Connecticut Envirothon
Soil Manual

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The pictures on the front cover are of the Woodbridge soil – a typical wooded landscape and a profile of the soil from an agricultural field. Woodbridge soils are found throughout Connecticut.

Introduction

How you define and characterize soil depends on your background. Many geologists combine everything above bedrock into a category called "overburden." Farmers view soil as a medium for plant growth. Engineers view soils as areas to build on.

The characteristics that make some soils highly desirable for agriculture also make them desirable for development. Engineers are concerned with many of the same physical characteristics that interest farmers: soil drainage, texture, depth, slope, and position in the landscape. Because of increasing land conversion to development, the loss of highly productive agricultural land is an issue causing concern in many states and communities.

When assessing the characteristics of a large parcel of land, it can be helpful to divide the parcel into smaller pieces which can be evaluated separately. For example, a 100 acre parcel may have 60 acres of open land and 40 acres of woodland. The 60 acres of open land could be split into 20 acres of steep pasture, 20 acres of gently sloping hayland, and 20 acres of nearly level cropland. The woodland could be split into 10 acres of shrubby wetland, 20 acres of sloping hardwoods, and 10 acres of steep softwoods. Each of these pieces can be evaluated for their potential for different uses.

This is what soil and land judging is all about -- judging a parcel of land and its soils for their potential for agriculture, forestry, and development. In the Envirothon Contest, a soil pit and adjacent land unit to be judged will be clearly identified. The soil is the factor we will evaluate most intensively. In this competition, land may be evaluated primarily from the agricultural, forestry, and engineering (development) standpoint.

This guide is meant to serve as a primer on soils for the Connecticut Envirothon.

Factors of Soil Formation

The formation of the soils in Connecticut involves many factors. The following excerpt from the *Soil Survey of the State of Connecticut* describes these factors in detail to provide some background for this manual.

Soil forms through the interaction of five major factors:
1) the physical, chemical, and mineral composition of the **parent material**;
2) the **climate** under which soil material has accumulated and existed since accumulation;
3) the **plant and animal life** on and in the soil;
4) the **topography** (lay of the land); and
5) the length of **time** the processes of soil formation have acted on parent material.

Parent Material

Parent material is the unconsolidated material in which soils form. Most of the different parent materials in Connecticut are related to the glaciers that covered New England about 15,000 years ago. Some of these materials were also affected by subsequent actions of wind and water.

Parent material determines the baseline chemical and physical composition of the soil. Even though most of the parent material in Connecticut is of similar glacial origin, the properties can vary greatly, sometimes within small areas. General categories of parent material in the state include glacial till, outwash deposits, lacustrine deposits, alluvial deposits, and organic deposits.

Glacial till was deposited directly by glaciers. It is a mixture of particles varying in size and shape. The coarse sand, gravel, cobbles, and stones so common in glacial till have not been worn smooth by flowing water like coarse fragment in outwash deposits – thus on close examination, these fragments have sharp, angular edges and corners. Glacial till can vary in acidity, depending on whether there is limestone bedrock in the area or not. It is usually loamy textured, although in some places, it can be silty or sandy. Many soils in Connecticut formed in glacial till, including the Paxton soil.

Glacial outwash deposits were deposited by running glacial meltwater. Most of these deposits are sandy or gravelly, especially in the lower part of the soil profile, and are located along streams and rivers above the level of the floodplain. Outwash deposits generally consist of layers (or strata) of soil particles of similar size, such as strata of sand or gravel. The Windsor soil is an example of a soil formed in sandy outwash deposits.

Alluvial deposits are material deposited by floodwater of streams in recent times. These deposits are found adjacent to stream channels. They range in texture from loamy and silty to sandy, depending in part on the speed of the floodwater that deposited the material. Alluvial deposits are typically stratified. The Hadley soil is a common soil formed in alluvial deposits.

Lacustrine deposits were deposited in still or ponded water in glacial lakes that were formed when the glacier blocked river and stream valleys. In this still water environment, finer soil particles such as silt and clay settled to the bottom. When the lakes eventually drained, the lacustrine deposits remained. Soils that formed in lacustrine deposits typically have clayey or silty textures, with very few sand particles or gravel. Many low-lying soils in the Central Valley, including the Brancroft soil, formed in clayey lacustrine deposits.

Organic deposits consist primarily of slightly to well decomposed plant material. In most places, a long period of saturation in depressional areas has been a factor in the build-up of these deposits. Some of the depressional areas actually began as ponds. The ponds were surrounded by grasses and sedges, which died and started accumulating in the water. The plant remains eventually closed in the edges of the ponds. Water-tolerant trees also grew in and around the ponds and the remains of the trees also accumulated in the water. Eventually, the ponds totally filled in with organic deposits. The Catden soil is a common Connecticut soil formed in organic deposits more than 50 inches thick.

Plant and Animal Life

Plants are one of the principal types of organisms influencing soil formation, but bacteria, fungi, earthworms, and human activities are also very important. Plants add organic matter and nitrogen and other nutrients to the soil. The kind of organic material in the soil depends on the plants growing on the soil. For example, organic material from pine and hemlock trees varies substantially from the organic material from native grasses found in the Great Plains states.

Plant remains accumulate on the surface, decay, and become incorporated into the soil with the help of various soil organisms. Plant roots provide channels for the downward movement of water through the soil and add organic matter to the soil as they decay. Soil bacteria help to break down the organic matter and release plant nutrients.

Climate

Climate affects soils in many ways. It can influence the kind of plant and animal life in the soil. Through its affect on soil temperature and moisture conditions, it influences the rate of chemical and biological activity in the soil. In colder soils and in soils saturated for long periods, the level of biological activity is low and organic matter accumulates. Chemical processes occur at a faster rate in warmer soils.

