SOILS AND LAND USE

Bedford County 7th & 8th Grade Envirothon

USDA Natural Resources Conservation Service

Bedford County Conservation District

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7th and 8th GRADE ENVIROTHON

SOIL AND LAND USE

Introduction to Soils

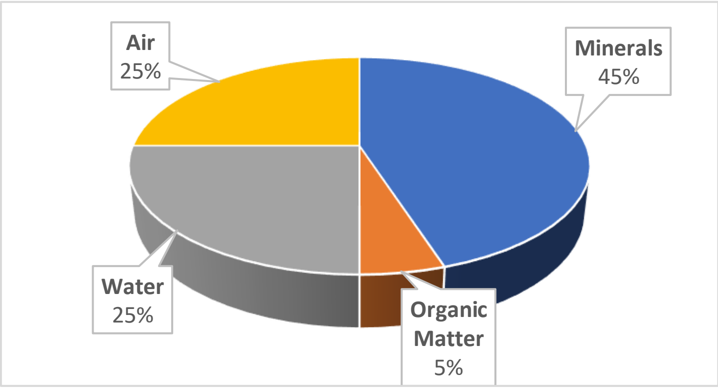
Soils: What Are They?

Soil. Earth. Dirt. No matter what we call it, it's the material that constitutes the outermost solid layer of the planet. We build on it. We raise food in it. We mine mineral resources from beneath it.

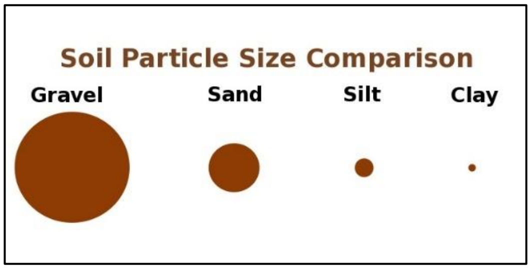
Apparently unchanging and lifeless, soils are dynamic mixtures, teeming with life. One teaspoon of soil in temperate regions can contain billions of organisms ranging from simple bacteria and fungi to more advanced forms. Earthworms, insects, and spiders are examples. Bedrock is continually fractured, dissolved, and changed into soil, but the process occurs slowly so we usually never notice.

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

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



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



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

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

(From "Conserving Soil," NRCS)

Soil Ecology: Plants and Animals Under Your Feet

Plants and animals have important roles to play in soil. Both plants and animals change the composition and structure of soil in many ways.

Plants with roots obtain nutrients and moisture from soil through their roots. The hard and durable root cap, located on the tip, protects the growing root. In the area immediately behind the root cap, cells are rapidly dividing to form new cells. This is called the region of cell division. Behind this area, cells elongate – grow longer. This is called the region of elongation. The combination of cell division and elongation creates great pressures that push the root through the soil. These pressures are often great enough to cause large boulders to fracture if a root grows into a crack.

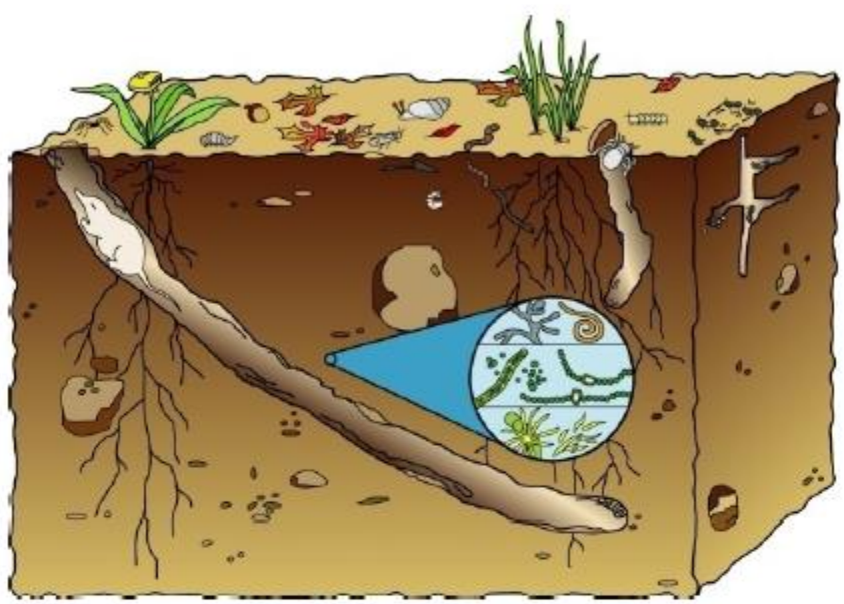
Roots get energy to grow from sugars that are made during photosynthesis – a process that occurs in the leaves. As the roots grow, they use oxygen from the surrounding pore spaces for respiration. The carbon dioxide given off reacts with soil water to form weak carbonic acid.

Roots absorb nutrients and water primarily through tiny projections called root hairs. This is called the region of absorption. Soil water places the root hairs in chemical contact with nutrients that are on the surface of clay and humus particles. The weak carbonic acid clinging to the root hairs provides hydrogen ions to the soil water. The hydrogen ions then exchange with chemical nutrients from the surfaces of soil particles. These nutrients, including ions of magnesium, calcium, sodium, potassium, phosphorus, and nitrogen, are absorbed by root hairs. The chemical ion exchange, called nutrient exchange, occurs continuously around the roots.

Although plants are the most visible large organisms, many animals also inhabit soils. Earthworms are perhaps the best known of this group. Scientists estimate that between 200 and 1000 pounds of earthworms can be found in an acre of soil. Earthworms eat organic matter and any other soil particles that get mixed in. They digest the organic matter and pass nutrient-enriched soil through their bodies. This recycles nutrients and makes soil richer. In addition, their tunnels allow air and water to penetrate the soil more rapidly. In short, earthworms, like many other organisms, are vital to soils. They keep them rich and productive.

The Soil Ecosystem

The soil ecosystem is a group of interrelated **biotic** (living) factors interacting with **abiotic** (non-living) factors. These components are related so that a change in any one factor results in changes in all the other factors.



The biotic component is composed of living plants and animals represented by soil flora and fauna (bacteria, fungi, springtails, nematodes, earthworms, and arthropods, for example.) The abiotic (non-living) components are the physical and chemical properties of soil (for example: minerals and dead organic material, water, gases, pH, temperature, and nutrients).

Roles within the Ecosystem

The terms **producers, consumers,** and **decomposers** are generally used to describe the essential roles played by organisms in an ecosystem. Plants are **producers**. Animals are consumers and microbes are decomposers.

Consumers eat organic material and digest it internally.

Decomposers (microorganisms like fungi and bacteria) release enzymes that help decay and transform plant and animal material into smaller organic compounds that can be absorbed by the microbes through the consumption of **detritus** (debris). Bacteria and fungi are the two main kinds of decomposers and occur in enormous quantities in soil ecosystems.

What are soil functions?

