Learning Objectives

Soil Ecosystems
1. Recognize that biological diversity is important for soil health and hence plant, human and environmental health.
2. Understand how the hydrologic, carbon and nutrient cycles relate to soil management.
3. Recognize that understanding soil ecosystems is important to soil management.

Chemical Properties of Soil and Soil Fertility
1. Understand the procedure for taking a soil sample and conducting nutrient analysis.
2. Know that plants must receive essential micronutrients and macronutrients from the soil in order to be healthy, and understand that soil fertility relates to the physical and chemical properties of the soil in addition to the quantity of nutrients.
3. Understand why soil fertility reflects the physical, chemical and biological state of the soil.

Soil Conservation and Land Use Management
1. Compare different land uses and conservation practices and their impact on soils and erosion.
2. Understand how soil is impacted by point & non-point source pollution & the importance of soil management to agriculture and clean water.
3. Understand that soil management and environmental protection requires agricultural and resource managers to use spatial tools such as Geographic Information Systems (GIS), and Global Positioning Systems (GPS) in order to make the best possible resource decisions.
4. Learn about career opportunities and the role of government in the management of natural resources

Web Soil Surveys and Soil Surveys
1. Access and use published and on-line soil data and other resources to learn how land use affects soil, and the limitations of local soils.
2. Understand the eight Land Capability Classes and how they are important in determining appropriate land use
3. Understand soil drainage classes and be able to recognize the characteristics of hydric soils and know how soils fit into the definition of wetlands.

You will need to be able to know or do the following skill:
1. Identify a soil given a sample (soil ribbon test- see soil texture)
2. Use a soil survey to obtain information about a piece of land (see resources at the end of the study guide)
3. Use a Munsell soil color chart/book.
4. Explain the relationships between soil to watersheds, wildlife, and aquatic and terrestrial ecosystems.
5. Explain how humans depend upon and impact soils.

Introduction

In preparing for the Oklahoma Envirothon you may want to reach out to your area Natural Resources Conservation Service or Soil and Water Conservation district offices for additional information and assistance. The information contained within this study guide is intended to provide a preview of basic information for the competition. Numerous resources are available from a variety of sources online.
WHAT IS SOIL AND HOW IS IT FORMED?

What Is Soil?

Soil is a complex, self-renewing, living system. It is a vital natural resource. It is the resource that most terrestrial life depends on directly or indirectly for survival as it provides water and nutrients necessary for plant life as well as providing mechanical support for root systems. It is a composite of inorganic minerals, organic humus, living organisms, moisture, and air. Soils are the product of interactions between abiotic and biotic processes and take thousands of years to form.

Roughly 45% of soil is made of inorganic rock material. The mineral portion of soils is derived from the weathering of rocks. Weathering over time produces smaller and smaller pieces of rocks and minerals that make up the bulk of soil. The mineral portion of the soils is divided into three size constituents of particles less than 2 millimeters (mm) in diameter: sand, silt and clay. Any particle larger than 2 mm is not considered soil, but is called a rock. The type of rock, or parent material, that the soil forms from will influence the characteristics of the soil profile.

Organic matter, or humus, is dead and decaying plants and animal matter. Most soils will contain between 0-18 percent. Organic matter is important for the soil because it provides a source of more readily available nutrients and acts as a sponge allowing the soil to hold more water. The presence of organic matter in the soil also improves soil tilth, or the ease with which the soil is worked, as it adds more pore space to allow water and air to move throughout the soil. Soils rich in organic matter will have a darker color often called “rich” soils. Organic matter is most often concentrated near the soil surface because that is where most of the plant and animal matter will occur.

Water is held within the pore spaces between the soil particles and can make up anywhere from 25-75% of the volume of soils. There are three types of water as it moves through the soil profile.

How Is Soil Formed?

The formation of soils is dependent upon many factors that are classified into five major categories:

1. The type of parent(source) material
2. The climate under which the soil components have existed since accumulation
3. The plant and animal life in and on the soil
4. The relief of the land
5. The length of time the other factors have interacted

The five soil-forming factors are interdependent. Soil formation begins with the degradation of the parent material. The parent material is unconsolidated, chemically weathered mineral, rock, or organic matter. Precipitation, temperature, humidity, and wind are the climatic forces that act on the parent material to form soil. The relief of the land greatly influences how wind and water act upon parent material components as well as the types of plants and animals that inhabit the area.
**Biotic** components of the ecosystem such as animals, insects, bacteria, fungi, and other plants furnish organic matter. Differences in the amount of organic matter, nutrients, structure, and porosity of soil are caused by plant and animal actions.

