Lesson 4: Soil Texture

Soil texture is a way to describe the particle sizes of the minerals present in the soil. It has an effect on the passage of air, water, and roots through the soil. Sandy materials usually cause little restriction of air, water, and root movement through the soil, whereas clayey materials often reduce movement. Every particle makes its contribution to the nature of the soil as a whole. A good blend of soil particle sizes makes the most ideal soil.

What Is Soil Texture?

Most soils are made up of a combination of sand, silt, and clay. **Soil texture** refers to the percentage by weight of sand, silt, and clay in a soil. Depending on how much sand, silt, and clay are present, the soils are given names like sandy loam, clay loam, or silty clay loam. Soils that also contain gravel or cobble may have names like gravelly loam or very cobbly clay.

Texture is an important soil property because it is closely related to many aspects of soil behavior. The ease of tilling and plant root development within the soil are both influenced by soil texture. Texture affects the amount of air and water a soil will hold and the rate of water movement through the soil.

Plant nutrient supplies are also related to soil texture. Tiny silt and clay particles provide more mineral nutrients to plants than large sand grains. Sandy soils require a high level of management to improve their productivity; they require more fertilizer and more frequent irrigation or rain than silty soils.

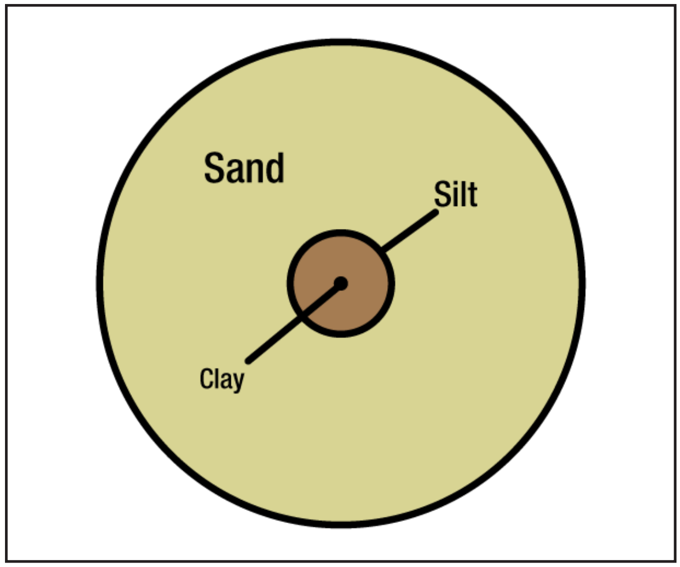
Particle Size in Soils

The determination of soil texture begins by separating the fine earth from the rock fragments.

Fine Earth

Fine earth includes all particles smaller than 2 mm in diameter. This is the soil fraction that passes through a number 10 sieve. Sand, salt, and clay are all smaller than 2 mm and are the components of fine earth. Sand, silt, and clay are called the **separates** of the fine earth. Figure 4.1 shows the relative sizes of sand, silt, and clay.

Figure 4.1 – Relative Sizes of Sand, Silt, and Clay



Sand particles range in size from .05 mm to 2 mm. They generally are spherical (rounded) and large enough to be seen without magnification. They feel gritty.

Silt particles range in size from .002 mm to .05 mm. They cannot be seen without a hand lens or microscope. Silt has a smooth feel, like flour or corn starch. It is not sticky.

Clay particles are less than .002 mm in size. They are usually flat, or plate-shaped, and can be seen only with high-powered microscopes. Clay feels sticky and can be molded into ribbons or wires.

Classes of Soil Texture

Every soil contains a mixture of sand, silt, and clay. A textural triangle is used to show all the possible combinations. The triangle is also used to form groups of soil textures, which can then be identified with a textural name. See Figure 4.2.

Any soil textural name will have a specific range of sand, silt, and clay. For example, a soil that is nearly all sand would lie close to the sand corner of the triangle. Its textural class name would simply be sand. A soil dominated by clay would be near the clay corner of the triangle. It would simply be named clay.

Now consider a balanced mixture of sand, silt, and clay. All three separates are present, though not in exactly equal proportions (Actually, it takes less clay to balance the mixture than either sand or silt). These soils lie near the center of the triangle and are called **loams**.