Soil performs many critical functions in almost any ecosystem (whether a farm, forest, prairie, marsh, or suburban watershed). There are seven general roles that soils play:

- Soils serve as media for growth of all kinds of plants.
- Soils modify the atmosphere by emitting and absorbing gases (carbon dioxide, methane, water vapor, and the like) and dust.
- Soils provide habitat for animals that live in the soil (such as groundhogs and mice) to organisms (such as bacteria and fungi), that account for most of the living things on Earth.
- Soils absorb, hold, release, alter, and purify most of the water in terrestrial systems.
- Soils process recycled nutrients, including carbon, so that living things can use them over and over again.
- Soils serve as engineering media for construction of foundations, roadbeds, dams, and buildings, and preserve or destroy artifacts of human endeavors.
- Soils act as a living filter to clean water before it moves into an aquifer.

(From “Dig Deeper,” Soil Science Society of America)

How Is a Soil Formed?

There are thousands of different soils throughout the world. Weakly developed, moderately developed, and well developed soils are formed as a result of five important **soil-forming factors.**

Parent Material

Parent material is the earthy materials, both mineral and organic, from which soil is formed. Parent material can be a volcanic deposit such as ash that fell upon an area. Mineral material includes partially weathered rock, ash from volcanoes, sediments moved and deposited by wind and water, or ground-up rock deposited by glaciers. Weathered (broken down) bedrock can also be a parent material. Moderately and well-developed soils are made when a parent material is changed both chemically and physically over time.

The material has a strong effect on the type of soil developed as well as the rate at which development takes place. Soil development may take place quicker in materials that are more permeable to water. Dense, massive, clayey materials can be resistant to soil formation processes.

Minerals and rocks are important to soil because they are the most abundant materials that weather or break down to form soil.

Minerals

A mineral is a natural occurring inorganic (non-living) substance that has a definite internal structure and composition that results in definite physical and chemical properties. A rock is simply a complex mineral aggregate.

The mineral groups that are of prime importance in soil development are:

- Feldspars
- Amphiboles and pyroxenes
- Micas
- Silicas
- Iron oxides
- Carbonates

Rocks

Though minerals are the main component of rocks, most soils are formed from materials that originated in rocks rather than pure mineral deposits. Rocks are classified by placing them into one of three groups depending on how they were formed. The three groups are **igneous**, **sedimentary**, and **metamorphic**.

Igneous rocks are formed from the cooling of molten materials that have been pushed upward from deep within the earth. These materials fall into one of two categories depending upon where they cooled and became solid rock: extrusive and intrusive.

Extrusive igneous rocks are formed from magma (molten rock) that was forced out onto the surface of the earth as either lava or volcanic ash. Once exposed to the air, these molten materials cool rapidly and produce a rock with fine crystals. These crystals are often too small to see without the aid of magnification, giving the rock a nearly uniform color.

Intrusive igneous rocks are formed when molten materials are pushed part of the way to the surface of the earth. This molten material or *magma* often cools very slowly producing larger size crystals in the rock. These crystals are easily visible giving the rock a multicolored appearance. Granite is an example of intrusive rock.

Sedimentary rocks are formed when sediments and small rocks are cemented together, either chemically or by compression. Although these rocks comprise only five percent of the rock volume of the outer ten miles of the earth's crust, they cover 75 percent of the Earth's surface. The coloration of these rocks depends upon the color of the original sediments. Sandstone, shale, and limestone are examples of sedimentary rocks.

The deposition of sediments is called ***sedimentation***. The agents responsible for this process are wind, running water, and precipitation. For example, if a strong wind passes over a barren area it may pick up sand and soil particles. The wind will carry these particles as long as it maintains its velocity. However, as weather patterns change, the wind may dissipate. As the wind slows, it will drop the largest particles until it stops. If this wind pattern prevails for a long period of time, the deposits from it may become quite thick. As the deposits become thicker and are subjected to heat and pressure they may be cemented into sedimentary rocks.

Sedimentary deposits are also formed when running water transports materials. This works much the same way as wind, but water can move much larger particles than wind. During severe floods, water running at high velocities can move boulders short distances while small rocks and coarse gravel can be carried great distances. As the velocity of the water decreases, the larger particles are left behind. Therefore, sediments deposited by water are commonly sorted by size.

Whenever the sedimentary products of wind, water, and precipitation are cemented together, a sedimentary rock is formed. The composition of the rock formed will depend on the type of material that was transported.

Metamorphic rocks are igneous or sedimentary rocks that have been subjected to heat, and /or pressure to radically alter their characteristics. This process is called metamorphism and occurs deep in the earth's crust. Metamorphic rocks are transformed but are not melted into magma. The soils formed from metamorphic rocks are very similar to those formed from the original igneous and sedimentary rocks. Marble and slate are examples of metamorphic rocks.

Climate

The term ***climate*** refers to both temperature and rainfall over time. The effects of climate result in weathering. ***Weathering*** is the breakdown or disintegration of rock by physical, biological, and chemical processes, at or near the earth's surface. Temperature and water are major climatic forces that influence weathering.

Climate helps change parent material (C layer) into subsoil (B layer) and topsoil (A layer). Freezing and thawing as well as wetting and drying make parent materials break apart. Rainwater can dissolve some minerals and transport them deeper into soil.

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.

Physical weathering consists of natural forces physically breaking rocks into smaller pieces. Examples of these forces are temperature, wind, ice, water, and plant roots. Rapid temperature changes can cause expansion and cracking of rocks.

Climate through its influence on soil temperature, determines the rate of ***chemical weathering***. The rate of chemical weathering is influenced by water, oxygen, and the presence of acids resulting from biochemical activity. Warm, moist climates encourage rapid plant growth and thus high organic matter production. The opposite is true for cold, dry climates. Organic matter decomposition is also accelerated in warm, moist climates. Under the control of climate, freezing and thawing or wetting and drying break parent material apart.

Living Organisms

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

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

Organic matter is important in the soil because it:

- Improves soil structure or aggregation providing the right combination of air and water to plant roots
- Increases pore space making it easier for air and water to penetrate the soil
- Reduces the soil's erodibility
- Minimizes the leaching of nutrients
- Provides a suitable habitat for valuable soil organisms, like bacteria, fungi, and earthworms

The amount of soil organic matter is controlled by a balance between additions of plant and animal materials and losses by decomposition or erosion. Both additions and losses are very strongly controlled by a farmer's or landowner's soil management activities.

Topography or Landscape Position

Topography or 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 (position) 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

The length of time that a soil's parent materials have been exposed to the forces of mechanical and chemical weathering and the other soil forming factors will greatly influence the kinds of soils present today. A typical soil's age must be measured in thousands to tens of thousands of years. It takes about 500 hundred years for these soil-forming factors to form one inch of soil from parent material (bare rock).

Soils on older, stable surfaces generally have well-defined horizons because the rate of soil formation has exceeded the rate of geologic erosion or deposition. As soils age, many original minerals are destroyed. Many new ones are formed. Soil formation processes are continuous.

