much clay, however, makes the soil slow to drain and hard to work.

Soil texture can be easily determined. The best way to determine it in the field is to feel the soil with your fingers. The soil should be moist because then the clay content is more readily estimated. The following procedure is recommended:

Moisten a sample of soil to the consistency of workable putty. From this sample make a ball about 1/2 inch in diameter. Hold the ball between thumb and forefinger, and gradually press the thumb forward, forming the soil into a ribbon (Fig. 18).

If a ribbon forms easily and remains long and flexible, the sample is probably clay or silty clay and is considered fine-textured. Soils in this group are very sticky and plastic.

Fig. 18A. If you can easily form a long, pliable ribbon from a ball of moistened soil, the soil is fine-textured.

If a ribbon forms but breaks into pieces 3/4- to 1-inch long, it is probably a clay loam or silty clay loam and is considered moderately fine-textured. Soils in this group are moderately sticky and plastic.

If a ribbon is not formed and the sample breaks into pieces less than 3/4-inch long, it is probably a silt loam, loam, or sandy loam. The sample would, therefore, be in one of two groups—medium-textured or moderately coarse-textured. The decision, then, depends on the amount of silt or sand in the sample.

If the soil feels smooth and talc-like, with no grittiness, silt predominates and the soil is termed medium-textured. If the soil feels slightly gritty, yet fairly smooth and talc-like, it is probably a loam or silt loam and is also included in the medium-textured group.

A marked gritty feel and a lack of smoothness indicate that sand likely predominates. The soil is then considered moderately coarse-textured.

If the sample is composed almost entirely of gritty material and leaves little or no stain on the hand, it is a sand and is considered coarse-textured. Soils composed of much gravel, with very little fine material, also fall into this classification.

Structure. Structure may be defined as the arrangement of the soil particles into

Fig. 18B. If a ribbon forms but breaks into pieces 3/4 to 1 inch long, the soil is moderately fine-textured.

Fig. 18C. If a ribbon is not formed and the soil feels smooth and talc-like with no grittiness, silt predominates and the soil is termed medium-textured.

**Fig. 18D.** If a ribbon is not formed and the soil feels very gritty, it is moderately coarse-textured.

clusters or aggregates of various sizes and shapes. Table 1 includes the principal kinds of structures found in Illinois soils.

The clusters of soil particles are called peds. In some soils the peds are quite distinct and are not easily crushed between the fingers. In other soils, the peds are barely discernible and fall apart easily when disturbed.

Some soils have no observable grouping of soil particles into peds and no definite arrangement of the peds in the soil profile. If the soil particles are coherent (sticking together), the soil is massive. If the particles are not coherent, the soil is single-grained. Sandy soils often have single-grain structure. Massive and single grain groupings are referred to as structureless.

Weak. Soil particles are incompletely grouped into peds that can barely be seen in place. When disturbed, peds break apart easily.

Structure does not change soil texture, but a desirable structure may greatly improve tilth and the ease with which water and air can move through the soil. Granular is the most desirable type of structure because it has the greatest proportion of large openings between the soil aggregates. Subangular blocky or nut-like structure is also desirable.

The blocky type of structure is intermediate in its effect. Least desirable perhaps is the platy type because the plates lie in a horizontal plane and overlap, leaving no continuous vertical openings. As a result, water and air move through the soil very slowly.

**Fig. 18E.** If the sample consists almost entirely of gritty material and leaves little or no stain on the hand, it is considered coarse-textured.

Strong durable peds in the topsoil increase resistance to the beating action of raindrops, and help to prevent the formation of crusts that reduce crop stands. Large clods, however, may let so much air get into the soil that it hinders the germination of seed and the development of plant roots.

Surface layers high in clay are likely to be cloddy when plowed unless the moisture content is optimum. They require more power for plowing and cultivation, increase the difficulty of preparing good seedbeds, and allow more water runoff.

Moisture holding capacity. The moisture holding capacity of a soil is closely related to its texture. As the clay content increases, there are more soil particles to hold water. So a soil high in clay — a fine textured soil — holds much more water than a sandy soil. Part of the water in a soil is held so tightly that plants cannot "pull" it away from the soil. Fine textured soils have a strong hold or attraction on water. Soils high in silt size particles have the largest capacity to hold water for use by plants. Common ranges in total and available soil moisture holding capacities are shown in Table 2.