**Time** is an important factor in soil formation. The physical and chemical changes brought about by climate, living organisms, and relief are slow. The length of time needed to convert raw geological materials into soils varies according to the nature of the material and the interaction of other factors. Some minerals weather fairly rapidly, while others are chemically inert and show little change over long periods of time.

![Fig. 3.1. Classification of parent materials. (Dubbin, 2001).](image-url)

![Diagram showing factors, processes, and pedon](image-url)
The Soil Profile

Soils are deposited or developed in layers. Soils with clearly defined layers are said to be mature. Immature soil is one that lacks well-developed layers. A vertical column of soil, such as might be seen where roads have been cut through a hill or where a river has scoured through a valley, is called a profile. The soil layers in the profile are called horizons. They are defined as follows:

**O Horizon.** The O horizon is dominated by organic material. It contains fresh and decaying plant matter from leaves, needles, twigs, moss, lichens, and other organic accumulations.

**A Horizon.** The A horizon is formed at the surface or below the O horizon. It is an accumulation of organic matter and minerals. It is generally darker than the lower horizons because of the decaying organic matter. This horizon is where most plant root activity occurs. It may be referred to as the surface layer in a soil survey.

**E Horizon.** The main feature of the E horizon is the loss of silicate clay, iron, or aluminum, or some combination of these, leaving a concentration of sand and silt-sized particles.

**B Horizon.** The B horizon lies directly below an A, E, or O horizon. It is referred to as the subsoil. It is usually lighter colored, denser, and lower in organic matter than upper horizons. As the recipient of material from upper and lower soil layers, the B horizon is often called the “zone of accumulation.” As rain and irrigation waters percolate downward, they wash (leach) soil components through the A horizon and into the B horizon. The process by which these materials are moved downward by water is called leaching. For this reason, the A horizon is called the “zone of leaching.” Some minerals are drawn upward from lower soil layers by high evaporation rates and plant absorption.

In many soils, a dense, nearly impermeable subsurface layer called fragipan develops. When this layer is the result of extreme compactness of soil particles, it is called claypan. In Florida, hardpan is the term applied when cementation of soil particles occurs. Layers cemented by calcium carbonate are called caliche and layers cemented by iron oxide are called ironpan. In many cases, the pan is so hard, water does not pass through it easily. This often causes water to flow horizontally through the soil until it reaches a break in the pan.
C Horizon. Still deeper is the C horizon or the substratum. This layer may consist of less clay or other less-weathered sediments than the layers above. Partially disintegrated parent material and mineral particles are in this horizon.

R Horizon. The very lowest horizon, the R horizon, is bedrock. It can be within a few inches of the surface or many feet below.

Each master horizon is subdivided into specific layers that have a unique identity. Those subdivisions are identified by suffix symbols which follow the master horizon letter.

These suffix symbols are as follows:

- a highly decomposed organic materials
- b buried soil horizon
- c concretions — grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains
- d physical root restriction
- e organic material of intermediate decomposition
- f frozen soil
- g strong gleying — soil that is formed under poor drainage, resulting in the reduction of iron and other elements and in gray colors and mottles alluvial accumulation of organic matter is slightly decomposed organic matter accumulation of carbonates
- m cementation and accumulation of sodium or residual accumulation of sesquioxides from tillage or other disturbance, accumulation of silica, weathered or soft rock
- s alluvial accumulation of sesquioxides and organic matter accumulation of alluvial clay plinthite
- w development of color or structure
- x fragipan character and accumulation of gypsum
- z accumulation of salts more soluble than gypsum

Hence, a B horizon with a large accumulation of clay might be designated as a Bt horizon.

The thickness of each layer varies with location (even in the same field). Few soils fit horizon descriptions perfectly. Under disturbed conditions, such as intense agricultural development or where erosion is severe, not all horizons will be present.

Soil pits are an excellent way for students to be able to study the soil profile. If unable to dig a soil pit at school, try finding a construction site or roadside cutaway.
SOIL CHARACTERISTICS

Soil characteristics are used to identify soil types. Most soil characteristics can be determined by field determination. Some need to be verified by laboratory testing. The most common soil characteristics that soil scientists examine are texture, color, porosity, compaction, and permeability.