If more sand is added to a balanced mixture of sand, silt, and clay, the sand would begin to dominate. The mixture would move away from the center of the triangle toward the sand corner. The texture would change from loam to sandy loam, and ultimately to a sand.

If clay is added to a loam, first the texture would change to a clay loam, then to a clay. If both silt and clay are added, the texture would move away from sand toward something intermediate between silt and clay. The texture becomes a silty clay loam.

Precise boundaries between textural classes are shown in Figure 4.3. Each side of the triangle is a base line, or zero point, for the separate in the opposite corner. A scale runs from zero percent at the middle of each base line up to 100 percent at the corner. If the amount of sand, silt, and clay is known, the location on the triangle can easily be plotted and the textural class can be identified.

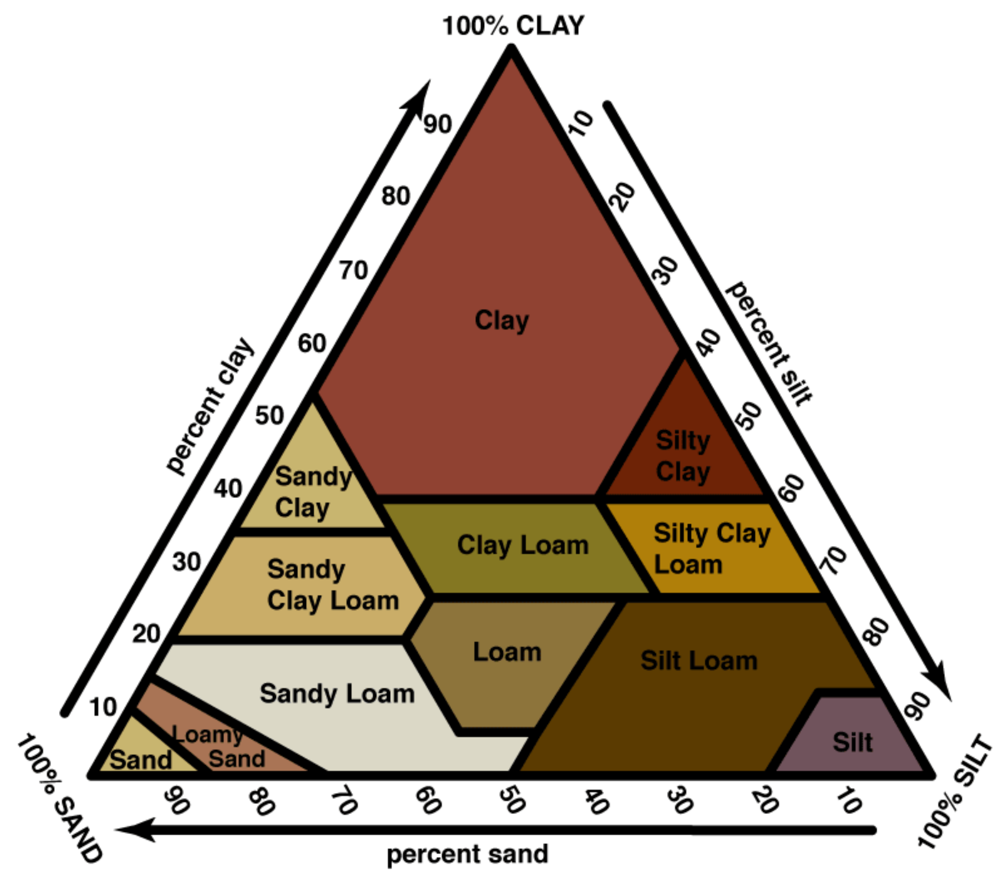
Determining Soil Texture

Soil texture can be determined from the results of a laboratory analysis or from a field estimate. Both methods are as follows.

Laboratory Analysis

Suppose the laboratory analysis shows that a soil contains 40 percent sand, 45 percent silt, and 15 percent clay. For this example, start with the clay content (although one could start with either silt or sand). Go to the midpoint

Figure 4.2 – USDA Soil Textural Classes



of the baseline running from sand to silt. Then go up to the horizontal line at 15 percent. Every soil along this line contains 15 percent clay.