Table 1. Common Types of Soil Structure

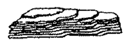
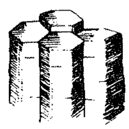
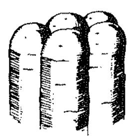
| Kind of structure | Description of aggregates (clusters) | | Horizon |
|---|---|---|---|
| Granular  | Aggregates are larger, harder, and strongly held together | Nearly spherical, with many irregular surfaces | Usually found in surface soil or A horizon |
| Platy  | Aggregates are flat or plate-like, with horizontal dimensions greater than the vertical. Plates overlap, usually causing slow permeability | | Usually found in subsurface or $A_2$ horizon of timber and claypan soil |
| Angular blocky or cube-like  | Aggregates have sides at nearly right angles, tend to overlap | Nearly block-like, with 6 or more sides. All 3 dimensions about the same | Usually found in subsoil or B horizon |
| Subangular blocky or nut-like  | Aggregates have sides forming obtuse angles, corners are rounded. More permeable than blocky type | | |
| Prismatic  | Without rounded caps | Prism-like with the vertical axis greater than the horizontal | |
| Columnar  | With rounded caps | | |
| Structure lacking Single grain | Soil particles exist as individuals such as sand and do not form aggregates | | Usually found in parent material or C horizon |
| Massive | Soil material clings together in large uniform masses, as in loess | | |

Table 2. Inches of Moisture Holding Capacity Per Inch of Soil

| Soil texture group | Total inches/in. | Available inches/in. |
|---|---|---|
| Fine | .40 - .50 | .15 - .20 |
| Moderately fine | .30 - .40 | .20 - .25 |
| Medium | .25 - .35 | .20 - .30 |
| Moderately coarse | .15 - .25 | .10 - .20 |
| Coarse | less than .15 | less than .10 |

Using these figures, you can easily estimate the amount of moisture that can be held in a soil profile, as is shown by the following example. (Laboratory tests are necessary, however, to determine moisture-holding capacity accurately.)

Ease of water and air movement. While moisture-holding capacity is important, too much water will crowd the air out of the soil. Without air, plant roots cannot grow, take up plant food, or even absorb water. Soil bac-

| Horizon | Texture | Thickness of horizon (inches) | | Inches of available water: Per inch of soil material | | In soil horizon |
|---|---|---|---|---|---|---|
| A ......... | Medium | 18 | X | .30 | = | 5.4 |
| B ......... | Moderately fine | 18 | X | .25 | = | 4.5 |
| C ......... | Coarse | 24 | X | .05 | = | 1.2 |
| Total ...... | -------------- | 60 | | --- | | 11.1 |

teria need air, too, to decompose organic matter. With air in the soil, the carbon dioxide produced by soil bacteria and by the respiration of plant roots can be diffused into the atmosphere.

If water moves freely through the profile, air can fill the empty pore spaces. When water moves too fast, however, the result is a drouthy soil. As shown in Fig. 1, the most desirable condition is one in which air and water are about equally divided in the pore spaces.

Soils are divided into six groups on the basis of permeability, or the ease with which water moves through the soil:

Very slow — less than 0.06 inch an hour

Slow — 0.06 to 0.2 inch an hour

Moderately slow — 0.2 to 0.6 inch an hour

Moderate — 0.6 to 2.0 inches an hour

Moderately rapid — 2.0 to 6.0 inches an hour

Rapid — more than 6.0 inches an hour

Water drains very slowly from the smaller pores; therefore, fine-textured soils have low permeability unless the structure of the surface and subsoil permits water to pass through freely. Coarse-textured soils have large pores through which water moves readily even though these soils usually have little structural development. Because of this, they have low water-holding capacity and are usually drouthy. Medium-textured soils, with good structure in surface and subsoil, are most desirable since they are fairly permeable and at the same time have good water-holding capacity.

It should be recognized that highly permeable soils are not necessarily well drained. For example, there are sandy soils of high permeability that have a high water table. Poor drainage has kept these soils from getting enough air. Because the B horizon has been water-logged, more or less permanently, these soils are dull gray.