The climate in Connecticut differs from place to place, depending on elevation and physiographic region. There are two different soil temperature regimes recognized in the state: 1) the *mesic* soil temperature regime in most of the state and 2) the *frigid* soil temperature regime on the highest hills and mountains of northwestern Connecticut, generally above 1500 feet in elevation.

Topography

Topography (the lay of the land) or landscape position has a marked influence on soil formation through its influence on drainage, erosion, plant cover, and soil temperature. Relief is measured by the “percent slope.” Slopes in Connecticut range from a nearly level 0% to very steep slopes well over 70%.

Relief influences the formation of soils by affecting runoff and drainage. On steeper slopes, runoff is greatest and the soils are better drained. On flatter slopes, water drains off soils more slowly. In low-lying depressional areas, the soils are often temporarily ponded. Water and air move freely through soils that are well drained and slowly through soils that are poorly drained. Through its effect on aeration and the oxidation-reduction status of minerals in the soil, drainage influences the color of the soil.

Well-aerated soils are brightly colored reddish-brown, because the iron and manganese compounds have been oxidized and have a rusty color. Poorly aerated soils are dull gray and mottled, due to iron and manganese being reduced. The wettest soils smell of hydrogen sulfide gas (with a rotten egg smell) because sulfur has also been reduced.

Time

The differences in time that the parent material has been in place are commonly reflected in the degree of development in the soil profile. Hundreds, if not thousands, of years may be needed for the processes of soil formation to develop distinct horizons from the parent material. Some soils develop into separate layers rapidly while others develop slowly. Sandy soils on outwash deposits, for example, have been in place long enough to develop distinct soil horizons and the sandy texture also helps to show horizons more clearly. Alluvial deposits on floodplains do not typically have distinct horizons.

Processes of Soil Formation

The most important soil forming processes are the accumulation and distribution of organic matter in the topsoil and the chemical weathering of primary minerals into silicate clay minerals. Other important soil forming processes include 1) chemical reactions such as oxidation, reduction, and hydration, and 2) physical weathering and breakdown of rock fragments into finer particles.

Some processes modify, retard, or reverse the effects of soil forming processes. The most important of these are the mixing of soil by windthrow, animal activities like burrowing, or frost action, and the deposition of fresh soil material from flooding, landslides, or other mechanisms.

Organic matter can accumulate to some degree in all soils in Connecticut. The dark color of the surface layer is an indication of organic matter accumulation. Soils formed in alluvial deposits often have enough organic matter to noticeably darken the color to a depth of 24 inches or more.

In many soils, chemical changes have been important in horizon differentiation. In some soils, iron compounds have moved down through the soil, forming metal-organic oxides. They are generally precipitated in the subsoil as iron oxides, which results in reddish or brownish colors in the subsoil. Gray colors often are a result of iron reduction. (For more information on soil colors related to iron reactions, see the “Redoximorphic Features” section of this Manual)

Mechanical breakdown is another soil process. This is mainly a result of freezing and thawing. Outwash soils have rounded rock fragments, because the parent materials of these soils were deposited by glacial meltwaters. On the other hand, glacial till soils have angular coarse fragments because the parent materials of these soils were deposited in place by the glacier and not carried elsewhere by glacial meltwaters.

In conclusion, all of our soils are still evolving and changing. These changes may be undetectable in a person's lifetime or, if a soil is mismanaged or abused, remarkable changes can be seen in a single growing season. To judge a parcel of land we must evaluate the natural features according to intended uses. The features we evaluate can then be used to determine if the intended use is ecologically feasible and economical.

Land judging required careful attention to such features as texture, color, soil drainage conditions, permeability, depth, stoniness or rockiness, slope and surface runoff.

I. Evaluating the Physical Features of the Soil

The Soil Profile

Soils are made of distinct layers called horizons (see Figure 1). The horizon closest to the soil surface in most Connecticut soils is referred to as the A horizon. It is turned over in a normal plowing operation, which is usually 6" to 10" deep. In the Envirothon, this layer is referred to as the topsoil. The horizon below the plow layer is referred to as the subsoil. It is also known as the B horizon. The C horizon is commonly referred to as the substratum and is relatively undeveloped parent material, with few, if any, roots. Its upper boundary is generally between 18 and 36 inches below the surface.

The makeup of the soil profile is important in assessing land use potential. It can give evidence of a seasonal high water table. It will clearly indicate the depth to impervious layers or bedrock. In addition, it can give an indication of internal soil drainage and organic matter content.

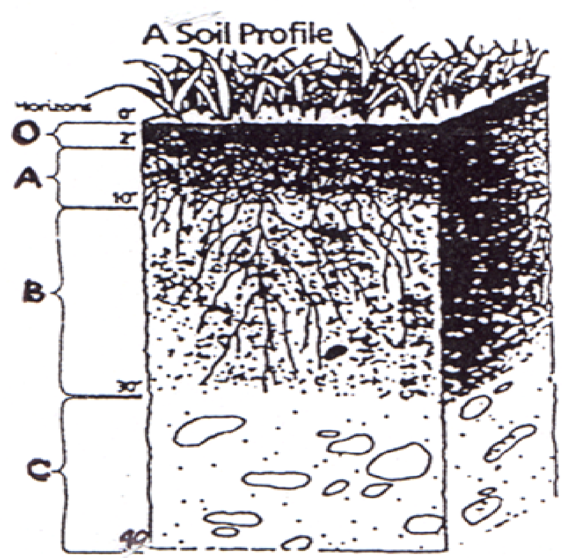


Figure 1: A soil profile from a forest, showing the basic horizons. The O horizon is composed of organic matter. The A horizon in this unplowed soil is darker in color because of the high organic matter content. In a plowed soil, the O horizon is mixed into the A horizon. The presence and variation of soil horizons are used to help differentiate one soil type from another.