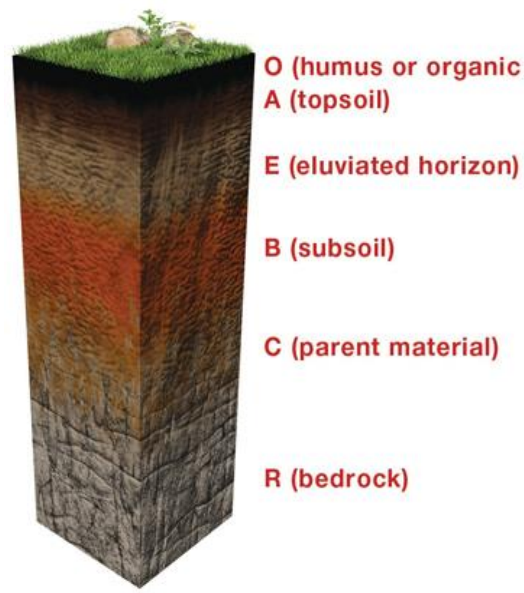
(Found in "From the Surface Down," NRCS)

What are soil horizons?

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

There are different types of soil, each with its own set of characteristics. Dig down deep into any soil, and you'll see that it is made of layers, or horizons (O, A, E, B, C, R). Put the horizons together, and they form a soil profile. Like a biography, each profile tells a story about the life of a soil. Most soils have three major horizons (A, B, C) and some have an organic horizon (O).

The horizons are:



O – (humus or organic) The uppermost layer generally is an organic horizon, or O horizon. It consists of fresh and decomposing plant residue from such sources as leaves, needles, twigs, moss, lichens, and other organic matter. The O horizon is thin in some soils, thick in others, and not present at all in others.

A - (topsoil) Mostly minerals from parent material with organic matter incorporated. It is generally darker than the lower horizons because of the varying amounts of humified organic matter. This horizon is where most root activity occurs and is usually the most productive layer of soil. A good material for plants and other organisms to live. This is generally the most productive layer of soil.

E – (eluviated) Generally is bleached or whitish in appearance. As water moves down through this horizon, soluble minerals and nutrients dissolve and some dissolved materials are washed (leached) out. Missing in some soils but often found in older soils and forest soils.

B – (subsoil) Subsoils are usually light colored, dense, and low in organic matter. The subsoil is a zone of accumulation since most of the materials leached from the topsoil accumulate here.

C – (parent material) This is a transition area between soil and parent material. Partially disintegrated parent material and mineral particles may be found in this horizon.

R – (bedrock) A mass of rock such as granite, basalt, quartzite, limestone, or sandstone that forms the parent material for some soils – if the bedrock is close enough to the surface to weather. Bedrock can be within a few inches of the surface or many feet below the surface. This is not soil and is located under the C horizon.

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

How Do Soils Differ?

Soils have both physical and chemical properties. When analyzing a soil's suitability for a specific use, soil scientists must first look at the properties or physical makeup of a given soil sample. There are tens of thousands of different types of soils on earth. There are many characteristics that differentiate one soil from another. For example, soil fertility, soil texture, soil color, and permeability are all used to describe different types of soil.

The important **physical** properties of soil include color, texture, structure, consistence, shrink-swell, compaction, soil depth, permeability, internal drainage, and available water capacity. Physical characteristics are the easiest to observe. By looking at a few physical characteristics several generalizations can be made about soil.

Two important physical properties are color and texture. The important **chemical** properties of soil include pH (aka reaction class, or acidity) and cation-exchange capacity (CEC), the total capacity of a soil to hold cations (positively charged ions).

Color

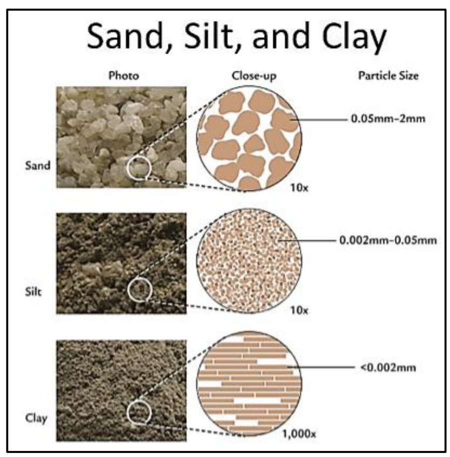
Soil color is a useful tool for providing information about other soil properties. The relative amounts of organic matter, the presences and abundance of certain elements and minerals, and the depth and duration of water tables can all be indicated by soil color.

There are three color categories of topsoil which relate to the amount of organic matter.

1. **Dark soils**. Dark soils are black, dark gray, or dark brown. Rich in organic content and usually very fertile, dark soils have a high degree of aeration (there is plenty of pore space for air). Since water soaks easily into these soils, they are slow to erode. They are excellent for gardening and agriculture.
2. **Moderately dark soils**. Colors range from brown to yellow brown in these soils. They have a medium fertility. They contain an average amount of aeration and are slightly erodible. With proper agriculture methods, moderately dark soils can be good for farming and gardening.
3. **Light colored soils**. Pale brown to yellow-colored soils are usually poorest for farms and gardens. They are low in organic matter, fertility, and aeration. Further, they are often highly erodible.

Texture

The United States Department of Agriculture (USDA) classifies soil particles in categories based on the size of the diameter of the particle. The categories are **sand** (0.05mm to 2mm), **silt** (0.002mm to 0.05mm), and **clay** (<0.002mm).



Particle Size

Soil is composed of three primary particle sizes. They are **sand**, **silt**, and **clay.**

Sand particles are the largest and can easily be seen. Sand feels gritty when rubbed between the fingers. Soils containing large amounts of sand cannot retain large amounts of water or nutrients.