Laboratory or field tests are also helpful in determining permeability, although it can be estimated by observing texture and structure as indicated in the preceding discussion.

Depth of soil favorable for root growth. If crops are to produce heavily, they must have a large root system so that they can obtain nutrients and water from a large volume of soil. Coarse sand and gravel discourage root growth because they hold little moisture or plant nutrients. Rock or other dense, compact layers also restrict the growth of roots.

The depth of soil is an indicator of the size of reservoir from which plants can obtain food and water. Usually a 1-foot layer of a medium-textured soil will hold 2.5 to 3.5 inches of water that is available to plants. A crop of corn during July and August will use about 1 inch of water each week.

For convenience, soils can be classified as follows on the basis of the depth suitable for root development:

Deep — 36 inches or more of soil free from root restricting materials.

Moderately deep — 20-36 inches of soil above soil materials that would restrict root growth.

Shallow -- 10 - 20 inches (Figs. 19 and 20) of soil above soil materials that would restrict growth of roots.

Very shallow — less than 10 inches (Fig. 21) of soil above root restricting material.

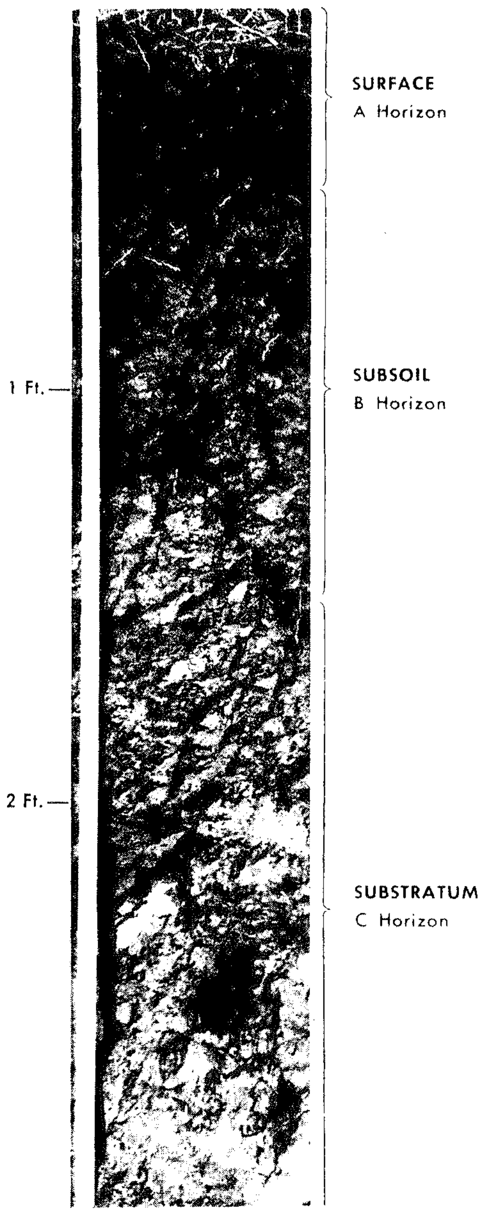



Fig. 19. Clarence silt loam has a shallow profile. The clay substratum limits root penetration. Clarence soils need to be managed carefully to prevent loss of the topsoil by erosion.