Next, go to the midpoint of the baseline running from silt to clay. This line represents zero percent sand. Move along the sand scale, down and to the left, until the 40 percent line is reached. Then move down the 40 percent sand line until it intersects the 15 percent clay line. Mark that point. One can find the 45 percent silt line and track it to the same point. This sample is a loam. Note, however, that it only takes two points to determine the texture.

Field Estimate

Actually, one needs to learn only four key points on the textural triangle: 27 percent clay, 40 percent clay, 20 percent sand, and 45 percent sand. See Table 4.1. These points do not exactly match the textural class boundaries in Figure 4.3, but they are close enough to make good estimates.

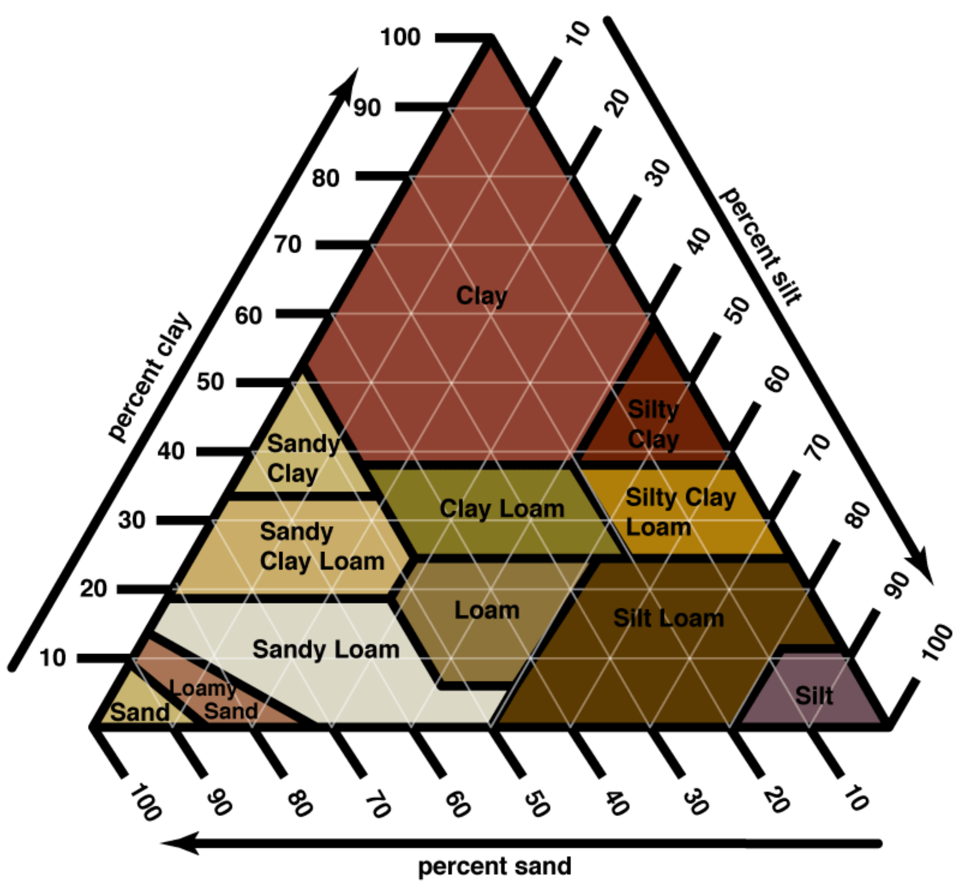
Table 4.1 – Four Key Textural Points

45 percent sand	27 percent clay
20 percent sand	40 percent clay

Study the locations of these key values in Figure 4.3 very carefully. Note that none of the texture names below 27 percent clay contain the word "clay." Texture names between 27 and 40 percent clay contain both the words "clay" and "loam." Texture names above 40 percent clay contain on the word "clay" unless it contains very little sand on one side or very little silt on the other side. Texture names above 60 percent clay contain only the word "clay."

Similarly, clayey soils having more than 45 percent sand all have names that include the words "sand" or "sandy."

Figure 4.3 – Percentages of Clay, Silt, and Sand in the Basic USDA Soil Textural Classes



If there is less than 20 percent sand, then "silt" or "silty" is usually part of the name. If the soil contains between 20 and 45 percent sand, "sand" is not part of the name. There is one exception between sandy loam and loam, which is 52 percent.