Soil Texture

Soil texture is defined as "the relative proportions of the various sizes of soil particles in a soil." These soil particles are small pieces of rocks and minerals. They are grouped by their size: sand (largest), silt (intermediate), and clay (smallest size particle).

Texture in combination with soil structure influences moisture holding capacity, nutrient availability and potential fertility, permeability, and erosion potential.

A laboratory test known as *Particle Size Analysis* can give very accurate percentages of sand, silt, and clay in a dried soil sample. The USDA Natural Resources Conservation Service (NRCS) uses a "Textural Triangle" (Figure 2) that illustrates how soil textures are determined by the percentages of each of the three mineral soil size classes.

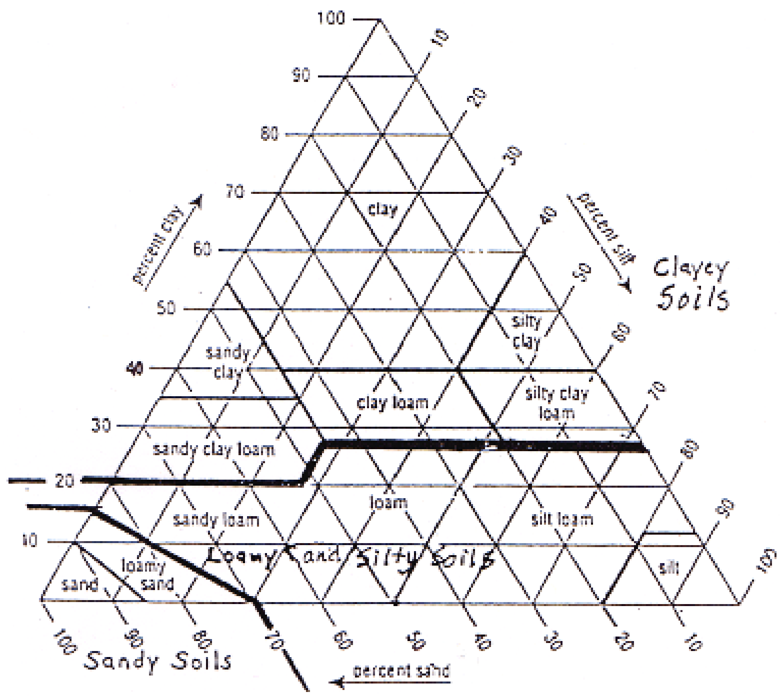


Figure 2: USDA NRCS Textural Triangle
(Bold lines show texture groups for Envirothon Event)

Soil texture is determined by feel – by moistening the soil and rubbing a small amount between the thumb and fingers. The relative proportions of sand, silt, and clay can be estimated to arrive at a general textural class. Anyone judging soil texture must learn to trust his or her sense of feel. Many soil scientists are able to accurately determine texture with only a pinch of soil. To become adept at this technique requires patience and practice using soils of known texture. This skill is one where experience counts.

The general soil textural classifications are shown in the textural triangle in Figure 2. The textural groups used in the Envirothon will be as follows:

> **Sandy**: Sandy soils feel gritty and do not hold together when moist. Textures included in this category are loamy sand and sand. Occasionally in soils, layers of

gravel texture may be stratified in between the sand layers. They are droughty (low moisture holding capacity) and permit water and air to move through rapidly. With ideal rainfall, or irrigation, these soils are well suited for farming. Where drainage is good and pollution of ground water supplied is not a potential threat, these textures are favorable for septic tank filter fields.

Loamy and Silty: Loamy and silty soils contain moderate proportions of sand, silt, and clay. Textures included in this class are loam, sandy loam, silt loam, and silt. When rubbed between the fingers, loamy soils feel slightly gritty, but not sticky. Silty soils feel relatively smooth, but also not sticky. A ribbon does not form very well when a moistened sample is rubbed out between the fingers and thumb. The ribbon may attain a length of an inch or two of unsupported material, but then will break under its weight. These textures have good moisture holding capacity and good fertility. They are typically the most productive agricultural soils. If these soils are well drained, have good structure, and do not have hardpan or bedrock at a shallow or moderate depth, septic tank filter fields often function well in them.

Clayey: Clayey soils are those containing at least 27 percent clay (with the exception of the sandy clay loam, which contains only 20 percent clay). Textures included in this class are sandy clay, sandy clay loam, clay loam, silty clay, silty clay loam, and clay. For clayey soils, when moist samples are rubbed between the fingers and thumb, a long ribbon can be formed. The more clay in the sample, the stickier and stiffer it will feel, and the longer and more flexible the ribbon will be. Because of their finer pores, clayey soils do not normally allow water to move through as rapidly as silty, loamy or sandy soils. Their slow permeability generally means severe limitations for septic tank filter fields. These textures have good moisture holding capacity and fertility levels. Very clayey soils can actually be droughty because their fine pores hold water molecules very tightly.

Parent Material

The majority of Connecticut soils are derived from different parent materials left behind after the last glacier. For the Envirothon, the contestant may be asked to determine the parent material category that best matches the soil. The parent material determination will be based on the soil in the pit and surrounding landforms, unless otherwise stated. On some occasions, it will be based on the soil in the texture buckets.

The four general categories are:

Glacial till: Mineral material deposited by glaciers consisting of sand, clay, silt, stones, and boulders. These materials are most commonly found in upland areas. There is no stratification of the materials. They sometimes have a dense compacted layer in lower subsoil. Rock fragments typically have sharp angular edges.