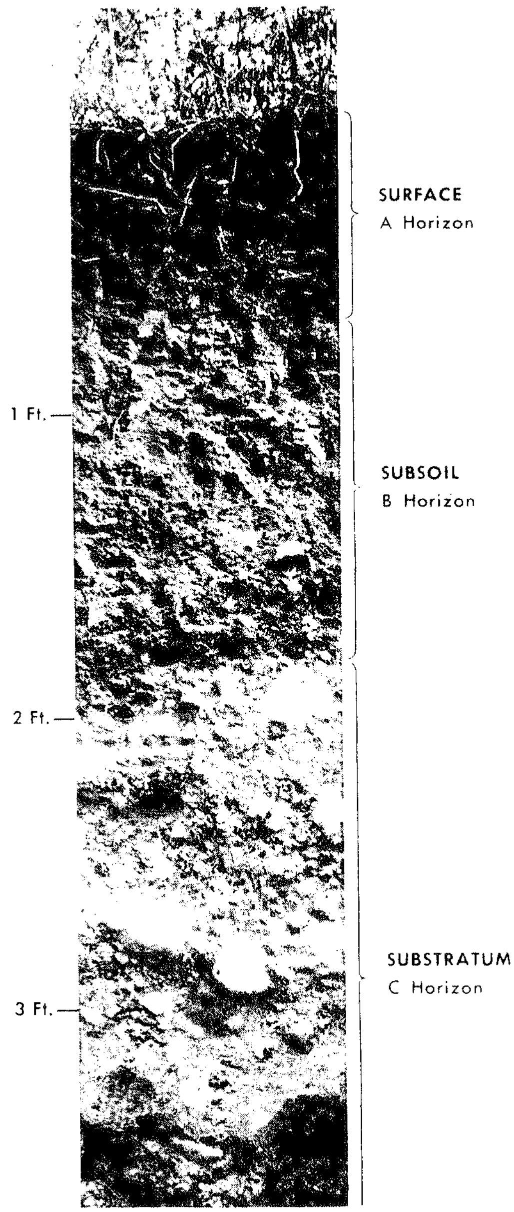



Fig. 20. Lorenzo silt loam is also a shallow soil. It has a coarse, gravelly substratum within 24 inches of the surface. The soil water and the plant-life supplies are largely limited to the medium-textured upper layer.

## Associated land features

After studying the characteristics which are inherent in a soil, you need to consider land features which would affect its use and management. Two areas of the same soil type, for example, might call for quite different levels of management because one area had been severely eroded while the other had suffered only moderate erosion. Slope of the land is also important in determining management practices. While slope and erosion are the only two features discussed in this section, other features, such as stoniness and flooding, also need to be considered.

Slope or topography. Slope of the land influences the speed with which water runs off a field and the amount of soil that washes off with the water. Slope also affects the amount of water that enters and drains through a soil, the ease of cultivation, and the use of farm machinery.

Usually slope is expressed in percent or feet of fall in each 100 feet of horizontal dis-

Fig. 21. This soil is extremely shallow, with the bedrock outcropping in many places. It has no use as cropland and very little as pasture.

tance (Fig. 22). An engineer's level, Abney level, simple hand level, or a carpenter's level equipped with simple sights can be used to measure slope in the field.

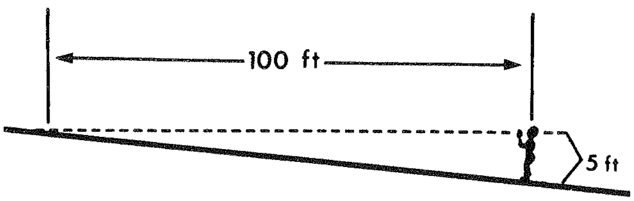



Fig. 22. A slope that has 5 feet of fall or drop in each 100 feet of horizontal distance is known as a 5-percent slope.

Percent, length, and uniformity of slope must all be considered when deciding on the best land use. It is important to remember that the rate of soil loss increases faster than the percent of slope. If the slope percent is doubled, for example, the rate of soil loss is increased 2 1/2 times. Also, long slopes suffer more erosion than short ones. Doubling the length of slope increases soil loss 1 1/2 times. If slopes are uniform, contouring and strip cropping can be used to slow down the water, and terraces will break long slopes into a series of shorter ones. On irregular slopes, however, it is difficult or impossible to use these measures. Conservation tillage systems such as chisel- and zero-tillage systems are very effective in controlling erosion.

Illinois soils have been classified into the slope groups shown in Table 3.

Degree of erosion. The topsoil is the most valuable part of the soil profile since it contains more plant food nutrients and organic matter and can often absorb more moisture than the other layers. To know your soil, it is important then, that you know how much topsoil remains and estimate the rate of erosion.

The seriousness of soil loss depends to a large extent on the nature of the soil. Losses from deep soils are relatively less important than those from shallow soils. Less damage is done too where the subsoil is of medium texture and permits free movement of air and water. The loss of surface soil is most serious where the subsoil or substratum is composed of such materials as plastic clay, loose sand or gravel, or rock.

As a rule, the surface soil can absorb water much faster than the subsoil. As the surface layer becomes thinner, less water soaks into the soil and more runs off the surface. This increases the rate of soil loss.

