ENVIROTHON SOILS GUIDE

This guide contains the information that teachers and students need to compete in the soils portion of the Tennessee Envirothon. Answers to contest questions will come directly from this material, or can be inferred from the information presented. The Envirothon competition is based on a team problem-solving concept. For this reason, some questions may require competitors to use information given to them to conclude answers to questions about soil/environmental issues not specifically discussed in the text. Answers to such questions can be formulated from the information presented in this guide. The list of references included recognizes major sources for the presented material. It is not necessary for students or teachers to review these references in preparation for competition.

PART I
ORIGINS AND USES OF SOILS AND RELATED ENVIRONMENTAL CONCERNS

WHAT IS SOIL? (Useful website: http://soils.usda.gov/)

- Soil--a three dimensional natural body covering much of the earth's land areas.
- Soil forms through the following natural processes:
  1. weathering and erosion of bedrock
  2. formation of minerals in the soil as part of weathering
  3. activities of plants and animals that influence soil characteristics

THE IMPORTANCE OF SOIL

- Mechanical support of the plant and root system
- A reservoir for water and plant nutrients
- An essential natural resource like air and water necessary for the existence of life on

earth

- Soil --not a renewable resource because soil formation processes occur over long periods of time that are not in the human time frame.

THE COMPOSITION OF SOIL

- Soil is composed of 5 main components—mineral matter, organic matter, water, air, and living organisms.
- Mineral matter--the major constituent of most soils. 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 what is called soil. The mineral portion of the soils is divided into three size constituents of particles less than 2 millimeters (mm) in diameter.
    1. Sand
    2. Silt
    3. Clay

    Any particle larger than 2 mm is not considered soil, but is called a rock
- Organic matter or humus--derived from dead and decaying plants and animals. Living roots and organisms are not considered in the definition of soil organic matter.
    1. Organic matter makes up between 0 and about 18% of most soils.
    2. Organic matter tends to give soil a dark color. These soils are sometimes referred to as dark or “rich” soils.
    3. Organic material is most often concentrated near the soil surface or topsoil because derived mostly from breakdown of plant materials. The lower part of

the soil or subsoil generally decreases in amount of organic matter with depth.

4. Soil organic matter can retain water in the soil for plant use and is chemically active to be able to store nutrients, pollutants, or other chemicals.
5. The presence of organic matter in the soil makes the topsoil easier to plow, till, and plants to grow in by improving soil structure which adds more pore space, water, and air to allow other materials to move easier through the soil.

- Water—held within pore spaces and voids in the soil. Voids make up between 25 and 75% of volume of most soils.
    1. Water moves through the soil and into the groundwater table. As it moves through the soil, the water picks up minerals and other materials from the soil and carries these into the groundwater. This action accounts for much of the mineral content in groundwater.
    2. Plant roots take up water that does not reach the groundwater, and part of it is held so tightly within small pore spaces in the soil that roots are not able to extract it from the soil.
    3. Although a very small part of the total water on earth (perhaps as little as 0.001 to 0.005 %) is stored in soil, this tiny portion of the earth's water supply is essential to plant growth and climate moderation.
- Air—occupies voids in soil not occupied by water.
    1. Air in the soil is richer in carbon dioxide than air in the atmosphere.
    2. Soil air, along with organic matter and soil water, plays a part in the natural cycling of carbon, nitrogen, and sulfur through the biosphere.

3. Soil also absorbs some types of air pollutants, including sulfur dioxide, hydrogen sulfide, hydrocarbons, carbon monoxide, and various nitrogen gases.

- Living organisms--microbes, bacteria, fungi, earthworms, plant roots, insects, and small animals that live in the soil.
    1. These organisms play various roles in breaking down organic matter in soils.
    2. They also mix and move the soil, therefore affecting its structure and porosity.

Even though the components of the soil are described and thought of individually, most soil properties arise out of interactions among the various components. An example is the water content of a given soil is in part determined by the amount of sand, silt, clay, and organic matter present in the soil.

ROCK WEATHERING AND SOIL FORMATION

- **Weathering**--the process of breaking down rocks into smaller and smaller pieces and altering the amounts and kinds of minerals present. Most of the material soils are made of began as hard rock.
- Weathering of rocks into soil occurs through two processes called physical weathering and chemical weathering.
    1. **Physical weathering** occurs through erosion of rock by water, repeated freezing and thawing, and cycles of heating and cooling. Physical stress is created in the rock to break it into smaller and smaller blocks or sheets. The volume of water increases 9% when it freezes, so if water is present in cracks of the rock and then freezes, enormous stress occurs and the rock fractures.