**Texture.** Soil texture is the term commonly used by the U.S. Department of Agriculture (USDA) to designate the percentages of sand, silt, and clay in a sample of soil. Other agencies may use other soil texture classification systems. Soil texture refers only to mineral particles smaller than 2 millimeters (mm). Each grouping of particle sizes is called a soil separate. Hence, sand, silt, and clay are soil separates. The USDA classification of mineral soil separates is as follows:

<table>
<thead>
<tr>
<th>Texture</th>
<th>Size Range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very coarse sand</td>
<td>2.00–1.00 mm</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>1.00–0.50 mm</td>
</tr>
<tr>
<td>Medium sand</td>
<td>0.50–0.25 mm</td>
</tr>
<tr>
<td>Fine sand</td>
<td>0.25–0.10 mm</td>
</tr>
<tr>
<td>Very fine sand</td>
<td>0.10–0.05 mm</td>
</tr>
<tr>
<td>Coarse silt</td>
<td>0.05–0.005 mm</td>
</tr>
<tr>
<td>Fine silt</td>
<td>0.005–0.002 mm</td>
</tr>
<tr>
<td>Clay</td>
<td>less than 0.002 mm</td>
</tr>
</tbody>
</table>

The texture of a soil gives an indication of

- The relative water-holding capacity
- Mineralogy
- Susceptibility to being transported by wind or water
- Chemical properties

The process by which soil separates are obtained is called mechanical analysis. All mineral soils are made up of a mixture of soil separates. Textural class names of soils are based on the proportion of these separates. There are 12 major textural class names: sand, loamy sand, sandy loam, sandy clay loam, sandy clay, clay, clay loam, loam, silt loam, silty clay loam, silty clay, and silt.
The determination of soil texture in the field is done by feel. That is, the soil is rubbed between the thumb and fingers and an estimate of the amount of the various separates present is made on the basis of the degree to which the characteristic properties are expressed.

Texture is the proportion of sand, silt, and clay in the soil.

- **Sand**, the largest particle of the soil, is visible to the eye. It is gritty, absorbs little water, and is not slick or sticky when wet.
- Medium-sized soil particles are called **silt**. Silt feels like flour or talcum powder. It absorbs moderate amounts of water and has a somewhat sticky feel when wet.
- The smallest particles of soil are called **clay**. Most individual clay particles can only be seen with an electron microscope. Clay feels sticky and plastic when wet, and hard when dry. Clay is more chemically active than sand and silt.

To determine the soil texture of a sample follow the directions on page 7.

Soil Ribbon Test Resources
- https://www.youtube.com/watch?v=GWZwbVJCNec
- http://www.ext.colostate.edu/mg/gardennotes/214.pdf
Texture by Feel

Start → Place 25-50 g soil in palm. Add water slowly and knead soil to wet all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.

Does soil remain in a ball when squeezed? → no → Is soil too dry? → no → Is soil too wet? → no → Sand

yes → Form a ribbon of uniform thickness by squeezing a ball of soil between the thumb and forefinger. Allow the ribbon to emerge and extend over the forefinger breaking under its own weight.

→ yes → Does the soil form a ribbon? → no → Loamy Sand

→ yes → Ribbon 2.5 cm or less → no → Ribbon 2.5-5.0 cm → no → Ribbon greater than 5 cm

→ yes → Excessively wet a small pinch of soil in palm and rub with forefinger.

→ Sandy Loam → Gritty feeling

→ no → Sandy Clay Loam → Gritty feeling

→ Silt Loam → Smooth feeling

→ no → Silty Clay Loam → Smooth feeling

→ Sandy Clay → Gritty feeling

→ no → Silty Clay → Smooth feeling

→ Silt Loam → Smooth feeling

→ no → Silt Loam → Smooth feeling

The USDA textural triangle showing the twelve major textural classes in the USDA system. Within the sands, loamy sands, and sandy loams, the proportions of the various separates of sands (very coarse sand, coarse sand, medium sand, fine sand, and very fine sand) must be considered in determining which textural name to assign. If the sand fraction of a soil sample is dominated by a particular sand separate, a modifier must be attached to the major textural name (e.g., coarse sand, loamy very fine sand, or fine sandy loam).

https://commons.wikimedia.org/wiki/File:SoilTexture_USDA.png
Soil Porosity

Porosity refers to the amount and size of spaces between soil or rock particles. Porosity determines the amount of water that a soil can hold. Sands and gravels have high porosity. Clays are very porous. Some can hold up to 60 percent of their total volume. High porosity does not always indicate good permeability. Porosity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems.