Glacial outwash: Mineral materials deposited by the glacial meltwater. These materials are often found in stratified layers. Sand, gravel, and thin silt lenses are common in the soil profile. Subsoil textures are sandy, often with much gravel content. Most stones and gravel have rounded edges from being rolled along a streambed by moving water. This parent material is commonly found on terraces along rivers and occasionally in upland areas. These sites are often used for sand and gravel extraction.

Alluvial deposits: This parent material is associated with soils on floodplains. An area with this type of parent material may flood several times annually or only during times of unusually high water every decade or two. The soils formed in alluvium on floodplains often have indistinct profiles. The soil texture is silty, loamy or sandy – but almost never clayey. Dark colored horizons with high organic matter content are sometimes found at various depths in the profile. These are buried topsoil layers, indicating an older surface layer that's been buried by more recent alluvial deposits by flooding. It is important to recognize the stratification and landscape position along streams that is characteristic of this parent material.

Lacustrine deposits: This type of parent material is consistently associated with clayey and silty soils with low sand content. The soils formed in this material are typically deep and uniform in texture. This parent material typically has very few stones in the soil or on the surface. It is found in areas that were under lakes during part of the last ice age. The main area of this material is in the Connecticut River Valley.

Organic deposits are another type of parent material, but because they are typically found in very wet, waterlogged soils, they are not included in the Envirothon contest for practical reasons.

Soil Drainage Conditions

a. Seasonal High Water Table

For the purpose of the Envirothon, a seasonal high water table is defined as the highest level in a freshly dug observation hole at which water stands during the year and hydrostatic pressure in the surrounding soil has come to equilibrium. During drier times of the year, determining the depth of the seasonal high water table is accomplished by noting where redoximorphic features occur in the soil profile.

Keep in mind that no water table is truly constant at any one depth. Drought, heavy rain, plant uptake of water, and many other factors affect water table levels – often by several feet. A seasonal water table will fluctuate substantially during a normal year. Note, too, that the seasonal high water table is not the same as groundwater that water wells are bored into. Groundwater wells typically go down into bedrock and are often over a hundred feet deep.

b. Redoximorphic Features

The presence of redoximorphic features in a soil profile generally indicates a seasonal high water table is present in the soil at some time during the year. Bright reddish-orange, yellowish-orange, and grayish “splotches” that are distinguishable from the dominant soil color are typical redoximorphic features in Connecticut soils.

Small areas with distinctly gray colors interspersed within the dominant soil color are an excellent indication of a seasonal high water table occurring at that depth in the soil. Reddish-orange redoximorphic features are actually small concentrations of oxidized minerals, primarily iron. The rusty color is appropriate, since the composition of these reddish-orange redoximorphic features is similar to rust that forms on a weathered bar of steel and older cars. They are commonly formed at a depth in the soil where water levels fluctuate, with alternating periods of aerobic and anaerobic conditions.

The presence of uniformly gray colors (referred to as “gleying”) in the subsoil is almost a sure sign of a seasonal high water table. Gleyed soils are formed under long periods of wetness that create anaerobic conditions and the reduction of iron and other minerals. Consequently, gray color and streaks result. Gleyed, poorly drained soils are usually in depressional landscape positions.

Note that some well and moderately well drained soils can also have gray colors, due to the color of the parent material from which the soil was derived (especially soils formed in lake sediments or from limestone/marble parent material). These soils are generally on more sloping or more convex landscape positions than truly poorly drained soils.

Redoximorphic features can also form between soil horizons that have strongly contrasting textures. The change in texture can slow or "perch" water due to the change in the size of soil pores. Under these circumstances, the redoximorphic features are found at only one depth and not below that depth, and should not necessarily be interpreted as an indication of a seasonal high water table. This condition should cause one to observe the location of the test pit in the landscape and to look for other site characteristics, such as vegetation, that substantiate that the soil may be moderately well drained or poorly drained.

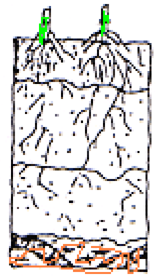
Although a seasonal high water table may not seriously limit a soil's agricultural capability, at certain times of the year when the water table is quite close to the surface it can limit access to fields for agricultural purposes. It can also seriously limit how well a septic system functions. The depth to redoximorphic features is a key consideration when designing a septic disposal system.

c. Soil Drainage Classes

The drainage class of a soil is based on the presence and depth of the seasonal high water table in the soil profile. The depth to redoximorphic features is the typical indicator used to determine soil drainage class and the depth of the seasonal high water table. Figure 3 illustrates and defines the soil drainage classes used in this Manual.

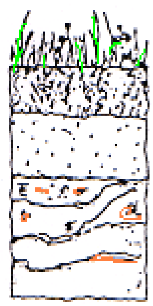
(**NOTE**: these depths are only to be used for the Envirothon – they are NOT to be used in any other context or for any regulatory purpose):

- A **poorly drained soil** has redoximorphic features and/or gleyed colors within 15 inches of the soil surface.
- A **moderately well drained soil** has redoximorphic features between 15 and 30 inches of the soil surface.
- In a **well drained soil**, redoximorphic features cannot be detected within 30 inches of the soil surface.



Well Drained: Redoximorphic features and gleying are not observed within 30 inches of the soil surface. Bright reddish, brown, or tan colors are dominant in subsoil horizons.

Row crops and deep rooted legumes typically do well.



Moderately Well Drained: Distinct redoximorphic features are observable between 15 and 30 inches below the soil surface.

Row crops, grass and clover hay often do well. Alfalfa may be subject to winter-kill.

Poorly Drained: Distinct redoximorphic features and/or gleying are observable within 15 inches of the soil surface. Water-loving plants are usually present.

Carefully managed agricultural uses are feasible in some poorly drained soils.