Other sources of heat, such as forest fires, create similar thermal expansion in rocks causing them to fracture.

2. **Chemical weathering** occurs when parts of a rock's mineral structure dissolves in water. The undissolved parts of the rock crumble into smaller pieces. The smaller the pieces, more surface area is present for chemical and physical weathering agents to work on breaking down the material even more.

Weathering continues to occur in soils throughout their existence. Many of the clay minerals in soils form in place through the chemical and physical alteration of other minerals present.

SOIL FORMATION

- Soil formation—result of the following five factors: parent material, time, climate, topography, and organisms
    1. First is **parent material**. Soils formed in different parent materials have different properties. The weathered rock debris in which a soil forms is called its parent material. Parent materials are named according to *if* and *how* the debris was moved before the soil started to form. Five main types of soil parent materials exist in Tennessee.
        - residuum--a parent material that weathers to soil in place, no movement
        - alluvium--debris moved by water and redeposited before soil formation
        - colluvium--debris that is moved by gravity (as sliding down a steep

slope)

- marine sediments--unconsolidated (soft) sediments deposited by ancient oceans
- Loess--fine debris that is moved long distances by wind and redeposited

2. The second factor is **time**. The longer a soil weathers, the more its mineral composition changes. This has a large influence on soil behavior.
3. **Climate** greatly affects soil weathering because water is such a powerful chemical and physical weathering agent. Soils vary in different areas of the world according to how much rainfall occurs. Areas of higher temperatures usually have more highly weathered soils because with every 10°C rise in temperature the speed of a chemical reaction increases by a factor of two to three.
4. **Topography** refers to the shapes and steepness of slopes soil forms on. Soils on steeper slopes experience more runoff of rainfall, thus more erosion. Also, since more water runs off, less water infiltrates the soil surface, and therefore the soil does not weather as deeply.
5. **Organisms** refer to the plants growing in soil as well as those organisms living in soil. Soil is churned by roots and burrowing animals, changing its characteristics. Also, different organisms leave behind different amounts of organic matter. Therefore, a prairie soil that formed under tall grasses will be dramatically different from a soil formed under hardwood forest.

SOIL- A NATURAL RESOURCE

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. For this reason, these civilizations were primarily starved out of existence because they could no longer feed their populations.

SOIL DEGRADATION

- **Erosion**--the most obvious cause for degradation of the soil when used for agriculture. Erosion occurs when sloping or steep soils are cultivated and left bare. Bare soil is easily washed away by rainwater or blown away by wind. 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.
- To prevent erosion of cropland, such things as winter cover crops and crop residue use are very valuable.
    1. Any kind of ground cover helps prevent erosion, whether it be a living plant like clover or rye used as winter cover, or decaying residue from the past year's crop which serves as a type of mulch.

2. Moving crops from one area to another (called crop rotation) to prevent constant cultivation on sloping land is also a useful conservation practice.
3. If steeper lands are used for crops, it is often necessary to use a conservation tillage method in which seeds or plants are grown in killed sod, and no plowing is done.

Numerous specialized techniques are available that are variations of these basic ideas. The main objective is to insure the future food supply for our civilization by making conservation of the soil a priority.

POLLUTION--when a part of the environment is made harmful or offensive to organisms that depend on it. In many cases the organism in question is humans. Pollution comes from high concentrations of contaminants in the ecosystem.

- 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.
- **"Natural pollution"--**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.
- Increased concentrations of carbon dioxide, chlorofluorocarbons (CFC's), methane, and nitrous oxide are thought to bring about climatic changes such as warming and

ozone depletion. All of these substances except CFC's are produced in soils. In fact, soils are the main source of nitrous oxide and methane in the atmosphere. These are by-products of the breakdown of organic materials in the soil.

USES OF SOIL

Humans have come to depend on soils for many things other than crop production.

- As a source of building material made from clay or sand.
- A number of food products contain materials that are taken from clay minerals.
- 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.
- 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.