http://www.tulane.edu/~sanelson/eens1110/groundwater.htm

Soil Structure

Structure in a soil refers to the arrangement of soil particles into clusters or compound particles called aggregates or peds. Individual peds are separated from one another by surfaces of weakness, making the soil mass tend to break along these surfaces. The aggregates vary in shape, size, distinctness, and durability. Soil structure is determined by slightly crushing or pulling apart a mass of moist soil and observing the shape, size, and durability of individual aggregates. The structure of the soil affects the tilth, or the ease with which soil is worked. It also improves how water, air, and other substances move through the soil. A lack of soil structure leads to problems with root penetration and water movement through the soil profile.
Soil Permeability

Permeability refers to the rate of water and air movement through soil or bedrock, if present. It is an indication of downward movement of water when the soil is saturated. This may be considered internal drainage. Permeability can be estimated from texture, compaction, and arrangement of soil particles (structure). The drawing illustrates the common ways particles may affect the soil’s internal drainage by either providing a pathway for water to drain or by retarding water movement.

Permeability is measured in the number of inches per hour (in/hr) that water moves downward through a saturated soil. Terms describing permeability and respective flow rates are as follows:

- **Very slow**: less than 0.06 in/hr
- **Slow**: 0.06–0.20 in/hr
- **Moderately slow**: 0.20–0.6 in/hr
- **Moderate**: 0.6–2.0 in/hr
- **Moderately rapid**: 2.0–6.0 in/hr
- **Rapid**: 6.0–20 in/hr
- **Very rapid**: more than 20 in/hr

Permeability is an important consideration in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of movement under saturated conditions affects soil behavior.

A healthy topsoil has about 50 percent pore space where gases and water are transmitted and held. A balance between pores filled with water and pores filled with gas is necessary for the soil to provide good plant growth. Soil porosity is destroyed by tillage, intense agricultural operations, or heavy vehicle and foot traffic. This destruction is known as soil compaction. The largest pores (macropores) are the most vulnerable to compaction. The macropores are essential to the movement of gases and water. Loss of macropores inhibits the movement of gases, including oxygen, into and out of the soil. Plant roots and many types of microorganisms cannot grow where oxygen is limited. Plant roots and microbes produce carbon dioxide, which also moves through the soil pores to the atmosphere.

The small pores (micropores) are important in holding and retaining water in the soil. The loss of these pores lowers the permeability of the soil, thereby restricting percolation (downward movement of water through the soil) and increasing runoff, erosion, and flooding.

Porosity and permeability influence the classification of soils by drainage patterns. **Drainage classes** refer to the periods of saturation or partial saturation during soil formation, as opposed to altered drainage. The latter is usually the result of human interaction. Seven classes of natural soil drainage are recognized.

- **Excessively drained**: Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse-textured, rocky, or shallow. Some are steep. All are free of mottling related to wetness.

- **Somewhat excessively drained**: Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost to runoff. All are free of the mottling related to wetness.
Well-drained. Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during the growing seasons. Well-drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained. Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum or periodically receive high rainfall, or both.

Somewhat poorly drained. Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a higher water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained. Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated directly below the plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained. Water is removed so slowly that free water remains at or on the surface during the growing season. Unless the soil is artificially drained, most crops cannot be grown. Very poorly drained soils are commonly level or depressed, are frequently ponded, or have impermeable layers close to the surface. Yet where rainfall is high and nearly continuous, they can have moderate or high slope gradients. Wetlands is a general term used for areas where the soil is covered or saturated with fresh or salty water for at least one month per year and where special vegetation has grown because of the wet conditions. Wetlands are usually at a low elevation compared to the surrounding land, but may be at a higher level with impermeable soil. They are located between terrestrial (dry upland) and aquatic habitats.