Additional clues to the way each kind of soil texture feels are given in Figure 4.4. The effect of these different textures on permeability, available water capacity, and erosion hazard will become clearer when specific interpretations of soil behavior are discussed.

Field estimates are determined by working the soil between the thumb and fingers and estimating the amounts of sand, clay, and silt. First, estimate the amount of sand by the grittiness. Next, estimate the amount of clay by the length of the ribbon formed. The rest of the content is silt. For example, if the amount of grittiness indicates sand content of less than 20 percent, the amount of ribbon formed indicates clay content greater than 40 percent, the rest of the content is silt (perhaps 35–40 percent). A step-by-step procedure for estimating the soil texture by feel is given in Figure 4.5.

Figure 4.4 – Clues to the Feel of Textural Classes

SAND
◊ Moist sample collapses after squeezing.
◊ Your hands don't get dirty working the sample.

LOAMY SAND
◊ Sample has very little body.
◊ Moist soil barely stays together after squeezing.
◊ Just enough silt and clay to dirty your hands.

SANDY LOAM
◊ Sand dominates noticeably.
◊ Enough silt and clay to give the sample body.
◊ Moist soil stays together after squeezing.
◊ Hardly forms any ribbon at all.

SANDY CLAY LOAM
◊ Feels gritty and sticky.
◊ Forms ribbon 1–2 inches (2.5–5 cm) long.

SANDY CLAY
◊ Feels definitely sandy.
◊ Forms ribbon 2–3 inches (5–7.5 cm) long.

LOAM
◊ Sand noticeably present, but doesn't dominate.
◊ Sample works easily between thumb and fingers.
◊ Contains enough silt and clay to give sample good body.
◊ Sample only forms short, broken ribbons.

SILT LOAM
◊ Feels smooth, like flour or corn starch.
◊ Tends to be nonsticky.
◊ Only forms short, broken ribbons.

CLAY LOAM
◊ Noticeably gritty, but sand doesn't dominate.
◊ Noticeably sticky.
◊ Noticeably hard to work between thumb and fingers.
◊ Forms ribbon 1–2.5 inches (2.5–6 cm long).

SILTY CLAY LOAM
◊ Feels smooth and sticky.
◊ Contains very little sand.
◊ Forms ribbon 1–2.5 inches (2.5–6 cm) long.

CLAY AND SILY CLAY
◊ Dry sample absorbs a lot of water before it is moist enough to work.
◊ Sample very hard to work between thumb and finger.
◊ Forms ribbon 2.5–4 inches (6–10 cm) long.

Figure 4.5 – Estimating Texture by Feel

1. Fill the palm of your hand with dry soil.
2. Moisten the soil enough so that it sticks together and can be worked with the fingers. Do not saturate it to runny mud. If the soil sticks to your fingers, it is too wet to texture. Add more dry soil.
3. Knead the soil between your thumb and fingers. Take out the pebbles, and crush all the soil aggregates. You may need to add a little more water.
4 Continue working the soil until you crush all the aggregates.
5. Estimate the **sand** content by the amount of textural grittiness you feel. Use the following chart on estimating sand content.
   a. More than 45% sand. Sand dominates. The textural name contains the word *sand* or *sandy.* See photo A.
   b. 20–45% sand. Sand is noticeably present, but not dominant. The texture is most likely *loam* or *clay loam*, though *silt loam* or *clay* are possible. See photo B.
   c. Less than 20% sand. Silt and clay dominate. The textural name is *silt loam, silty clay loam*, or *clay.*
6. Estimate the **clay** content by the size of the soil ribbon formed by pushing the sample up between your thumb and index finger.
   a. Clay is less than 27%. A ribbon is not present or it is less than 1 inch (2.5 cm) long. Textural names contain the word *loam* but not the word *clay.* See photo B.
   b. Clay is 27–40%. The ribbon is 1–2.5 inches (2.5–6 cm) long. Textural names contain both the words *clay* and *loam*.
   c. Clay is more than 40%. Clay dominates. The ribbon is more than 2.5 inches (6 cm) long. Textural name contains the word *clay* but not the word *loam.* See photo C.
7. Combine your estimates of sand and clay.