SOIL QUALITY-- Soil Quality Information Sheets (found on the following website: **http://www.soils.usda.gov/sqi/)**

Because of the great interdependence among parts of the ecosystem, the soil is intimately a part of what happens in the areas of forestry, agriculture, wildlife, aquatics, etc. The interactions among natural systems are many and inseparable. Changes in any component of an ecosystem affect changes in the other components. Soil quality is a term being used to describe the ecological condition of soils. The soil quality concept is receiving wide recognition as a useful means of evaluating soil conditions.

- **Soil quality** (also called soil health)--the ability of a soil to function as part of an ecosystem, and to positively interact with its environment. This definition has led to the use of various soil properties as indicators of if or how a soil may have been adversely affected by human uses.
- The emphasis in soil quality is related to the concept of sustainability, particularly agricultural, ecological, and economic sustainability of the soil resource.
- Soil quality indicators reflect how a soil functions in several major ways in the ecosystem.
    1. Can the soil accept and release plant nutrients and water to plants, streams, and groundwater?

2. Can it promote and sustain root development?
3. Does it provide a suitable habitat for soil organisms?
4. Does the soil respond well to management and resist degradation?

- Major soil properties used to indicate quality of a soil to perform these various functions include **soil texture, organic matter content, acidity or alkalinity (pH), subsoil structure, density, and presence of organisms**.

References

Birkeland, Peter W. 1984. Soils and Geomorphology. Oxford University Press. New York.

Bohn, H.L. , McNeal, B.L. and O'Connor, G. A. 1985. Soil Chemistry. 2nd ed. John Wiley and Sons. New York.

PART 2
IDENTIFYING AND DESCRIBING SOIL PROPERTIES AND FEATURES
IDENTIFYING PROBLEMS AND RECOMMENDING MANAGEMENT MEASURES

This part contains the information to use in answering questions about specific soil properties, as well as some management issues. Several important soil properties and features are described. At the contests, students will be shown soil profiles, either in pits, road cuts, or by other means, and recognize and describe some of these soil properties, and make some soil interpretations based on the information given in this section.

SOIL TEXTURE

- **Soil texture** is probably the single most important soil property.
- It affects movement of water absorption, water movement in the soil, how much water soil provides to plants, and how easily pollutants can leach into groundwater.
- It also affects many land uses and cannot be changed without great cost and effort.
- Texture is the proportion of sand, silt, and clay in the soil.
    1. **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.
    2. 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.
    3. 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.

- Although it is possible to describe up to 12 classes of soil texture, three groups of texture will be used in the Tennessee Envirothon competition. These are called coarse (sandy), medium (loamy), and fine (clayey).

For contest purposes, the texture of the surface layer will be taken from the upper 7 inches, and the texture of the subsoil will be taken between 18 and 24 inches of the subsoil.

- Texture is judged by rubbing a moist sample of soil between the thumb and finger.
- The consistency of the sample should be like firm mud or modeling clay.
- Press the ball between the thumb and finger, trying to form a thin ribbon.
- Refer to the following table for information on determining which of the three classes the sample is in.

Textural Group	Description
Coarse (sandy)	Will not form a ribbon. Feels very gritty because it is mostly sand. The ball holds together loosely, but falls apart easily when handled.
Medium (loamy)	Either will not form ribbon, or form a very short ribbon that breaks easily. Ball will hold together. The ball may fall apart easily if there is considerable sand, or it may compress slightly without cracking when pressed. Will not leave a shiny surface when ball is smoothed with fingernail or knife blade. May feel sticky when wet.
Fine (clayey)	Forms a ribbon easily. Ribbon holds together well. Ball of moist soil can be molded into shapes with little cracking. When smoothed with fingernail or knife blade, leaves a shiny surface. Very sticky when wet.

ROOTING DEPTH

- Rooting depth is the depth of soil and parent material that allows root penetration through most of its volume.
- Rooting depth stops at soil or rock layers that either stop roots or limit their growth to

only a small part of the volume.

- A few roots may be found growing in cracks in some types of root restricting layers, but they cannot penetrate the areas between the cracks. If root growth is only observed in cracks, the layer is considered unfavorable for roots.
- Rooting depth is important because it represents the soil volume plant roots can extract water and nutrients from. It also affects the mechanical support for large plants such as trees.
- Four classes exist for rooting depth.