The principal loss of soil is usually by sheet erosion — that is each erosive rain will remove a thin layer of surface soil as the rain water runs off (Fig. 23). If the water is

Table 3. Slope Group Classification of Illinois Soil

| Letter designation | Slope group description | Percent slope | Percent of Illinois in slope group |
|---|---|---|---|
| A | Nearly level | 0-2 | 50.3 |
| B | Gently sloping | 2-5 | 22.5 |
| C | Moderately sloping | 5-10 | 10.3 |
| D | Strongly sloping | 10-15 | 7.0 |
| E | Moderately steep | 15-20 | 4.0 |
| F | Steep | 20-30 | 4.1 |
| G | Very steep | Over 30 | 1.8 |

Fig. 23. The above soil has been moderately eroded. Sheet erosion may occur on soils almost without notice.

concentrated in a small stream, a rill or miniature gully may develop (Fig. 24). If rill erosion continues long enough, deep rills or gullies may develop (Fig. 25). The gullies interfere with farming operations. Severe sheet, rill, or gully erosion mean higher production costs and often result in soil destruction.

How much erosion has occurred can be estimated by measuring the depth to the sub-

Fig. 24. Rill erosion or miniature gullies may develop on unprotected lands following sheet erosion.

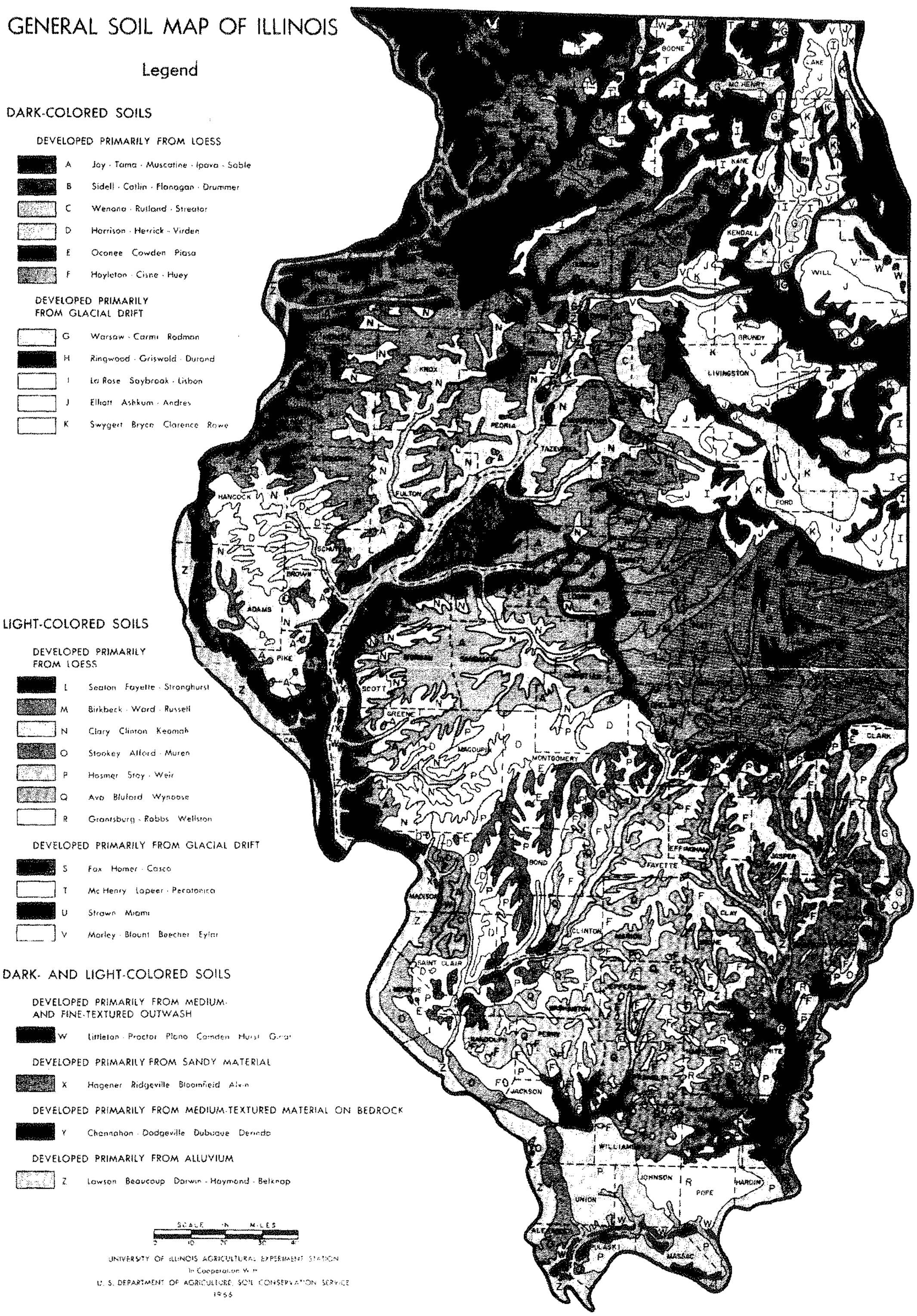
soil and comparing it to uneroded areas. Usually the difference between the topsoil (surface and subsurface) and the subsoil is quite noticeable. Ordinarily the subsoil is finer-textured, more plastic, and lighter in color than the topsoil. Except on sands the structure will also frequently change from a granular to a blocky or subangular blocky type.