These are general and will not fit every possibility on the textural triangle. An alternate way of estimating soil texture is given in the flowchart in Figure 4.6.

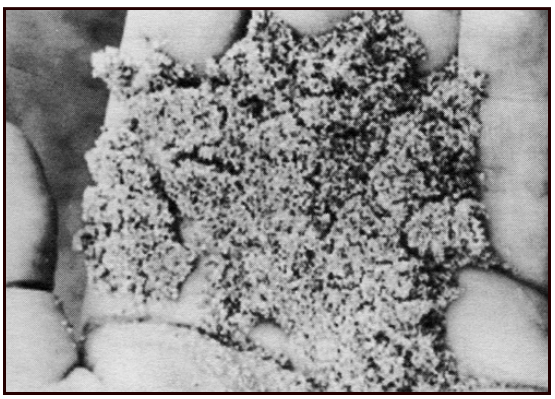


Photo A *– Sand texture: Individual sand grains are evident and little or no fine soil particles are present in this moist sand sample.*

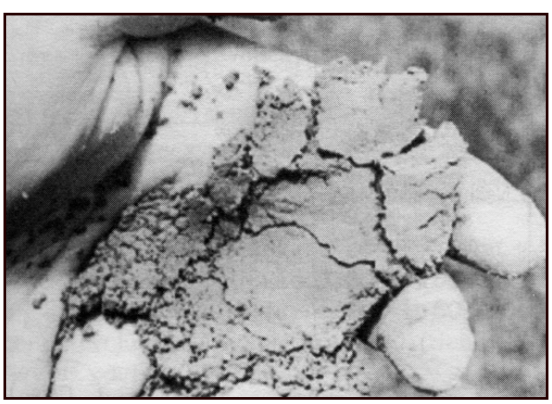
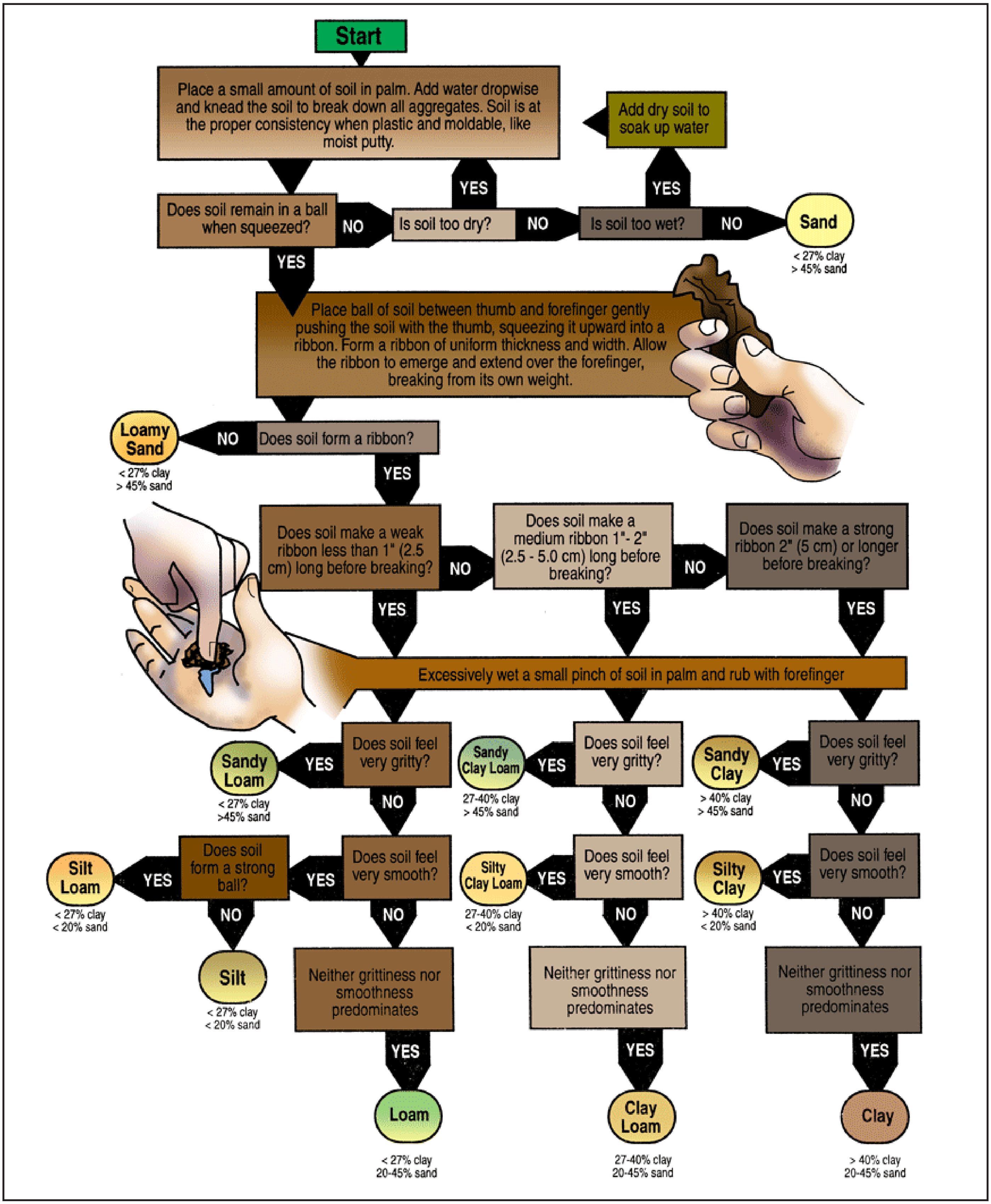