Figure 3: Soil Drainage Classes used in the Envirothon
(NOTE: these depths are NOT to be used in any other context or for any regulatory purpose)

Redoximorphic features can be difficult to detect in some soils. Some other clues to help determine the soil drainage class are:

- vegetation in the area (water-loving plants indicate poorly drained soils)
- rooting depth (shallow rooting depth may indicate a seasonal high water table)
- soil color (uniform bright reddish-brown subsoil colors generally indicate a well drained soil; gray subsoil colors within 15 inches of the surface generally indicate a poorly drained soil)
- landscape position can also provide a clue to the soil drainage class (well drained soils are typically on knolls and more sloping land, while poorly drained soils are typically in depressions or footslopes where water accumulates)

Soil Permeability

It is often assumed that soil permeability deals only with water movement, which is not true. The permeability of a soil is defined as "the ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass such as a layer of soil."

Many things affect the permeability of a soil. Soil texture, soil density, soil structure, and impermeable layers all affect the internal movement of water and gases.

For this event, look at the subsoil texture and the structure and density of the subsoil in the soil pit to make your determination.

Three classes of soil permeability are defined as follows:

> **Rapid**: Water moves through the subsoil at a rate of at least 6 inches per hour. Sandy subsoil textures are in this group. Soils with these textures transmit water readily and tend to be droughty.
>
> **Moderate:** Water moves through the subsoil at rates ranging from 0.6 to 6.0 inches per hour. Most of the loamy and silty subsoil textures fall into this group.
>
> **Slow**: Water moves through the subsoil at a rate of less than 0.6 inches per hour. Clayey subsoils or loamy and silty subsoils that qualify as a dense subsoil layer are in this group.

Depth to Bedrock

The depth to bedrock refers to the depth to the top of a solid rock contact. This determination will be made from observation of the soil profile in the test pit. The depth categories used to describe the soil are as follows:

> **Deep –** greater than 40 inches to bedrock
>
> **Moderately Deep –** 20 to 40 inches to bedrock
>
> **Shallow –** less than 20 inches to bedrock

Root Limiting Layers

Root limiting layers are features in the soil which limit the depth to which most plant roots can be expected to grow. A root limiting layer can be one of the following features:

- **bedrock –** presence and depth based on soil profile in the soil pit
- **seasonal high water table –** presence and depth based on soil profile in the soil pit
  - considered a root limiting layer only if the soil is poorly drained

- **dense subsoil layer –** presence and depth based on soil profile in the soil pit
  - key characteristics of this layer are:
    - massive, structureless condition
    - very firm consistence, difficult to break pieces by hand
    - extreme resistance to penetration by pencil or knife
    - visual indications of root penetration refusal
    - at least 6 inches thick and extending to the bottom of the soil pit

If more than one root limiting layer is present in the soil, the root limiting layer is defined as the one with the shallowest depth in the soil profile. For example, if a soil is poorly drained (based on identifying redoximorphic features within the upper 15 inches of the soil profile), and a dense subsoil layer is at 30 inches, then seasonal high water table is the limiting feature.

Surface Stoniness and Rockiness

Stoniness and rockiness of the surface affects a soil's Prime Farmland rating because of the effect on the ease of planting and cultivation. **Stoniness** refers to stones and boulders greater than 10 inches in diameter in at least one direction (note that these can be removed from a field to create a non-stony condition suitable for tillage). **Rockiness** refers to bedrock outcrops (note that these outcrops are a permanent feature on the land). An area near each soil pit will be marked off as the test area. The classes of stoniness and rockiness on the scorecard are as follows:

- **none or few –** distance between stones and/or rock outcrops is typically greater than 25 feet
- **very stony to extremely stony (stony) –** distance between stones and boulders is typically less than 25 feet throughout the test area marked by flags or stakes, and there are no rock outcrops
- **very rocky to extremely rocky (rocky) –** distance between rock outcrops is typically less than 25 feet throughout the test area marked by flags or stakes. Stoniness can range from none to extremely stony.

Slope

The slope of the land is important for determining the best land use. The steepness and length of the slope influences the speed that water runs off and the amount of soil erosion that could occur.

Steepness of slope is expressed in <u>percent</u>, such as “14 percent slope.” The percent slope can be translated to indicate the number of feet of rise or fall over a 100 foot distance. For example, a 14 percent slope translates to a 14 foot rise or fall over a 100 foot distance. The steepness of slope is determined by using a slope finder, an Abney level, or a clinometer. The slope finder is used extensively in land judging events to determine the slope percentage. Directions on the construction and use of a slope finder are included below.

The steepness of the slope affects the ease of cultivation and use of farm machinery, especially in terms of safety. The use of farm machinery is more difficult and hazardous on slopes over 15%. The steepness of the slope also affects non-farm uses such as housing, septic tank filter fields, roads, and recreational uses. It is difficult and more expensive to develop home and commercial sites on steep slopes. Erosion is also a hazard in these areas.

The slope classes are as follows:

1. **Nearly level –** less than 3% slope
2. **Gently sloping –** 3 to 8% slope
3. **Sloping –** 9 to 15% slope
4. **Moderately steep –**16 to 35% slope
5. **Steep –** greater than 35% slope

How to make a slope finder

1. Mount the prepared slope finder sheet (on the back cover of this guide) on a 9" X 12" board. Either 1/2-inch plywood or 3/4-inch lumber may be used. The thicker board is recommended in order for the nails to be securely attached.

2. Place three "finishing nails" at the points indicated on the slope finder. Attach a large nut or weight to a string tied to the top nail on the slope finder. Adjust the length of string to allow the weight to swing freely just below the edge of the board.