DEEP	36 inches or more
MODERATELY DEEP	20 to 36 inches
SHALLOW	10 to 20 inches
VERY SHALLOW	less than 10 inches

ROCK FRAGMENTS

- **Rock fragments** in the soil are mineral particles larger than 2 millimeters in diameter. Fixed outcrops of bedrock are not considered as rock fragments.
- Presence of rocks in the soil affects water storage, infiltration, and runoff. If rocks occupied 50% of a soil's volume, it would have about half the water holding capacity of a similar soil with no rocks.
- Rock fragments also interfere with tillage, depending their size and number.
- Rock fragment content is determined by estimating the volume of the whole soil occupied by the rock fragments. A rough estimate can be determined by the following method:

1. Separate the fragments (>2 mm) from the fines (<2 mm).
2. Estimate the percentage of the material made up of fragments. For example, if the stack of fragments is 1/4 as high as the stack of fines, there are about 25% rock fragments by volume.
3. Three classes are used.

NONE OR FEW	0 up to 15% by volume of rock fragments
COMMON	15 to 35%
MANY	more than 35%

Rock fragment content is averaged over the entire rooting depth.

ROCK OUTCROPS

- **Rock outcrops** are hard, fixed exposures of bedrock.
- Limestone is the most common type of rock outcrop in Tennessee, but outcrops of any bedrock type can occur.
- Rock outcrops cannot be removed using ordinary machinery.
- Rock outcrops are usually described based on the percent of the ground they cover and the distance between them.

For the purposes of the Tennessee Envirothon, any question about rock outcrop will only deal with their presence or absence.

SOIL COLOR (useful website: http://www.mo14.nc.nrcs.usda.gov/features/colorofsoil.html **)**

- Soil color reveals a lot about what the soil is made up of.
- Organic matter produces dark colors in soils.
- Brown and red soil colors are usually produced by types of iron oxides in the soil.
- Soils that are very light colored (particularly those high in sand and silt) have colors

that represent the colors of the minerals present.

- One of the most important things about soil that can be learned from its color is whether or not it is wet or has drainage problems.
    1. Gray colors develop in soil layers where water remains for a large part of the year.
    2. When soil minerals are saturated with water for long time periods, the iron in the soil is turned to a gray color. This is what happens in soil with high water tables or soils that have layers that prevent water from moving through.
    3. The entire soil layer may be gray, or the gray colors may occur as splotches(mottles) or small contrasting areas in the soil.

These contrasting splotches (mottles) may be referred to by several terms; but for the purposes of the Tennessee Envirothon refer to them as mottles.

SOIL WETNESS

- Soil wetness relates to how readily water is drained from the soil profile.
- Red, brown, or yellow soil colors indicate that water is removed readily from the soil.
- Soil wetness influences the soil in several ways.
    1. Water standing in soil limits root penetration.
    2. Wet soils warm up slowly, delaying land preparation or harvesting.
    3. Wetness influences land use, crop management, adapted plants, planting and harvesting dates, and crop yields.
- The soil wetness class will be used in the Envirothon competition as a means of determining how high water comes within the soil profile. The wetness class is

determined by measuring the depth to any gray mottles or gray soil layers. Five wetness classes are used.

CLASS 1	no gray colors above 60 inches or within depth of pit if pit is less than 60 inches
CLASS 2	gray colors at depths between 40 and 60 inches
CLASS 3	gray colors at depths between 20 and 40 inches
CLASS 4	gray colors at depths between 10 and 20 inches
CLASS 5	gray colors at depths shallower than 10 inches

AVAILABLE WATER HOLDING CAPACITY

- **Available water holding capacity (AWHC**) is the amount of water a soil can store and release to plant roots.
- Sandy soils hold little water and are therefore droughty.
- Clay holds a large amount of water, but much of it is held so tightly by the clay that plant roots cannot extract it. For this reason, clayey soils have intermediate AWHC.
- Silt particles hold a moderate amount of water, most of which plant roots can extract. Therefore, medium textured soils high in silt have the highest AWHC and are least subject to drought.

In the Envirothon, AWHC is estimated based on the textural group, rooting depth, and rock fragment content. It is expressed as inches of water a soil can hold per inch of soil depth, based on texture as follows:

Texture Group	AWHC inches/inch
COARSE	.05
MEDIUM	.20
FINE	.15

Follow these steps to determine AWHC of a soil:

1. Determine the rooting depth. If 36 inches or more, use 36 inches.

2. Determine the thickness of each layer in the rooting depth having different textures (coarse, medium or fine).

3. Multiply the AWHC for each different texture (from table above) by the thickness of the layer it corresponds to.

4. If any layers contain 15 or more percent rock fragments, reduce the AWHC for that layer by the percentage of rock fragments, because the volume occupied by rocks will not store water.