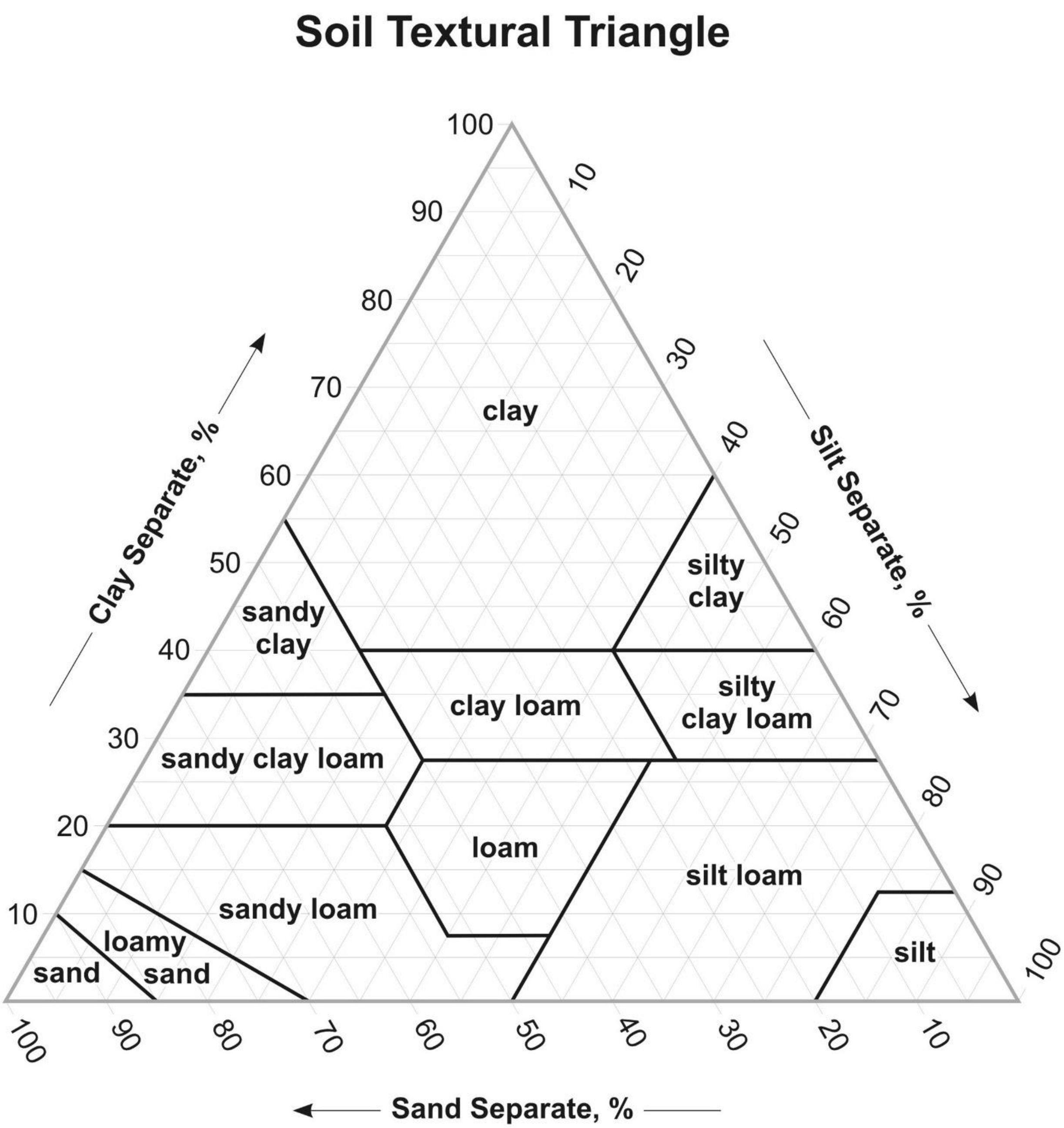
Silt is the medium sized particle and is so small that an individual particle is barely visible. Silt feels silky when wet and like flour when dry. Soils high in silt tend to be favorable for agriculture because they have high water holding capacities. However, they can present problems for engineers since they will shift under stress and slide and flow when wet.

Clay is the smallest sized particle and is microscopic. Clay feels sticky when wet and gives a soil its plasticity (the quality of being easily shaped or molded). A portion of the water that is held by clay is bound so tightly that most root systems cannot absorb it. Because young plant rootlets cannot readily penetrate clay, soil composed of very high amounts of clay is poorly suited for growing crops.

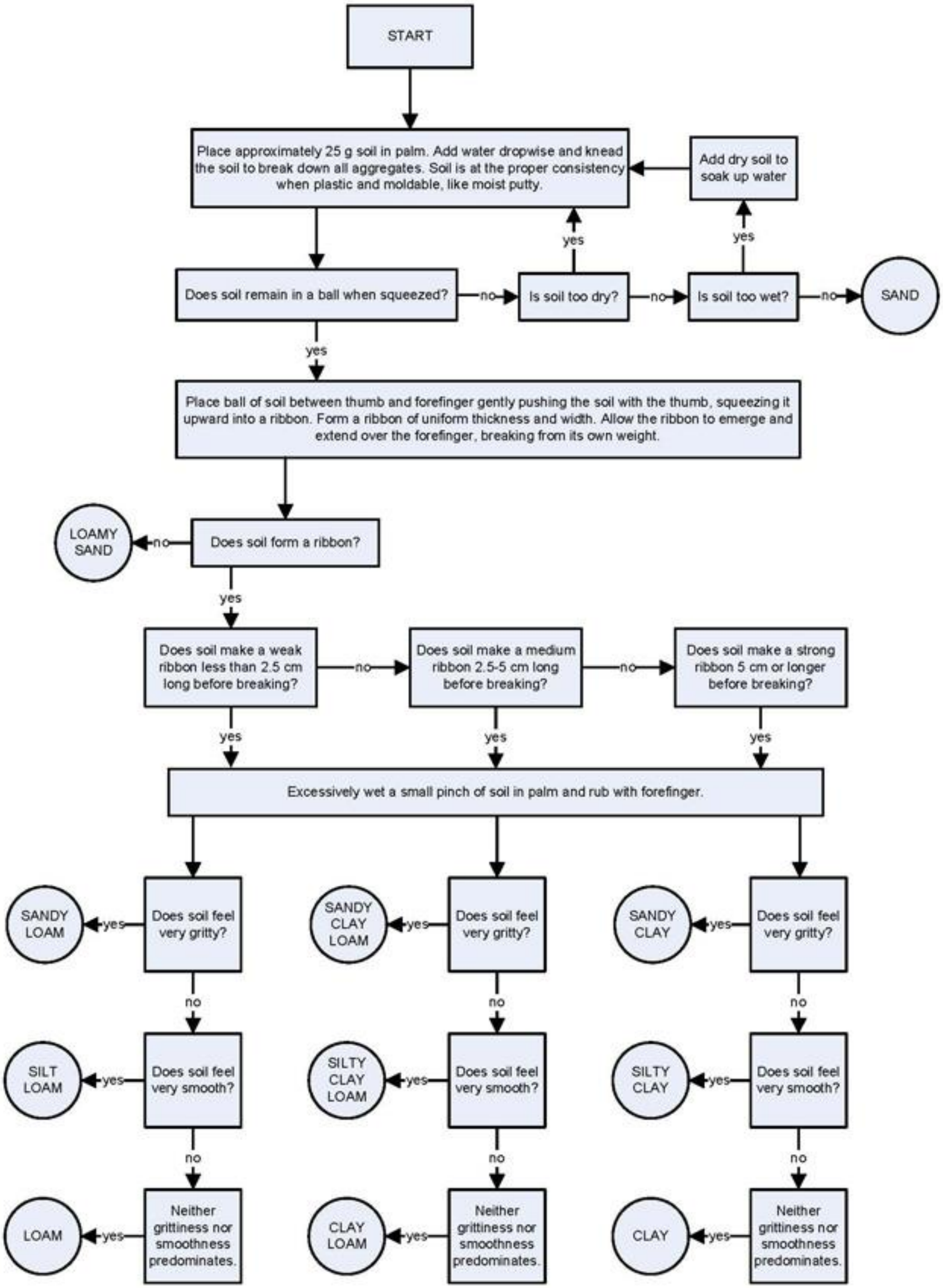
Texture Triangle

The texture triangle is a tool used by soil scientists to determine the named texture of a soil. To use the triangle, the percentage of sand, silt, and clay must be determined or estimated. Field soil scientists frequently estimate the texture by feel using their hands. (For more exact measurements, there are laboratory techniques that can determine the exact amount of sand, silt, and clay.