### Water Holding Capability

The amount of water a soil profile can hold can be calculated to determine the amount of water available for plant growth and production. This is referred to as the **water holding capacity** of the soil. There are three types of water in the soil profile: gravitational, capillary, and hydroscopic. Gravitational water is that which freely runs through the soil. Think of a sponge that has been saturated with water and

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**Soil Permeability and Porosity Labs**

- [http://coloradoriver.org/pdfs/Permeability_and_Porosity_labs_CRF.pdf](http://coloradoriver.org/pdfs/Permeability_and_Porosity_labs_CRF.pdf)
is removed from the source. The water that freely runs of the sponge would represent gravitational water in the soil. This is water that will continue through the soil and enter an aquifer and so plants are not able to use this water. Capillary water is that which is held within the pore space between the soil particles. This would be the water that is left in the sponge it is stopped dripping. This water is freely available to plants to use. The last type of water, hydroscopic, is that which is bonded tightly to the soil particles and is not available for plants to use. Using the sponge analogy, if you squeezed the sponge as tightly as possible, there would still be water remaining within the material. Water that you have no way of retrieving.

How much water a soil profile can hold is determined by texture. The finer the soil, the more moisture it will hold; the more coarse a soil the less water it hold. To determine soil moisture holding capacity you first must determine root depth for the field. This is the deepest point at which the roots are found in the profile or how deep the roots are expected to grow. You also much know the soil texture and the depth of each horizon to root depth. Then multiply the depth of each horizon by the water holding capacity figure in the chart below.

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Water Holding Capacity (inches/foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand (Coarse texture)</td>
<td>.8”</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>1.2”</td>
</tr>
<tr>
<td>Clay</td>
<td>1.35”</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>1.6”</td>
</tr>
<tr>
<td>Fine Sandy Loam</td>
<td>1.9”</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>2.4”</td>
</tr>
</tbody>
</table>

A horizon is 6” deep comprised of loamy sand: 
\[
\text{6 in} \times \frac{1}{12} \text{ in} \times \frac{1}{1} \frac{\text{ft}}{\text{in}} = .40 \text{ in of water}
\]

B horizon to a depth of 14” (root zone) comprised of silty clay: 
\[
\text{14 in} \times \frac{1}{12} \text{ in} \times \frac{1.6}{1} \frac{\text{in}}{\text{ft}} = 1.87 \text{ in water}
\]

Total water in soil profile available for plants: 2.27 in

**Soil Color**

Soil color is probably the most obvious feature of soil. A soil scientist can often associate soil color with specific physical, chemical, and biological properties of soil. Soil colors are produced by organic matter, iron compounds, silica, lime, manganese compounds, aluminum hydroxide, various salts, and coatings of silts and clays and are sometimes an indication of water table or depressional soils.

Soil colors are most conveniently measured by comparison with a chart known as the Munsell Soil Color charts. There are 322 different color chips in the Munsell Soil Color charts. The chips are arranged by three characteristics — hue, value, and chroma.

The hue indicates the color’s relation to spectral colors such as red, yellow, green, blue, and purple. The colors displayed on an individual chart are the same hue, which is designated by a symbol in the upper right corner of the card. The symbols for hue are the letter abbreviation of the colors. Hence, R is for red, YR is for yellow-red, Y is for yellow, etc.
The **value** (sometimes called brilliance) indicates the relative lightness or darkness of the chip. Vertically, the chips become lighter as the column progresses from the bottom to the top, and the value increases with each step. The value for each chip is noted by the vertical scale on the far left of the chart. The notation for value consists of numbers from 0 for absolute black to 10 for absolute white.

The **chroma** is the chip color’s relative purity or the degree of vividness in contrast to grayness. Horizontally, the chips increase in chroma from left to right. The chroma is noted by the horizontal scale across the bottom of the chart. The notation for chroma consists of numbers beginning with 0 for neutral grays and increasing at equal intervals to a maximum of about 20.

Soil colors are classed as achromatic and chromatic. The achromatic colors are white, all shades of gray, and black. They have a neutral hue and a zero chroma, but differ in value. All other colors are chromatic and represent various combinations of hue, value, and chroma.

When making soil color notations, the color name is written first, followed by the Munsell notation in parentheses. In writing Munsell color notation, the order is hue, value, and chroma, with a space, hue letter, and succeeding value number, and a diagonal line between the two numbers for value and chroma. Thus the notation for a yellowish-red colored soil of hue 5YR, value 5, and chroma 6 is yellowish-red (5YR 5/6).

Accurate comparison of a soil sample to the Munsell Soil Color charts is accomplished by holding the specimen behind the openings next to the closest matching color chip. Rarely will the soil sample be perfectly matched by any color in the charts.

Munsell Soil Color charts are expensive to purchase, but a simplified version can be made by following the directions on the next page.