5. Add the AWHC for each layer to determine the total. Assign an overall AWHC for the soil using the following table.

AWHC of Soil	Total Inches of AWHC
LOW	Less than 4.0
MEDIUM	4.0 to less than 6.0
HIGH	6.0 or more

Examples of AWHC calculations:

A. Medium textured soil with less than 15 percent rock fragments and rooting depth of 26 inches.

26 inches x .20 inches/inch = 5.2 inches total

AWHC is medium.

B. Rooting depth > 36 inches -- use 36 inches. Top 10 inches is medium textured, lower 26 inches is fine textured. Rock fragments < 15% throughout.

10 inches x .20 inches/inch = 2.00
26 inches x .15 inches/inch = 3.90
Total = 5.90

AWHC is medium.

C. Rooting depth > 36 inches -- use 36 inches. Top 15 inches is medium textured with 20% rock fragments. Lower 21 inches is fine textured with 30% rock fragments.

15 inches x .20 inches/inch Minus 20% for rocks = 2.40
21 inches x .15 inches/inch Minus 30% for rocks = 2.20
Total = 4.60

AWHC is medium.

SOIL SLOPE

- **Soil slope** is the vertical change in elevation over a given horizontal distance.
- Slope is expressed as a percent, which is the change in elevation divided by the horizontal distance times 100 percent.
- Example: elevation change of 8 feet over a horizontal distance of 50 feet. 8 ft. / 50 ft. x 100% = 16% slope.

For the Envirothon, stakes will be placed at a given distance. Students will estimate the vertical elevation change over that distance to determine the soil slope.

- Slope classes of soils are used by soil scientists for mapping soils into management units.
- Soil slope is a very important management factor since erosion hazard becomes greater as slope increases.
- Steeper slopes also have more runoff, are droughtier, and limit the use of machinery.
- The following slope classes are to be used by Envirothon contestants.

	Middle & East TN	West TN
Nearly level	0 to 2%	0 to 2%
Gently sloping	2 to 5%	2 to 5%
Sloping	5 to 12%	5 to 8%
Moderately steep	12 to 20%	8 to 12%
Steep	20 to 30%	12 to 20%
Very steep	30% or more	20% or more

DEGREE OF SOIL EROSION

- **Erosion** is the removal of soil from the soil surface by flowing water or by wind.

- Erosion is a natural process that shapes the landscapes over long time periods.
- Soil erosion becomes a concern, however, when human activities such as agriculture or construction increase it to a rate far beyond the natural rate.
- Erosion by water results when sloping and steep soils are left unprotected by vegetation or some type of ground cover such as crop residue or mulch.
- The energy of raindrop impact detaches soil particles, which are carried down slope in runoff water.
- In most soils, the original topsoil has higher fertility, better structure, higher water holding capacity, and less clay than the subsoil.
- More eroded soils have lost original topsoil, and tend to have lower productivity. The amount of lost productivity depends on the degree of erosion, and the difference between the original topsoil and subsoil.
- Erosion is especially damaging on soils that have limited rooting depth. When rooting depth is decreased further by erosion, the AWHC is decreased and droughtiness is increased.
- The ideal way to determine degree of soil erosion is to compare with an uneroded soil under natural vegetation. Since this is not usually possible, Envirothon contestants will estimate degree of erosion using the following guidelines. Remember that most Tennessee soils have subsoils with more clay than the original topsoil, and the original topsoil of most of these soils was similar in thickness to original plow depth. *These estimates are based on the upper 7 inches of soil if no distinct plow layer is visible.* Three classes are used.

NONE TO SLIGHT -- The plow layer contains less than 25% or original subsoil material.
MODERATE -- The plow layer consists of 25 to 75 % of original subsoil material.
SEVERE -- The plow layer consists of more than 75 % of original subsoil material.

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.
- Desirable structure improves the tilth or workability of the soil.
- It also improves how water, air, and other substances move through the soil.
- Granular structure is quite desirable in topsoils because they have a large proportion of openings between peds.
- A lack of soil structure leads to problems with root penetration and water movement through the soil profile.
- Two common types of soil structure are as follows:
    1. **GRANULAR**-- Aggregates are small and weakly held together. They are roughly spherical in shape. Granular structure is common in topsoils in Tennessee.
    2. **BLOCKY**-- Aggregates are either angular on the corners, or somewhat round (subangular). Peds vary in size from about 1/16 to 1 inch in size. Blocky

structure is common in Tennessee subsoils.