Soil Texture Triangle



Guide to Texture by Feel – from NRCS website



Soil Structure

Soil structure is defined as the naturally occurring arrangement or grouping of a soil's primary particles (sand, silt, and clay) into aggregates (clumps of soil bound together). These aggregates may have a variety of shapes: granular, blocky, prismatic, or platy. Soil scientists describe structure by type or shape (what it looks like), grade (how easy it is to see it), and size (how big it is).

The aeration (amount of air in the soil), moisture content, permeability, and erosion resistance of a sol is, to some degree, dependent on its structure. Liming and manuring often improve a soil's productivity by improving and stabilizing its structure.

Other factors affecting soil structure include alternate freezing and thawing, wetting and drying, plant root penetration, burrowing by animals like worms and insects, the addition of slimy secretions from animals (e.g., earthworms), and the bacterial decay of plant and animal remains.

Soil structure can be degraded by compaction from farm equipment and other vehicles as well as the impact of raindrops on unprotected soil.

Good (or strong) structure enhances crop production. Soil with good structure has an abundance of pores for water and air to move readily to plant root systems. Such soil allows water to infiltrate after a rainfall instead of carrying away sediments (eroding). Soil that has good structure is resistant to the erosive factors of wind and water. Soil structure can be improved by adding crop residues such as stubble or adopting no-till planting practices.

Poor (or weak) structure has a minimum of pore spaces for air and water because of closely packed soil aggregates. Individual soil aggregates tend to fall apart. Because water infiltration is greatly reduced in arid regions, irrigation water may not penetrate deeply enough to sustain crops. In areas of abundant rainfall, lack of pore spaces can cause drainage problems on low-lying sites and result in severe runoff and erosion in upland sites.

Types of soil structure

There are seven structural types commonly recognized in soil profiles: platy, prismatic, columnar, blocky, granular, lenticular, wedge, single grain, and massive.

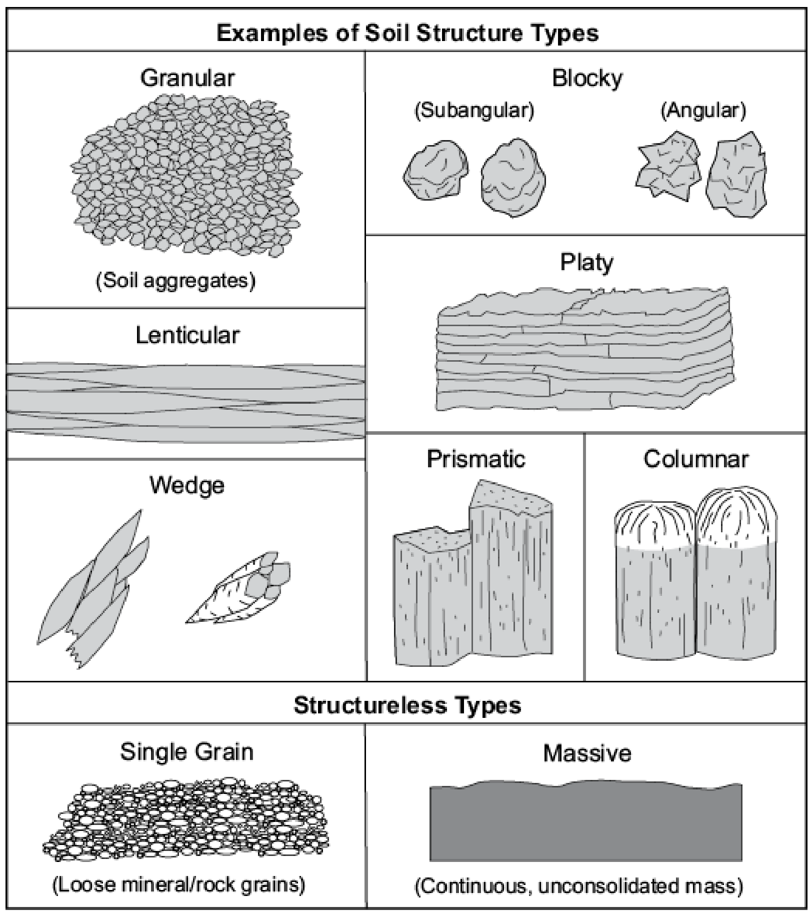
> *Platy.*—The units are flat and platelike. They are generally oriented horizontally.
>
> *Prismatic.*—The individual units are bounded by flat to rounded vertical faces. Units are distinctly longer vertically, and the faces are typically casts or molds of adjoining units. Vertices are angular or subrounded; the tops of the prisms are somewhat indistinct and normally flat. Figure 3-17 shows a soil profile with prismatic structure in the subsoil.
>
> *Columnar.*—The units are similar to prisms and bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those of prisms, are very distinct and normally rounded.
>
> *Blocky.*—The units are blocklike or polyhedral. They are bounded by flat or slightly rounded surfaces that are casts of the faces of surrounding peds. Typically, blocky structural units are nearly equidimensional but grade to prisms and plates. The structure is described as *angular blocky* (fig. 3-18) if the faces intersect at relatively sharp angles and as *subangular blocky* if the faces are a mixture of rounded and plane faces and the corners are mostly rounded.
>
> *Granular.*—The units are approximately spherical or polyhedral. They are bounded by curved or very irregular faces that are not casts of adjoining peds.

Wedge.—The units are approximately elliptical with interlocking lenses that terminate in acute angles. They are commonly bounded by small slickensides.

Lenticular.—The units are overlapping lenses parallel to the soil surface. They are thickest in the middle and thin towards the edges. Lenticular structure is commonly associated with moist soils, texture classes high in silt or very fine sand (e.g., silt loam), and high potential for frost action.

Single Grain.— Each individual soil particle is separate and there is essentially no structure. This is found only in very sandy soils and is the type of structure commonly seen in sand dunes at the beach.

Massive.— The complete absence of structure (structureless). This condition is the opposite of single grain because all the soil particles cling together. This type of structure is common for the parent material (C horizon).



We Depend Upon Soils

Each person cannot produce all the food, obtain all the energy sources, or manufacture all the products used in our modern society. A system of producing goods has evolved to supply these basic requirements. Often this system involves many steps between extracting the resource from the land and using the manufactured product at home. Many soils throughout the world are affected.

Production of the goods we use can be categorized into two procedures: obtaining, then processing resources. First the resources are obtained from the land and its soils. For example, vegetables are grown in soil. Animals are raised on grasses, grains, and soybeans that are grown in soil. Mineral resources – coal, iron ore, petroleum, and many others – are mined from beneath the soil and the bedrock below.