To practice with a real Munsell Soil Color chart, contact your local Soil and Water Conservation district office and ask a representative to bring one for demonstration.
SOIL CLASSIFICATION

Various soil classification systems have been used for centuries. Most of the systems were based on specific purposes for local areas. Unfortunately, they relied upon opinions which were difficult to reproduce and therefore had limited use and meaning. In 1951, the soil taxonomy classification system was developed and is still is used today. The taxonomic system recognizes six categories: order, suborder, great group, subgroup, family, and series.

Soil orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in the suffix sol. There are 12 soil orders. The soil orders and their dominant features are as follows:

Alfisols.* Well-developed soils with a relatively fine-textured subsoil horizon that has a base saturation of 35 percent or more.

Andisols. Soils of volcanic origin.

Aridisols. Dry soils that occur in arid or semi-arid regions.

Entisols.* Soils with little or no horizon development.

Gelosols. Soils of cold climates influenced by permafrost.

Histosols.* Soils composed of relatively thick (usually 16 inches or more) organic materials (muck and peats).

Inceptisols.* Soils of humid regions with profile development sufficient to exclude them from the Entisols, but insufficient to include them in Spodosols, Ultisols, or other well-developed soils. Soils that appear to be like Mollisols but have less than 50 percent or more base saturation may also be Inceptisols.

Mollisols.* Soils with thick (usually 10 inches or more), dark surfaces that have a base saturation of 50 percent or more in the surface soil.

Oxisols.* Highly weathered soils of the tropics.

Spodosols.* Soils with a spodic horizon (a dark-colored subhorizon with a mixture of organic matter and aluminum, with or without iron).

Ultisols.* Well-developed soils with a relatively fine-textured subsoil horizon that has less than 35 percent base saturation.

Vertisols. Soils with more than 30 percent clay which appreciably expand upon wetting and contract upon drying.

To determine the order to which a soil belongs, you must know the key to soil taxonomy.

Soils are further differentiated by
• Suborders
• Great groups
• Subgroups
• Families
• Series

SOIL USES

Knowledge of soil characteristics helps to determine the land’s capability for farming and ranching, proper agricultural and urban use, and conservation practices necessary. Land uses include crop and pasture lands, rangeland, forestry, recreation, wildlife habitat, and engineering uses, including building sites, sanitary facilities, water management, and construction materials.

Residential/Industrial. Soils are also used in most rural parts of the United States as our waste disposal medium. Using a septic tank and drain field is a widely accepted way of disposing of household liquid waste and sewage. Use of this type of system requires that the soil where the drain field is located must be able to filter contaminants out of the wastewater before it returns to surface water or groundwater.

Some soils are used in similar ways to dispose of various industrial, household, and municipal wastes, either by land filling, or by surface applications. These practices are environmentally acceptable, provided the soils are initially suitable, and that their capacities are not exceeded by amounts of waste to be treated.

Farming. Identification of soil types helps to analyze potential erosion problems, soil drainage, soil fertility, and soil tilth, all of which are important factors in determining which crops are best suited to an area and the productivity potential for those crops.

Ranching. Rangeland is land on which the natural vegetation is predominately native grasses, grass-like plants, and shrubs, suitable for grazing by domestic livestock and wildlife. In addition to livestock forage and wildlife habitat, rangeland provides wood, water, recreation, and scenic beauty. Rangeland includes grassland, open forest, wetlands, and shrub-land.

Range management requires a knowledge of the kinds of soil and of the plant communities. The objective of range management is to control grazing so that the plants growing on the site are about the same in kind and amount as the natural plant community for that site. Such management generally results in the optimum production of vegetation, reduction of undesirable brush species, conservation of water, and control of erosion. Sometimes a range condition somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Forestry. Knowledge of soils can be used by forest managers to increase the productivity of forest lands. Some soils respond better to fertilization than others, and some are more susceptible to erosion after roads are built and timber is harvested. Some soils require special efforts to reforest. Soils vary in their ability to produce trees.

Recreation. Recreational uses include camping areas; picnic areas, playgrounds, paths and trails for hiking, horseback riding, and bicycling; and golf courses. Provision of camping areas requires the consideration of a number of factors, including preparation of tent or RV sites, parking areas, sanitary facilities, roads, and the installation of utility lines.
The best soils for camping areas have mild slopes, few or no stones or boulders, absorb rainfall readily and remain firm, are not dusty when dry, and are not subject to flooding. Picnic areas are subject to heavy foot traffic. The best soils are not subject to flooding and do not have slopes, stones, or boulders that increase the cost of shaping sites or building access roads and parking lots. Playgrounds require soils that can withstand intensive foot traffic. The best soils are level, are not subject to flooding, are free of stones and boulders, and are firm after rain and not dusty when dry. These same soil considerations are important for paths, trails, and golf courses.