LANDSCAPE POSITION

- **Landscape position** refers to the location of a soil relative to the landscape surrounding it.
- Position is often related to the type of parent material.
- Position is important because it is related to flood hazard, water supply, and wetness problems.
- Four landscape positions are recognized.

1. **FLOOD PLAIN --** Nearly level areas adjacent to streams and upland drainage ways that are subject to flooding. Flood plains are prone to periodic flooding unless protected by dams or levees. These are the lowest areas of the landscape. Soils in flood plains usually have relatively little profile development, meaning the topsoil and subsoil is quite similar in properties. **The parent material associated with flood plains is alluvium**.
2. **FOOT SLOPE --** The area at the base of a slope where material accumulates after moving down the slope. They are concave positions, meaning the slopes above them are steeper than the slopes below them. The soils in foot slopes generally have slight to moderate profile development. They are not usually subject to flooding. Foot slopes receive runoff from higher areas, giving them a higher source of water for plants. **The soil parent material is at least partly colluvium, although the lower soil layers may be in residuum or alluvium.**

3. **DEPRESSION --** A low area surrounded on all sides by higher land. There is no natural outlet for water to run off. Open holes in the bottom of sinkholes are *not* considered outlets for surface water. Most depressions flood or pond during heavy rain periods. Soils in depressions usually have slight to moderate profile development. **The parent material consists of mixtures of alluvium, colluvium, and residuum.**
4. **UPLAND OR TERRACE --** Actually two positions, often difficult to distinguish on the landscape. They are side slopes, ridge tops, and broad, level to gently sloping areas higher in elevation than flood plains. The soils usually have moderate to strong profile development. Terraces are actually old flood plains that have been left above the modern flood plain by erosion and landscape development. **The parent material on upland soils is commonly residuum or marine sediments. These materials may be overlain by loess or influenced by colluvium in some areas. Soils on terraces form in alluvium, but are often very highly weathered and do not resemble soils on modern flood plains.**

POTENTIAL ENVIRONMENTAL PROBLEMS

In addition to controlling erosion to maintain soil productivity, proper agricultural management should avoid other offsite damage to the environment. The major environmental problem related to agriculture is water pollution. Envirothon contestants will determine potential for two types of water pollution problems. Potentials are rated as high, medium, or low.

1. **SEDIMENT, NUTRIENTS, AND/OR PESTICIDES IN STREAMS**. Sediment is

probably the most common water quality problem associated with Tennessee agriculture. Nutrients and/or pesticides may be attached to the sediment or dissolved in runoff water. Potential sediment movement is related to potential for erosion. Potential classes for this problem on croplands are rated as follows: *(Cropland is defined as land that is <20% slope, deeper than very shallow, has no more than few visible rock outcrops, and is in wetness class 1, 2, 3, or 4.)*

HIGH - *cropland* with slopes greater than 5 percent

MEDIUM - *cropland* with slopes between 2 to 5 percent

LOW - *cropland* on 0 to 2 percent slopes, or land not suitable for crop production. Land not suitable, as used here, means land > 20% slope, or that is very shallow, or has numerous rock outcrops, or is in wetness class 5.

2. **NITRATES AND/OR PESTICIDES IN GROUNDWATER**. This hazard exists in situations where nitrogen fertilizers or pesticides are not properly used. Potential problem areas have soils that allow water to move rapidly through the soil profile, meaning the soil is not capable to filter out the contaminants before they reach the groundwater.

HIGH - soils with coarse texture in the subsoil beginning at less than 24 inches, and extending to a depth of 36 inches or more to bedrock; or soils which are shallow or very shallow to bedrock, or soils in wetness class 4.

MEDIUM - soils with a medium texture between 18 and 24 inches, but with coarse texture beginning between 24 and 36 inches and extending to 36 inches or more to bedrock, or soils in wetness class 3. Also, soils with medium textured subsoils that are moderately deep to bedrock, or medium textured soils that have many rock fragments, regardless of depth.

LOW - other soils, or soils not suitable for *cropland*.