Processing, the second procedure, usually occurs in industrialized locations that may be far removed from the resource. The result of the various steps in processing is a consumer good and usually waste by-products that need to be recycled or discarded.

Consider, as an example, the production of an aluminum beverage can. The can started as a mineral resource, bauxite ore. Since we must import most of this ore, the can probably began in a foreign nation such as Surinam in South America. After it arrived in the United States, the ore was smelted into aluminum metal. Then the metal was formed into beverage cans and filled.

Nine thousand miles from Surinam, with one kilowatt-hour of electricity invested in its processing, the aluminum can is ready to be purchased. Most of the products we buy are obtained through such a system of production. And every product is obtained either directly or indirectly from the land and its soils. In our complex society, not only local soils, but soils across the world are affected by the items we purchase.

How People Have Used Soils

People have always used the plant and animal resources of the land to supply themselves with food and shelter. This is just as true today as it was when the land now designated the United States was inhabited by Native Americans.

The ancient Native Americans had a limited technology to alter the land and soils to produce items they needed. In general, their cultures evolved to fit the environment. For instance, in areas of favorable climate and soils, local tribes established a stable agrarian (agricultural) culture with organized villages. Some tribes even irrigated their fields. In harsher locations, for example Alaska and the Great Plains, a nomadic lifestyle usually developed. Individual tribes followed the primary food sources of seal and whale in Alaska and buffalo on the Plains. Agriculture in other areas was difficult. These nomadic cultures had little effect on the land since they lacked the technology to alter large areas of the environment.

In contrast, modern technology can alter the land and soil in both beneficial and detrimental ways on a massive scale. For example, large-scale, intensive monoculture of grain crops and extensive urbanization can be detrimental. The practices increase the erosion potential and can deplete the soil or remove large acreages from farming. Conservationists have learned much about soil erosion and flood control and have made advances in reducing these problems. However, for various reasons erosion is still a very severe problem.

With our tremendous technological ability to alter land and soil comes a responsibility. This responsibility must be seriously considered to balance the benefits of the land use with the possible detriments it may cause.

U.S. History Was Affected by Soils

The land is the surface of the earth and all its natural resources: the plants, the animals, the underlying minerals, and, most important, the soils. Plants grow in soil and ultimately animals depend upon the nourishment of these plants. Thus, the plants, animals, and minerals are products of the soil: a more basic resource than any of the others.

The land and the soil have had a dramatic effect upon United States history. In the 1500's and the 1600's the New World was viewed as a utopia, a land of abundance. This was due primarily to reports of rich, fertile soils and vast amounts of timber, fur pelts, and other resources that could be obtained from the land and the soil. This perception of abundance continued throughout our very early period of settlement and expansion when many nations claimed large tracts of American land. The perception of abundance and plenty lasted through the Revolutionary War period and culminated in the 19th century.

Many, including our government officials, believed it was our nation's right and duty to expand and to reap the benefits of the land and the rich soils of the West. The expansion was judged essential to meet the needs of a young, growing nation. Pioneers moved west seeking flat, fertile land at little or no cost.

Although the trip was rough and the life on the Plains difficult, land rushes, the Homestead Act, and several inventions urged settlers ever westward. Three key inventions during this period were the steel plow, barbed wire, and the windmill. Barbed wire helped control the grazing of cattle on cropland and windmills provided water for parched soil and livestock. But the steel plow, which made it possible to break up the tough matting of the prairie grasses, is the invention that did more than anything else to spread the intensive agriculture that has been practiced on the Plains ever since. During this period agriculture changed. It was no longer subsistence level because farmers were selling crops. This was the beginning of modern agribusiness.

When the railroads ventured west of the Mississippi River they carried the products of western soils – cattle and grain – to their market in the rapidly industrializing East. Clearly, the land and its rich soils have had a remarkable impact on U.S. history.

Managing and Conserving the Soil

How We Degrade Soils

The quality of soils can be reduced by human actions. Soil degradation usually occurs because people do not understand soils and how they act under various conditions. Often poor decisions are made, and soils cannot support a particular land use practice. Such soil degradation can occur in both rural and urban locations.

When a farm removes an agricultural crop from a field, the soil can degrade. The tires of heavy equipment may compact the soil. If the whole plant is removed, valuable organic matter is lost. These actions can reduce not only the nutrients available in the topsoil but also the ability of the soil to hold water and air. In addition, a plowed agricultural field left without plant cover will erode more rapidly.

Certain agricultural chemicals, like pesticides, can also build up in the soil. In short, highly mechanized, intensive agriculture without proper soil conservation tends to reduce soil quality. Farmers must spend more time and money to raise crops on the poorer soil.

In urban areas, soils are also degraded by human activity. For example, on construction sites, all trees and other vegetation are often removed, exposing the soil to erosion. Homes, factories, and roads are built on the land. This land, for practical reasons, can never again be used for agriculture. Large landfills are dug in the soil to dispose of our waste materials. This practice can also remove land from productive agriculture.

Food is our largest export commodity. In many nations the lives of millions of people depend on our food and the productivity of our soils.

At a time when food is so important to the world, we must preserve the quality and quantity of soils. We must carefully protect soils and conserve agricultural land.

Soil Erosion

Erosion is the process which moves soil from one location to another by wind, water, or other natural action. It is a natural process until accelerated by our actions. It has several harmful effects. Farmers harvest a small crop per acre, field become less productive if large gullies develop, and silt from eroded soil builds up in our waterways, causing more frequent flooding and higher costs for navigation.

Types of Erosion

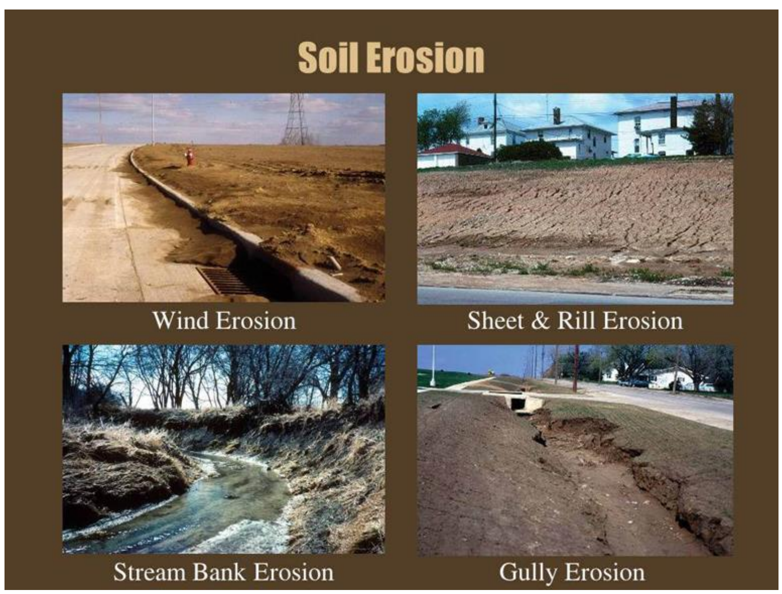
It is easy to find evidence of soil erosion from moving water. Scientists have identified three types: **sheet**, **rill**, and **gully**.