How to use the slope finder

The following procedures are recommended with two stakes and a slope finder:

1. The percent slope may be determined by either sighting up or down the slope.
2. It is not necessary to know the distance between the stakes.
3. Sighting through the two bottom nails, aim across from the top of one stake to the top of the other stake. The top of the stakes must be the same height above the ground surface.
4. The string and weight should swing free.
5. On windy days, guard against wind error.
6. When the weight has stopped swinging, pinch the string against the board and read the percent slope.
7. It can help to tilt the board at a slight forward angle and when the weight stops swinging, to tilt it at a slight back angle to stabilize the string to read the slope.

Surface Runoff

Surface runoff is the rate at which water will move off a particular slope. This factor is important to engineers who design structures to convey or hold water. The ability of a watershed to absorb water is influenced by both surface runoff and subsurface drainage.

There is a direct relationship between surface runoff and the steepness of the slope. You must first determine the slope class of the soil before deciding on the surface runoff class.

The surface runoff classes and their slope ranges are:

- **slow surface runoff –** soils with slopes less than 3%
- **moderate surface runoff** – soils with slopes of 3 to 8%
- **rapid surface runoff** – soils with slopes greater than 8%

Soil texture and permeability also influence the amount of surface runoff relative to the amount of water that is absorbed by the soil. As water moves downslope, a certain amount of water will infiltrate into the soil, depending on texture and permeability. This is why less than half of a two-inch rainfall may actually run off the land in some cases.

The condition of the soil and its existing land use cover will also affect the amount of water that runs off. Saturated soils will absorb far less water than when they are dry, increasing the amount of surface runoff. A soil in a wooded area will have less runoff when compared to an identical soil that is bare and free of vegetation, partly because bare soils become "crusted" by raindrop impact, which increases the amount of surface runoff.

II. Applying the Evaluation of Soil Physical Features to Land Use Potential

Agricultural Potential

Prime Farmland soils must have all of the following characteristics:

- depth to bedrock is more than 40 inches (deep)
- drainage class is well drained or moderately well drained
- slope is 8% or less (nearly level to gently sloping)
- topsoil texture is loamy or silty
- surface has none or few stones or rock outcrops

Soils with Good potential do not meet one or more of the *Prime Farmland* criteria, <u>and</u> have the following range of characteristics:

- slope is 15% or less
- depth to bedrock is 20 inches or greater (moderately deep or deep)
- drainage class is well drained or moderately well drained
- surface has none or few stones or rock outcrops
- note that all textures are allowed in this category

Soils with Low potential have one or more of the following characteristics, but do not qualify as a *Soil with No Agricultural Potential*:

- slope is greater than 15%
- depth to bedrock is less than 20 inches (shallow)
- drainage class is poorly drained
- surface is either very stony to extremely stony or very rocky to extremely rocky

Soils with No agricultural potential are limited to soils that have the following combination of characteristics:

- slope is greater than 35% **and**
- surface is very rocky to extremely rocky

Woodland Potential

In general, the majority of Connecticut's soils have good woodland potential. But one should be aware of the factors or limitations that can lower woodland potential.

1. Slopes greater than 35% limit harvesting techniques, interfere with proper layout of wood roads and trails, and create severe erosion hazards during logging operations.

2. Soils that are less than 20 inches (shallow) to bedrock have a windthrow hazard, seedling mortality, and problems with limited moisture holding capacity.

3. Soils that are poorly drained can result in harvesting problems with heavy equipment, seeding mortality (frost heaving), and windthrow hazards.

4. Sites with a very rocky to extremely rocky surface can be difficult for establishing roads and trails, harvesting damage (felled trees can break on rock outcrops) and equipment limitations.

In summary, sites that have limitations for tree growth and timber harvesting have one or more of the following conditions:

- slopes greater than 35%
- shallow to bedrock soils
- poorly drained soils (redoximorphic features within 20 inches of the surface)
- soils with very rocky to extremely rocky surface

Evaluating Limitations for Land Use

Limitations for homesites, row crops, hayland, and woodland are listed in the chart below.

Limitations	Land Use			
	Home/Septic	Row Crops	Hayland	Woodland
Texture	**Clayey Subsoil**	**Clayey Topsoil**	**None**	**None**
Permeability	**Slow**	**Slow**	**Slow**	**Slow**
Depth to Bedrock	**<40 inches**	**<20 inches**	**<20 inches**	**<20 inches**
Slope is greater than:	**15 percent**	**8 percent**	**15 percent**	**35 percent**
Depth to Seasonal High Water Table	**<40 inches**	**<20 inches**	**<20 inches**	**<20 inches**
Flooding from Water Courses	**Yes if any**	**Yes if any**	**None**	**None**
Stoniness or Rockiness Class	**Stony** or **Rocky**	**Stony** or **Rocky**	**Stony** or **Rocky**	**Rocky**

After evaluating limitations to land use, one must determine if the site is suitable for different uses and whether specific management practices need to be applied to address limitations.

Identification of Factors that affect Site Suitability

For the Envirothon, if a site has one of the factors listed below, the site is considered not suitable for that land use.

1. Housing (homes with on-site septic systems and basements).
Any one of the following factors will make a site not suitable for housing:
- ~ a seasonal high water table within 15 inches (poorly drained soils)
- ~ bedrock within 20 inches (shallow to bedrock)
- ~ slope greater than 35% (steep slope)
- ~ areas that flood (parent material is alluvial deposits)

2. Row crops (annual crops grown either continuously or in rotation with grasses and/or legumes).
Any one of the following factors will make a site not suitable for row crops:
- ~ bedrock within 20 inches (shallow to bedrock)
- ~ slope greater than 15%
- ~ very rocky to extremely rocky surface

3. Hayland (continuous grasses and/or legumes).
The combination of **both** of the following two factors will make a site not suitable for hayland:
- ~ slope greater than 35% (steep slope), **and**
- ~ very rocky to extremely rocky surface

4. Woodland.
There are no factors that make a site not suitable for woodland in Connecticut.

Land Treatments and Management Practices to overcome Limitations

1. Subsoil Drainage – This practice involves the installation of "elephant trunk" or perforated pipe to minimize wet areas in a field or around a house site by lowering the seasonal high water table. The soil must be greater than 40 inches to bedrock to allow installation of the pipe at least 3 feet into the ground. This practice would be beneficial on poorly drained agricultural soils. And for house sites on moderately well drained soils, subsoil drainage is recommended around the foundation and upslope of the septic tank filter field.