CONSERVATION AND MANAGEMENT PRACTICES

- Good conservation and soil management systems include a number of practices.
- Practices used depend on the limitations of the soils and landscape characteristics at the site.
- Some of the more important practices are given below with criteria for recommending them. *Note: the term cropland, as used here, means land that is <20% slope, is deeper than very shallow, has no more than few visible rock outcrops, and is in wetness class 1, 2, 3, or 4.*

    1. **CONSERVATION TILLAGE/NO-TILL** - Conservation tillage systems are those that leave at least 30% of the soil surface covered by residue after planting. These systems are highly effective in controlling erosion. No-till, which disturbs only enough soil to allow seed placement, is the most effective form of conservation tillage. Management problems limit the use of conservation tillage in some crop situations. But, because it is highly effective and economical, it is recommended on all *cropland* with slopes of 2% or more.
    2. **TERRACES** - These are constructed ridges and channels across slopes that closely follow the contour or shape of the landscape. They catch and carry runoff out of the field in a non-erosive manner. Terraces empty into an outlet, either by a pipe or waterway. Terraces can be effective, but are expensive to install and maintain. Terraces are recommended on *cropland* with slopes of 2 to 8%.
    3. **GRASSED WATERWAYS** - a vegetated channel, either natural or

constructed, designed to prevent gullying and collect runoff water from contour rows or terraces and carry it off the field. Waterways are recommended on *cropland* with slopes greater than 2%.

4. **CONTOUR FARMING -** This means conducting farming operations and running crop rows across the slope, rather than up and down the slope. Operations should parallel the contour of the land as much as possible. Contour farming is recommended on *cropland* with slopes greater than 2%.
5. **STRIP CROPPING -** Growing crops in a pattern of alternating strips across the slope. Strips of row crops are grown between strips of close growing crops or grass. It is recommended on all *cropland* with slopes greater than 2%.
6. **FILTER STRIPS -** These are strips of grass or other perennial vegetation. Strips are placed along the border of cropped fields in areas where runoff leaves the field. Filter strips filter out sediment, nutrients, and chemicals from runoff before it enters streams, thus protecting water quality. Filter strips are recommended for all *cropland*.
7. **COVER CROPS -** These are crops planted in the fall to provide vegetative cover during the winter. They protect soil from erosion during this period. They are either small grains or annual legumes such as vetch or crimson clover. They are recommended for all *cropland* with slopes greater than 2%.
8. **APPLY LIME, FERTILIZER, AND OTHER MATERIALS ACCORDING TO SOIL TEST OR LABEL RECOMMENDATIONS -**

Most Tennessee soils need nutrient additions to remain productive over time. To guess about nutrient needs can be expensive and improper or unnecessary applications of fertilizers or pesticides can be expensive and potentially harmful to the environment. Therefore, all *agricultural land* should have regular soil tests conducted, and applications of lime and fertilizer should follow those recommendations. Pesticides should only be applied according to label directions.

USEFUL REFERENCES

Denton, H.P. 1993. Tennessee Land Judging Guide. University of Tennessee. Agricultural Extension Service.

"From the Surface Down" An Introduction to Soil Surveys for Agronomic Use

http://www.tn.nrcs.usda.gov/technical/soils/whatis.html

http://school.discovery.com/schooladventures/soil/index.html

SAMPLE QUESTIONS

1. The smallest soil particles are called ______________
   a. clay   b. silt   c. gravels   d. loams

2. List the 5 major soil forming factors.
   __________   ___________   ___________   _________   ________

3. On less steep slopes, infiltration of rain water is higher than on steep slopes.
TRUE FALSE

4. Rock fragments are those mineral particles in soils that are greater than _____ millimeters in diameter.

5. Which of the following soils is most effective in delivering water to plants during dry seasons?
   a. clay soil high in rock fragments
   b. sandy soil with no rock fragments
   c. medium textured soil, high in silt with none or few rock fragments
   d. fine textured soil containing none or few rock fragments

6. Soils on steep slopes usually weather more deeply than soils on more level areas.
TRUE FALSE

The following questions concern the pit and the field in which the students are standing.

7. What is the soil wetness class of this soil?
Class 5 wet within 10 inches
Class 4 wet between 10 and 20 inches
Class 3 wet between 20 and 40 inches
Class 2 wet between 40 and 60 inches
Class 1 not wet within 60 inches (or to bottom of pit)

8. Which soil structure type best represents the subsoil in this pit?
Granular Subangular blocky

9. Terraces would be an appropriate conservation practice to recommend on this field.
TRUE FALSE

10. What is the texture of the surface soil or topsoil?
coarse medium fine