Sheet Erosion

Sheet erosion is the most difficult to see. It is the gradual wearing away of a thin, uniform layer (or sheet) of soil. There are not channels formed by the moving water. Sheet erosion occurs where there is not enough vegetation covering the soil to stop erosion completely, yet there is enough cover to prevent rill erosion. It is seen as muddy runoff water.

Rill Erosion

This type of erosion occurs on slopes where the runoff water accumulates into small channels. Rill erosion can be seen as many small channels of a few inches in depth. Yet the channels are not large enough to interfere with the movement of farm equipment. Rill erosion occurs on slopes that are gentle or have little protective vegetation.



Gully Erosion

Gully erosion is the most dramatic form of soil erosion. Gullies form when the runoff water accumulates into channels. The rapidly moving water causes the channel to grow wider and deeper. Gullies may become too deep for farm equipment to cross. Gully erosion occurs on steeper slopes that have a little or no vegetation.

Although gully erosion is the most evident, sheet and rill erosion are a greater national concern. Sheet and rill erosion remove an average of five tons of soil from every acre of cultivated cropland each year. (A pickup truck can hold about one to two tons of material, and an acre is about the size of a football field).

Other Causes of Soil Movement

In addition to sheet, rill, and gully erosion by water from unprotected soils, soils are moved by wind, land slippage, and stream bank erosion.

Most **wind erosion** occurs in areas of high prevailing winds and low annual rainfall or in areas of very sandy soils. A good way to control wind erosion is to keep a cover crop on the soil or to plant windbreaks.

The most famous case of wind erosion in the United States occurred during the Dust Bowl. From the late 1920s through the early 1930's, the western United States endured a terrible drought. Areas of the Great Plains, once protected by the dense root systems of native grasses, were suddenly vulnerable to wind erosion due to overgrazing and plowing of the land for farming. With little to hold the soil in place, large dust storms swept across the plains, carrying away the topsoil. Great clouds of dust blackened the sky as far away as the east coast. Dust storms are not a thing of the past. Implementation of soil conservation practices through NRCS has greatly reduced the risk of large scale, devastating dust storms. However, every year dust storms occur in the western plains and Southwest, although not as severe as the occurrence in the 1930s. Continued conservation efforts are still needed.

Land slippage or **mass movement** refers to blocks of water-saturated soils moving down slopes in response to gravity. An example would be the cave-in or a cliff or bluff that overhangs a river. Land slippage can also occur along steeply cut road embankments.

Streambank erosion is eroding of the banks of streams by water. This is usually caused by an increase in the volume of water in the stream after heavy rainfall events. In most cases, this increase in stream flow is due to changes in the watershed above the stream. Increased amounts of runoff can occur from activities such as the logging of forests and increases in impervious surfaces (water resistant areas like roads) due to urbanization.

No one benefits from soil erosion. It contributes to higher food prices, creates equipment breakdowns, increases flooding, makes dredging (removal of bottom sediments) necessary for navigation, and decreases the biotic potential of fish, oysters, clams, and other aquatic water animals.

Problems Facing Farmers

Urbanization (an area changing from rural (farms) to towns and cities), soil erosion, high fuel costs, flood and sediment damage, limited water supplies, salinization (increase of salts in soil), high fertilizer costs, harmful effects of pesticides, atmospheric pollution, and soil compaction are a few of the problems facing farmers. In response to these problems, many farmers have borrowed a term from the corporate world and adopted the use of a *best management practices* system.

Best Management Practices (BMPs)

Best Management Practices (BMPs) are activities that farmers and suburban and urban landowners can use to help conserve soil and water resources. BMPs are very effective when installed according to design parameters, and properly used and maintained.

Animal waste management – Animal waste management is the handling and recycling of animal wastes in an environmentally responsible manner.

Animal waste management plans should seek to use the nutrients of these waste products for the highest or best benefit of the farmer by application to cropland, pasture, and hay land.

Application of animal wastes to the land at the right time, using proper management techniques, and in the right amounts provides nutrients for plant growth and improves soil tilth. It also reduces the expense of fertilizers and improves soil quality by adding organic matter to the soil.

Conservation tillage – Conservation tillage refers to no-till, strip-till, minimum-till, ridge till, and sod planting. For maximum benefits from conservation tillage, a crop residue must be left on the surface as mulch. This crop residue can be dead plant parts from the prior year's crop or residue of grasses and/or legumes planted as cover crops and then killed with herbicides. The amount of mulch should be enough to cover at least 30 percent of the soil surface and should be evenly distributed. This mulch reduces soil water evaporation and erosion and adds organic matter. The next planting season, the crop is planted through the mulch without plowing the soil.

Contour farming – Contour farming is the practice of performing tillage on a nearly level grade following the curves of the terrain. This creates small dams and diversions that slow the flow of water flowing down hill and sends it along the contour with the row. This practice allows the water to slowly seep into the soil for plants to use. It also reduces plant nutrient losses, improves surface water quality, and reduces soil erosion. Contour farming normally requires less fuel and power since farming operations will be on nearly level elevations.

Contour Strip-cropping – Contour strips are generally an even width although uneven widths may improve "farmability" in areas with rolling or irregular topography. Traditionally, strip-cropping was defined as alternating strips of row crop with strips of either small grain or hay. Today, strips with high levels of residue on the surface may be used as substitutes for alternate hay or small grain strips.

Cover crops – Cover crops are crops that are planted in the fall after the previous crop is harvested to get an actively growing plant cover on the bare fields. The cover crop protects the bare soil during the winter.

Cover crops are commonly used after low residue crops such as tobacco, cotton, peanuts, and vegetables. These low residue crops may not have left enough plant residue on the surface after harvest to protect the soil during the winter.

Cover crops are usually a small grain that may be harvested during the next year, plowed under to provide organic material for the soil, or killed with herbicides for its residue and used as cover to plant a no-till crop. Cover crops provide protection against soil erosion and runoff.

Crop residue management – Crop residue management is the practice of cutting up and leaving the unharvested crop remains on top of the ground to provide ground cover. This cut up material is called residue. The plant material provides mulch, which helps to break up the impact of the rain hitting the soil and slows down runoff allowing more of the rainwater to soak into the soil. Enough crop residue on the surface also reduces the hazards of wind and water erosion as well as reduces soil compaction.

Crop rotation – Crop rotation refers to a planned cropping sequence where different crops are planted in consecutive years. Included are rotations that contain grasses and legumes as well as field crops. Some of the important objectives are to reduce soil and water losses; maintain or improve physical, chemical, and biological conditions of the soil; and aid in controlling weeds, insects, and diseases. A cropping sequence should be based upon the limitations of the land if it is to provide the needed treatment for soil and water conservation. Crop rotations are typically used on most cropland in Pennsylvania.