Fig. 25. Soils on unprotected slopes may be severely eroded. In this example, gullies are beginning to form.

Erosion, or topsoil thickness, classes are designated as follows:

| | |
|---|---|
| none to slight | more than 9" of topsoil |
| moderate to severe | 3" to 9" of topsoil |
| severe | less than 3" of topsoil |

On soils that have been flooded, the original soil may be buried by a new soil. This is called deposition. The new soil material differs from the buried soil in color and texture. Deposits less than 8" thick become mixed with the old soil with tillage. Deposits more than 20" thick mask the influence of the buried soil.


GENERAL SOIL MAP OF ILLINOIS
Legend
DARK-COLORED SOILS
DEVELOPED PRIMARILY FROM LOESS
A Joy · Tama · Muscatine · Ipava · Sable
B Sidell · Catlin · Flanagan · Drummer
C Wenona · Rutland · Streator
D Harrison · Herrick · Virden
E Oconee Cowden Piasa
F Hoyleton · Cisne · Huey
DEVELOPED PRIMARILY FROM GLACIAL DRIFT
G Warsaw · Carmi Rodman
H Ringwood · Griswold · Durand
I La Rose Saybrook · Lisbon
J Elliott Ashkum · Andres
K Swygert Bryce Clarence Rowe
LIGHT-COLORED SOILS
DEVELOPED PRIMARILY FROM LOESS
L Seaton Fayette · Stronghurst
M Birkbeck · Ward · Russell
N Clary Clinton Keomah
O Stookey Alford · Muren
P Hosmer Stoy · Weir
Q Ava Bluford Wynoose
R Grantsburg · Robbs Wellston
DEVELOPED PRIMARILY FROM GLACIAL DRIFT
S Fox Homer · Casco
T Mc Henry Lapeer · Peratonica
U Strawn Miami
V Morley · Blount Beecher Eylar
DARK- AND LIGHT-COLORED SOILS
DEVELOPED PRIMARILY FROM MEDIUM- AND FINE-TEXTURED OUTWASH
W Littleton · Proctor Plano Camden Hurst
DEVELOPED PRIMARILY FROM SANDY MATERIAL
X Hagener Ridgeville Bloomfield
DEVELOPED PRIMARILY FROM MEDIUM-TEXTURED MATERIAL ON BEDROCK
Y Channahon · Dodgeville Dubuque
DEVELOPED PRIMARILY FROM ALLUVIUM
Z Lawson Beaucoup Darwin · Haymond · Belknap
SCALE IN MILES
0 10 20 30 40
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ADAMS
PIKE
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GREENE
MONTGOMERY
BOND
FAYETTE
CLARK
CLAY
MADISON
CLINTON
SAINT CLAIR
JACKSON
JOHNSON
POPE
UNION
PULASKI

This subject-matter unit was prepared by W. R. Oschwald and R. L. Courson and was revised by David T. Nolan. This unit was adapted from materials prepared in Illinois Circular 758, Understanding Soils and Illinois Bulletin 725, Soils of Illinois.

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