**Wildlife Habitat.** Numerous elements provide for good wildlife habitat. They include grain and seed crops, grasses, and legumes, wild herbaceous plants, hardwood trees coniferous plants, wetland plants, shallow water areas, and open land. A primary factor in evaluating wildlife habitat is the plant diversity in the area. Increasing dominance by a few plant species is commonly accompanied by a corresponding decrease in wildlife. Soils affect the kind and amount of vegetation that is available to wildlife as food and cover.

Soil in its natural state is able to buffer changes in acidity or alkalinity. Acid forming substances, such as sulfates, are introduced to the atmosphere by industrial activities, especially the burning of coal or other fossil fuels, and by natural occurrences such as volcanic eruptions. These substances interact with rainwater to form acid rain. Soil’s buffering property allows rainwater to return into surface water and groundwater without the added acidity.

If soil has been altered in any way that lowers its buffering capacity, the net effects of acid rain on the ecosystem become more severe. The main processes that lower the buffering capacity of soil are removal of certain metal ions from the soil through leaching, erosion, or plant uptake; and lowering the organic matter content.

**Engineering Uses.** Engineering uses require a careful examination of soil characteristics and properties. Soil strength, shrink-swell potential, permeability, drainage, and erosion potential are all important factors to consider for building sites, roads, and sanitary facilities.

**Threats to Soil**

Humans have been cultivating soils to produce food and fiber for about the last 10,000 years. During that time, our ability to obtain higher yields has increased as knowledge and technology has increased. Some early civilizations were essentially wiped out as a result of using soil resources beyond their capabilities. The soils were too intensively used for crops causing erosion and nutrient depletion, and becoming inadequate for food production. Many farming, ranching, and industrial uses for land are threatening the soil health that allows us to feed and clothe the world. Today there is a heavy focus on restoring the health to our soils in order to continue producing food and fiber for future generations.

The most obvious cause for degradation of the soil is erosion. Erosion occurs when sloping or steep soils are cultivated or developed and left bare. Bare soil is easily washed away by rainwater or blown away by wind. Beyond agricultural fields that are cultivated and left bare, erosion also occurs when homes and businesses are built on land that is not suitable for holding structures. This leaves the surrounding ground unstable and can lead to mud-slides. In either case, the result is that the fertile topsoil is lost. Erosion
also causes other problems to the environment. Sediment washed from eroding fields is carried by water into streams and bodies of water. This sediment load, along with any chemical, contaminants, or nutrients it carries with it, can have a serious negative impact on water quality.

Pollution is another source of soil degradation. Pollution can come from different sources including human and natural. In the great majority of cases, human activities have caused the pollution problems. Certain heavy metals such as arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc are products of the industrial society and are quite hazardous. Unfortunately, these materials also tend to be quite persistent in soils, and are very difficult to rid the soil of them once it is contaminated. In recent years, legislation has been passed to set allowable levels of such substances in soil, air, and water. There are also new products being developed using polymers to bind heavy metals from soil to help clean up contaminated agricultural lands. Another source of pollution is natural. Pollution that is caused by such things as rocks or soil parent materials that are high in heavy metals or other contaminants. An example is certain gases and materials ejected during volcanic eruptions.

**Soil Conservation Methods**

There are many methods that have been developed to help conserve soil. Agricultural and residential practices are very similar and mostly differ on the scale in which they are implemented.

1. Keep soils covered by using cover crops that can be incorporated back into the soil through tillage when it is time to plant the next crop.

2. Cover the soil with mulch which can reduce the impact of rain drops and slow running water.

3. Conservation tillage practices are techniques of soil preparation and cultivation that disturb the soil in the least amount possible. Such practices include no-till, where a farmer does not plowing of the soil and plants the next year’s crop in the residue of the previous years, and low-till in which farmers plow a limited amount.

4. Contour Tillage is best for operations on hills or non-level land. It is the practice of tilling sloped lands along lines of consistent elevations.

5. Strip Cropping is a practice that uses alternating strips or rows of crop with a close-growing grass. This helps to reduce the amount of water that is lost as the grass roots will hold the soil in place and capture more water and soil form the crop rows.