2. Diversions – A wide shallow surface ditch designed to intercept surface water moving downslope. This would be beneficial on agricultural and housing sites with slopes greater than 8% that have soils with bedrock greater than 40 inches deep. It is not practical in woodland management.

3. Benching – This is a bench or terrace constructed on a slope, primarily for the installation of a septic system. This practice applies only to house sites with slopes between 16 - 35% that have soils with bedrock greater than 40 inches deep.

4. Land Clearing – This is the removal of stones and boulders (and brush and trees if necessary) to establish housing, row crops, or hayland. This practice applies to sites with a very stony to extremely stony surface, regardless whether they are wooded or not.

5. Contour Farming – This practice, for row crops only, involves planting crops across the slope (on the contour) in order to minimize erosion. It also includes contour strip cropping, which alternates row crops and hay crops, planted on the contour. It is beneficial in fields used for row crops with slopes greater than 8%.

6. Specialized Harvesting Equipment – The use of specialized timber harvesting equipment, such as cables and tracked vehicles. These should be used on woodland sites with slopes greater than 35%.

7. Erosion Control – The installation of water bars and ditches to minimize erosion on logging roads and trails. It also involves siting skid trails and log landings based on a site plan designed to minimize soil erosion. This practice should be applied to all woodland sites with slopes greater than 8%.

8. Seasonal Harvesting – Limiting logging operations to drier periods of the year, or when the ground is frozen, to minimize rutting of wet soils. This practice should be applied in all woodland sites with poorly drained soils.

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On the next page is the worksheet for the FFA Land Judging competition. It is NOT used as the scorecard for the Connecticut Envirothon contest, but filling it out for a few sites may help in your study of soils.

Connecticut FFA Soil and Land Judging Contest
Worksheet for Evaluating Soil and Land – Revised 2006

Part A. Physical Features of the Soil. Mark only one answer for each question.

1. **Texture, Surface Soil**
   - **A** **Sandy**
   - **B** **Loamy or Silty**
   - **C** **Clayey**
2. **Texture, Subsoil**
   - **A** **Sandy**
   - **B** **Loamy or Silty**
   - **C** **Clayey**
3. **Parent Material**
   - **A** **Glacial Till**
   - **B** **Glacial Outwash**
   - **C** **Alluvial deposits**
   - **D** **Lacustrine deposits**
4. **Drainage Class**
   - **A** **Well drained**
   - **B** **Moderately well drained**
   - **C** **Poorly drained**
5. **Permeability**
   - **A** **Rapid**
   - **B** **Moderate**
   - **C** **Slow**
6. **Depth to Bedrock**
   - **A** **Deep**
   - **B** **Moderately Deep**
   - **C** **Shallow**
7. **Root Limiting Layer**
   - **A** **Bedrock**
   - **B** **Seasonal High Water Table**
   - **C** **Strongly Contrasting Textural Change**
   - **D** **Dense Subsoil Layer**
   - **E** **None**
8. **Stoniness or Rockiness**
   - **A** **None or Few**
   - **B** **Very Stony to Extremely Stony**
   - **C** **Very Rocky to Extremely Rocky**
9. **Slope**
   - **A** **Nearly Level**
   - **B** **Gently Sloping**
   - **C** **Sloping**
   - **D** **Moderately Steep**
   - **E** **Steep**
10. **Surface Runoff**
    - **A** **Slow**
    - **B** **Moderate**
    - **C** **Rapid**

11. Part B: Agricultural Potential. Check one.

A **Prime Farmland**
B **Good Potential**
C **Low Potential**
D **No Agricultural Potential**

. **Part C: Factors that keep the site out of Prime Farmland. Answer all questions. Mark T to select those factors that keep site out of Prime. Mark all other answers F.**

12. Slope	**T F**	**15. Stony/Rocky**	**T F**
13. Depth	**T F**	**16. Texture**	**T F**
14. Drainage	**T F**	**17. None**	**T F**

Part D: Woodland Potential

Judge all sites for woodland potential even if they are open land. Check as many answers T as are correct. Mark all other answers F. Limitations to woodland productivity are:

18. T F Slope
19. T F Depth to bedrock
20. T F Drainage
21. T F Rockiness
22. T F None

Part E. Limitations to Land Use. Determine which physical characteristics will limit the use of the land for a specific land use. Mark the characteristics that are limiting for each land use T. Mark the characteristics that are not limiting for that land use F. Evaluate each land use separately.

Limiting Soil Characteristic	Land Use											
	House with Basement & Septic			Row Crops			Hayland			Woodland		
Texture	**23.**	**T**	**F**	**31.**	**T**	**F**	**39.**	**T**	**F**	**47.**	**T**	**F**
Permeability	**24.**	**T**	**F**	**32.**	**T**	**F**	**40.**	**T**	**F**	**48.**	**T**	**F**
Depth to Bedrock	**25.**	**T**	**F**	**33.**	**T**	**F**	**41.**	**T**	**F**	**49.**	**T**	**F**
Percent Slope	**26.**	**T**	**F**	**34.**	**T**	**F**	**42.**	**T**	**F**	**50.**	**T**	**F**
Depth - Seasonal Water Table	**27.**	**T**	**F**	**35.**	**T**	**F**	**43.**	**T**	**F**	**51.**	**T**	**F**
Flooding	**28.**	**T**	**F**	**36.**	**T**	**F**	**44.**	**T**	**F**	**52.**	**T**	**F**
Stones and Rock Outcrops	**29.**	**T**	**F**	**37.**	**T**	**F**	**45.**	**T**	**F**	**53.**	**T**	**F**
None	**30.**	**T**	**F**	**38.**	**T**	**F**	**46.**	**T**	**F**	**54.**	**T**	**F**

Part F: Overcoming Site Limitations. Determine the appropriate management practice that may be used to overcome the limitations determined in previous parts of this scorecard.