Diversion - A diversion is an individually designed channel running across a hillside (slope) with a supporting ridge to divert the moving rainwater out of the field and into an area where the water can infiltrate without causing erosion down the slope and without contaminating surface water.

A diversion is used in areas where there is excessive runoff to help reduce the hazard of rill and gully erosion.

Field borders – A field border is an area of grass or other permanent vegetation along the outside of a cropped field. Field borders are used to reduce sediment, organics, nutrients, pesticides, and other contaminants from running off the field and to maintain water quality.

Field borders intercept undesirable contaminates from runoff before they enter a water body. They provide a buffer between crop fields, a potential contaminant source, and streams and ponds.

Field borders slow the velocity of water, allowing the suspended soil particles to settle out. Field borders allow for convenient travel and turnaround of farm equipment at the end of a crop row. Field borders are also beneficial for wildlife like quail, turkey, rabbit, deer, and for pollinators.

Windbreaks and Shelter Areas– A planting of single or multiple rows of trees and/or shrubs that are established to protect sensitive plants, livestock, or structures, and to create or enhance wildlife habitat.

Vegetative Barriers– A very narrow permanent strip of stiff–stemmed, tall, dense perennial vegetation established in parallel rows perpendicular to the dominant field slope.

Filter strips –Filter strips, also referred to as buffer strips, are strips of permanent vegetation (vegetative, forested riparian, and wind buffers) planted to filter out sediment and other pollutants from rainwater run-off.

They are usually planted around ponds, lakes, man-made channels, and other sensitive areas. Filter strips filter out pollutants from the water such as sediment, nutrients, pesticides, and debris. The close growing grass allows the movement of the water while trapping sediments.

Grass waterway – A grass waterway is a natural or constructed vegetated channel that carries runoff water down a slope and off a field.

A grass waterway is shaped and graded so that it allows surplus water to exit the field without causing severe erosion problems. The grass also slows down the velocity of the water allowing most of the soil in suspension (sediment) to drop out before the water exits the field at a stable outlet. The stable outlet is designed to slow and spread the flow of water before the water enters a vegetated filter.

Grassed waterways may convey runoff from terraces, diversions, or other areas where water concentrates. Grassed waterways are used where water concentrates and gully erosion is a problem, commonly in draws and other low-lying areas. Grassed waterways also allow for convenient travel of farm equipment across the waterway (sometimes the waterways were previously a ditch or a gully).

Integrated pest management – (IPM) Integrated pest management ideally combines biological and cultural controls with limited pesticide use to keep pest populations below economically damaging levels, prevent future pest problems, and minimize the harmful effects of pesticides on humans and natural resources, including wildlife and water quality.

Field scouting and action thresholds can be used to provide much of the information needed to determine extent of crop pest activity. Thorough field scouting provided by an unbiased source who understands the crop and cropping system remains a major tenant of IPM.

An action threshold is a point at which pest populations or environmental conditions indicate that pest control action must be taken. Sighting a single pest does not always mean control is needed. The level at which pests will become an economic threat is critical to guide future pest control decisions.

Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs then evaluate the proper control method both for effectiveness and risk. Effective, less risky pest controls are chosen first, including highly targeted chemicals, such as pheromones to disrupt pest mating, or mechanical control, such as trapping or weeding. If further monitoring, identification, and action thresholds indicate that less risky controls are not working, then additional pest control methods would be employed, such as targeted spraying of pesticides. Broadcast spraying of non-specific pesticides is a last resort.

Conservation Buffers

Conservation Buffers Used to Improve Water Quality

(Near Stream) Vegetated Buffers– A regulatory term for a strip of permanent, perennial vegetation (35–feet minimum width of herbaceous, woody, or any mixture of herbaceous and woody vegetation) established and/or maintained immediately adjacent to a water body or sinkhole and is perpendicular to the dominant field slope.

The area may meet the criteria for several different conservation practices, typically riparian herbaceous cover or filter strips when the vegetation is herbaceous, and riparian forest buffers when it is woody.

Riparian Herbaceous Covered Strips– Grasses, sedges, rushes, ferns, legumes, and forbs tolerant of intermittent flooding or saturated soils, established or managed near or adjacent to streams, lakes, ponds, or wetlands.

Filter Strips– Strips or areas of permanent herbaceous vegetation established to remove sediment, organic materials, nutrients, pesticides, and other contaminants from runoff. They may also be established near or adjacent to environmentally sensitive areas such as streams, lakes, ponds, or wetlands, or they may be established in upland areas to intercept runoff. They are frequently harvested for hay or biomass.

Riparian Forest Buffers – Areas of trees and/or shrubs located near or adjacent to a body of water (streams, lakes, ponds, or wetlands). The vegetation extends outward from the water body for a specified distance necessary to provide a minimum level of protection and/or enhancement. This type of riparian buffer provides the most environmental benefits of all the buffers presented.

Importance of Soil

In summary, soils are one of a country's most valuable natural resources. In agriculture production, they are an integral part of the ecological system that produces food and fiber. Soils are the medium that physically supports plants while also functioning as a storage and exchange area of the water, gases, and nutrients needed for plant growth.

Though generally, when you think of soils, you think plants and agriculture uses (trees, food crops, and livestock) it is important to remember the other contributions of soil.

Soil is also important when you landscape a home or plant a garden. It is the growth medium for lawns, plants, shrubs, and gardens.

Soils are also an important consideration in locating septic systems, and construction of buildings, roads, and recreational facilities. Engineers, as well as farmers and soil scientists, must be concerned about the properties of the soil since soil serves as the foundation material for construction projects and the purification material for septic systems. Soil also determines the amount of precipitation an area can handle. Before any building is built, the soil is examined to see what, if any, modifications need to be made to the soil before construction can proceed.

Soils are major determinants of *terrestrial* ecosystems. They are the sources, transformers, and storage areas of plant nutrients. They are also the recycling factories of plant and animal remains (organic manure).

Soils are a major support system of human life and welfare. They determine the agricultural and forest production capacity of the land. They are our source of food, raw materials for clothing, and shelter. Soils are foundations for the construction for building, road, and recreation facilities.

Soils have a direct impact on wildlife as the source of both food and shelter. The composition and distribution of plant communities, the availability of suitable dens and nesting areas, and the storage of water supplies are crucial to wildlife survival.

Soils are natural buffers and filters for pollutants, in many forms and to various degrees. Soils also purify water and store and breakdown waste.

Soils are important sources and links in biogeochemical cycles involving the greenhouse gases – carbon dioxide, methane, and nitrous oxides.

Soils are a key link and buffer system in the world's hydrological cycle.

Soil influences heat exchange as well as land surface reflection.

Soil is the key to the history of the earth.

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Learning Enhancement

The following Pennsylvania Envirothon YouTube video explains the method for determining Soil Texture.

Envirothon Soils Study Session 3