Photo B *– Loam texture: This moist loam soil clings together well but small cracks, a rough surface, and shiny, fine sand grains are evident when pressed between the fingers.*

Photo C *– Clay texture: A firm ribbon of soil with a slick, shiny surface is clearly evident when pressed between the fingers.*

		SAND		
		>45%	20-45%	<20%
CLAY	>40%	Sandy clay	Clay	Silty clay Clay
	27-40%	Sandy clay loam	Clay loam	Silty clay loam
	<27%	Sandy loam Loamy sand Sand	Loam	Silt loam

Figure 4.6 – Flowchart for Estimating Textural Classes

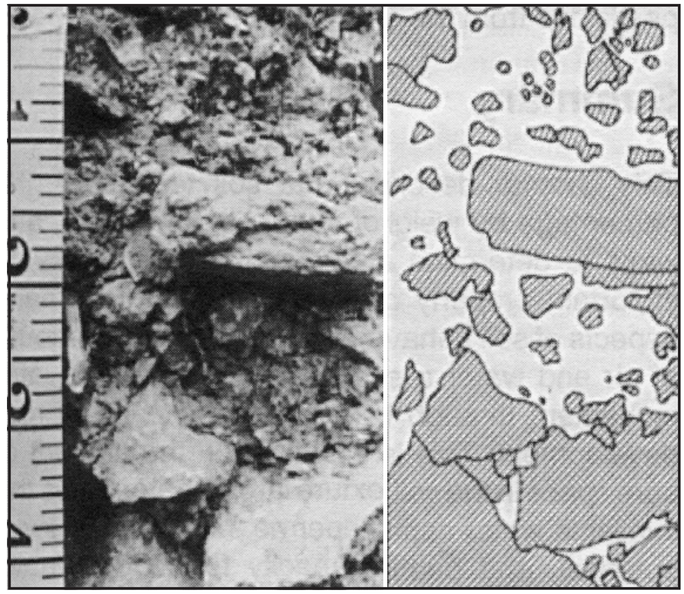


Flowchart courtesy of Dr. Steve J. Thien.

Rock Fragments

Rock fragments include all fragments larger than 2 mm including boulders. Rounded rock fragments 2 mm to 25 cm (10 inches) are called gravel and cobbles. Flat rock fragments 2 mm to 37.5 cm (15 inches) long are called channers and flagstones. In USDA engineering guides, gravel, cobbles, channers, and flagstones are used differently in some soil interpretations than those which are more than 10 inches (25 cm) in size (rounded) or more than 15 inches (38 cm) in size (flat). Rounded rock fragments larger than 10 inches (25 cm) and flat rock fragments larger than 15 inches (38 cm) are called **stones** and **boulders**. They are described as characteristic of the site and are discussed in Lesson 11. The quantity of rock fragments in the soil greatly affects the available water capacity and ease of tillage. It should be noted that the term "coarse fragment" is not in common use in the most recent literature.