- Mark T to select the correct answers. You may mark more than one answer T if appropriate.
- After you have marked the correct answer(s), mark the remainder of the answers in that section F.
- Remember, if you mark "Site not suitable" T, be sure to mark the remainder of the answers in that section F.

Housing (with basement and septic)

55. T F Site not suitable
56. T F Subsoil drainage
57. T F Diversions
58. T F Benching
59. T F Land clearing

Row Crops

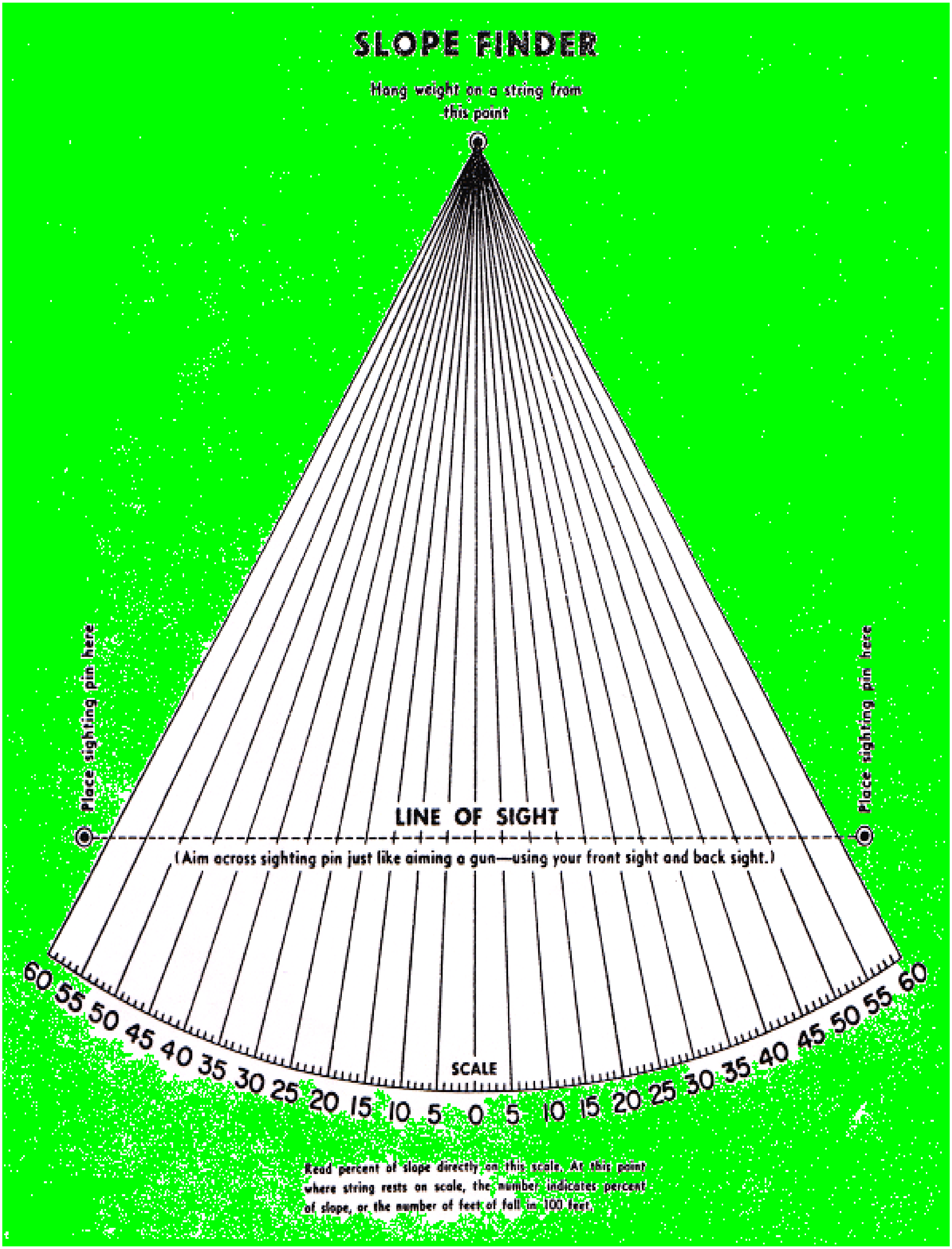
60. T F Site not suitable
61. T F Subsoil drainage
62. T F Diversions
63. T F Land clearing
64. T F Contour farming

Hayland

65. T F Site not suitable
66. T F Subsoil drainage
67. T F Diversions
68. T F Land clearing

Woodland

69. T F Specialized harvesting equip
70. T F Erosion control
71. T F Seasonal harvesting



SLOPE FINDER
Hang weight on a string from this point
Place sighting pin here
Place sighting pin here
LINE OF SIGHT
(Aim across sighting pin just like aiming a gun—using your front sight and back sight.)
60 55 50 45 40 35 30 25 20 15 10 5 0 5 10 15 20 25 30 35 40 45 50 55 60
SCALE
Read percent of slope directly on this scale. At this point where string rests on scale, the number indicates percent of slope, or the number of feet of fall in 100 feet.