6. Grass waterways are strips of grass that are grown in the field in areas where water tends to flow and cause erosion. This grass will stabilize the soil and protect it from run-off.

7. Terracing of land involves a wall or structure built across the slop to capture water and move it to an area where it won’t cause erosion.
Land Use Capability

Based on the characteristics of the soil profile, a land use capability classification can be assigned. Land use capability is the suitability of land for specific uses for agricultural production. The way in which the ground is used should not cause damage to the land. The land is judges as capability units, or groupings of one or more individual soil types that have similar potentials and limitations or hazards. The uses are judges based on the soil surface texture (top 7”), soil permeability, soil depth, slope, and potential for erosion and surface run-off.

Land Capability classes are based given using roman numerals I through VIII.

Class I: Good land that has no limitation, nearly level, has deep soil, good internal and surface drainage. Can be cropped every year without special practices to control erosion.

Class II: Good land - Land has deep soils with few limitations. The soil requires moderate attention with conservation practices. Contour plowing is a preferred method.

Class III: Moderately good land. This land has more limitations than Class II. Crops must be carefully selected as the land is often found on gently sloping hills. Increase attention must be given to conservation practices such as terraces and strip cropping. Land can be productive with proper management.

Class IV: Fairly good land. This class of land is the lowest that should be cultivated. It has very severe limitations that restrict the choices of crops and requires special conservation management practices. This land is on hills and has more slopes than found in Class III. The land is frequently subject to erosion, especially gullies.

Class V: Unsuit for cultivation. Class V lands can be used for pasture crops, cattle grazing, hazy crops, and tree farming. The land is often used for wildlife and recreation areas. The soil typically has good tilth and fertility but is restricted in use by rock outcrops or frequent overflow from nearby waterways. The land is often gently sloping or nearly level.

Class VI: Not suited for row crops- This land class has too many slopes fro growing row crops. The soil may have fair productivity if it has not been damaged by erosions. Gullies often quickly form if not carefully managed.

Class VII: Highly unsuit for cultivation. Class VII land has severe limitations. This class should not be cultivated. Best uses are permanent pasture, forestry, and wildlife. Slope is often well over 12 percent. The soil is very shallow. Large rock surfaces may be present. This land is often found in dry areas.

Class VIII: Unsuit for plant production. This land cannot be used for row crops or other crops in which the land is tilled. It is often lowland covered with water most of the time. The soil may be wet and high in sand or clay. This class of land is often used for waterfowl habitat.

Land Capability subclasses indicate factors that limit soil use by means of a letter code added to the number class:

- Runoff and erosion- Land with a slope greater than 2 percent
w  Wetness- soils may be poorly drained or occasionally flood.

s  Root Zone or tillage problems- soils are shallow, stony, droughty, infertile, saline

c  Climate hazard- areas of rainfall or temperature extremes making farming difficult

A land use capability may be listed as IIIe.

**Oklahoma Land Use Capability Classes**

<table>
<thead>
<tr>
<th>Land Class</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I, II</td>
<td>28%</td>
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<tr>
<td>Class III</td>
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<tr>
<td>Class IV</td>
<td>16%</td>
</tr>
<tr>
<td>Class VI</td>
<td>18%</td>
</tr>
<tr>
<td>Class VII, VIII</td>
<td>16%</td>
</tr>
</tbody>
</table>

**SKILLS PRACTICE**

**Determining Slope Using a Clinometer (Post method)**

1. You'll need 2 posts the same height. Place one post in the ground at the top of the slope and the other at the bottom of the slope. Make sure that both posts are the height out of the ground.

2. Place the clinometer on the top of one of the posts. Keep both eyes open. Determine which side of the scale has the percentage sign. This is the side you use when determining a slope.

3. Hold the clinometer up to your right eye. Be sure that the hand holding the clinometer is not obstructing the vision of your other eye

4. While holding the clinometer to your eye, line up the crosshair with the top of the other post

5. Read the number on the scale with the percentage sign that corresponds with the crosshair.

6. Line up that reference point with the crosshair visible in the clinometer and read the right hand scale. This will tell you the percent of the slope.
How to Read a Soil Survey
• https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053375

Web Soil Survey
• https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

How to use Web Soil Survey
• https://websoilsurvey.sc.egov.usda.gov/App/Help/WSS_HomePage_HowTo_3_0.pdf