Figure 4.7 – Fifty Percent Rock Fragments



A section of rocky silt loam surface soil. The adjacent diagram outlines exposed rock fragments in a vertical cut.

Rock Fragments Used to Modify Texture

Soil textural names based on the fine earth must be modified if the soil contains a significant amount of gravel or cobbles. The two most common kinds of rock fragments in Missouri soils are gravel and cobbles. **Gravel** refers to rounded rock fragments with diameters between 2 mm and 3 inches (7.5 cm). **Cobbles** are rounded or partly rounded, with diameters of 3–10 inches (7.5–25 cm). See Plate 16, p. 50-D. Rock fragments that are more nearly flat than rounded are measured differently than gravel or cobbles and are called channers or flagstones, depending on their size. A **channer** is 2 mm to 6 inches (15 cm) in length. **Flagstones** range from 6 to 15 inches (15–38 cm) in length.

Rock fragment names depend on the volume of the soil mass occupied by the fragments. See Figure 4.7.

One can estimate the volume by looking at the vertical surface exposed in a soil profile. If 50 percent of the surface consists of fragments, then 50 percent of the soil volume is fragments as well. See Plates 9, 17, and 18, pp. 50-C and 50-E.

Once both the percentage by volume and the dominant size of fragments are known, the correct modifier can be found in the key in Table 4.2. If a soil contains both gravel and cobbles, at least 60 percent of the fragments must be gravel to use the gravelly term. If more than 40 percent of the fragments are cobbles, use the cobbly term. The same calculations are made if the rock fragments are channers or flagstones.

Pore Space (Soil Porosity)

The soil is made up of solids (for example, soil particles such as sand, silt, and clay) and pore space. Texture is the distribution of sand, silt, and clay particles. **Pore space** is the space between the soil particles. One might think of pore space as just open space, but that really is not true. Pore space contains air and/or water. See Figure 4.8.

The A horizon (surface soil) contains approximately the same amounts of solids and pore space. The B and C horizons (lower layers) usually contain somewhat less than one-half pore space because of the finer soil

Table 4.2 – Key to Naming Rock Fragment Modifiers

PERCENT BY VOLUME	GRAVEL (2 mm–3 inches, 7.5 cm) CHANNER (2 mm–6 inches, 15 cm)	COBBLE (3–10 inches, 7.5–15 cm) FLAGSTONE (6–15 inches, 15–38 cm)
<15	No modifier	No modifier
15–35	Gravelly/channery	Cobbly/flaggy
35–60	Very gravelly/very channery	Very cobbly/very flaggy
>60	Extremely gravelly/extremely channery	Extremely cobbly/extremely flaggy

Figure 4.8 – Pore Space Filled With Water or Air

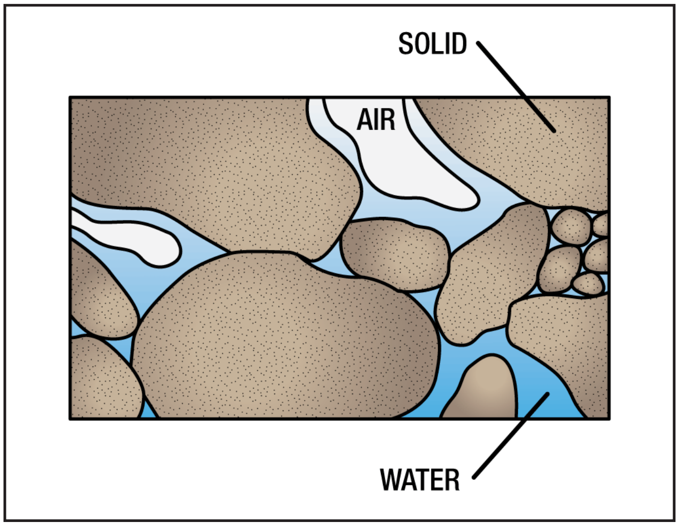
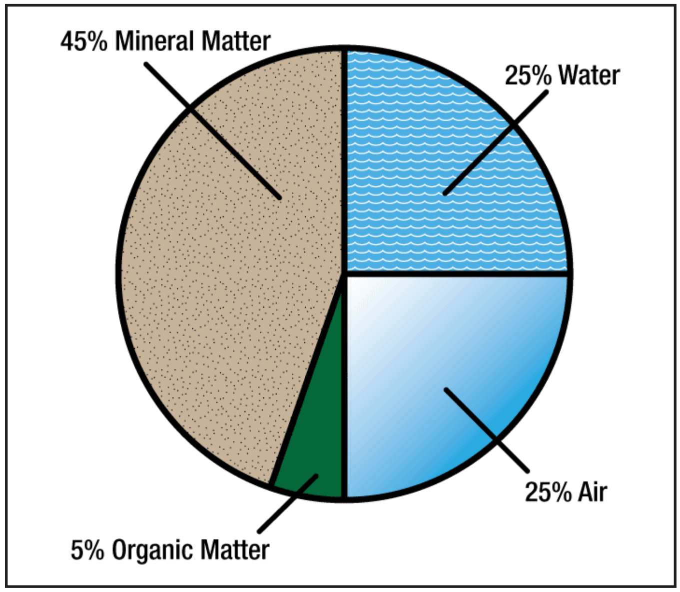


Figure 4.9 – Relative Volumes of Solids, Air, and Water in a Typical A Horizon



particles. This relationship depends on the size of the soil particles and the soil structure. The pore space in clayey soils is so small that it is always filled with a very thin film of water that is unavailable to plant roots. Also, the pore space available for air is too little for adequate soil aeration. A mixture of large and small pores is the most desirable in the soil. Pore space often is referred to as **soil porosity**. The relative amounts of solids, air, and water in the soil are very important for good plant growth. See Figure 4.9.

Also important to soil porosity is a good mix of the soil separates (sand, silt, and clay). A sandy soil has mostly large pore spaces but cannot hold the water as it passes on through the profile; therefore, the soil is droughty (very low water capacity). Clayey soil has many tiny pore spaces that are completely filled with a thin film of hygroscopic water that will not allow good aeration or infiltration of water through the profile. Soils that have a good balance of particle sizes will have the best balance of pore space size, and thus will have the best soil properties for maximum plant growth. See Lesson 10 for more information.

Excessive tillage will cause compaction and reduce pore space. Minimum tillage will leave more plant residue and allow for an increase in root growth, organic-matter content, and better aeration. Without adequate pore space, the soil would not be a good place for roots to grow.

Factors Affected by Soil Texture

When soil is wet, it can swell, and when it dries, it can shrink. This phenomenon is called **shrink-swell**. Soil texture affects the shrink-swell potential of the soil, which in turn affects how buildings and highways are designed to prevent damage from cracking. See Plate 19, p. 50-E.

Soil texture in relation to the content of rock fragments greatly affects the bearing capacity of the soil for roads, heavy buildings, and earthen dams. Soil texture affects the functioning of septic tank filter fields and sewage lagoons. It affects the available water capacity, tillage of crops, and the leaching of pesticides from the soil.

Summary

This chapter describes what soil texture is (the percentage by weight of sand, silt, and clay), and ways to determine soil texture. Texture is a very important property of soil, and is related to many aspects of soil behavior. Texture affects the amount of air and water a soil will hold, the rate of water movement through the soil, and the ease of root development. This is dependent on the amount of pore space in the soil. Texture largely determines the available water capacity, permeability, shrink-swell potential, and bearing capacity for roads, heavy buildings, and dams.

Soil texture can be determined by laboratory analysis or by an estimate in the field by working the soil between the thumb and fingers. Textural class names are determined using a textural triangle. Soil textural names based on the fine earth must be modified if the soil contains a significant amount of rock fragments.

Credits

Huddleston, J. Herbert, and Gerald F. Kling. *Manual for Judging Oregon Soils,* Corvallis: Oregon State University Extension Service, 1984.

Soil Survey Division Staff. *Soil Survey Manual, Handbook #18,* rev. Washington, DC: U.S. Government Printing Office, U.S. Department of Agriculture, Soil Conservation Service, 1993.

Soil Survey Division Staff, Lincoln, Nebraska. *National Soils Survey Handbook* (Title 430-VI). Washington, DC: U.S. Department of Agriculture, Soil Conservation Service, 1993.