

Vermont Soil and Land Judging Manual



Revised October 5, 2012

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The picture on the front cover is of a painting by Reed Prescott of Lincoln, VT. More information can be accessed at <http://www.vermontagriculture.com/Ag%20Art/agartmain.htm>.

Introduction

How you define and characterize soil depends on your background. Farmers and foresters view soil as a medium for plant growth. Engineers view soils as areas to build on. But a geologist just might look at everything above bedrock as "overburden" and not give it a second thought!

The characteristics that make some soils highly desirable for agriculture can 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 that can be evaluated separately. 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 Agricultural and Natural Resources Education Soil and Land Judging Skills and Career Development Event, a land unit to be judged will be clearly identified. The soil is the factor we will evaluate most intensively. In this competition, land will be evaluated primarily from the agricultural, forestry, and engineering standpoint.

This guide can also serve as a primer on soils for other curricula and skills events, including the Vermont Envirothon (<http://www.vacd.org/vermont-envirothon>).

Factors of Soil Formation

The formation of the soils in Vermont involves many factors. The following excerpt from the Windham County Soil Survey¹ 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 lay of the land or its **relief** or **topography**; and 5) the length of **time** the processes of soil formation have acted on the parent material.

Parent Material

Parent material is the unconsolidated material in which soils form. Most of the different parent materials in Vermont are related to the glaciers that covered New England about 12,000 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 Vermont is of similar glacial origin, the properties can vary greatly,

¹ Soil Survey of Windham County, Vermont, pages 139-141

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 Vermont are formed in glacial till, including the **Vermont State Soil** - the **Tunbridge** 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. Windsor soils are typical of soils formed in sandy outwash deposits.

Alluvial deposits are material deposited by floodwater of streams in recent times. These deposits are found directly beside 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. Hadley soils are 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 soils in the Champlain Valley, including the Vergennes soil, are formed in clayey lacustrine deposits.

Organic deposits consist primarily of slightly to well decomposed plant material. In most places, long periods of saturation over many years has been a factor in the build-up of these deposits, which are typically in depressional areas. 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. Bucksport soils are formed in organic deposits more than 50 inches thick.

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 Vermont differs from place to place, depending on elevation and physiographic region. There are three different soil temperature regimes recognized in the state: 1) the mesic soil temperature regime in warmer river valleys and the Champlain Valley, 2) the frigid soil temperature

regime in most of the state, and 3) the cryic soil temperature regime on the highest mountains in the state, generally above 2500 feet.

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 spruce 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.

Relief or Topography

Relief, topography, or the lay of the land, 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 Vermont 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 1) the mixing of soil by windthrow, animal activities like burrowing, or frost action, and 2) the deposition of fresh soil material from flooding, landslides, or other mechanisms.

Organic matter can accumulate to some degree in all soils in Vermont. 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 color the subsoil reddish or brownish. Mottling and gleying result from reduction in the soil horizons.

Mechanical breakdown is another soil process. This is mainly freezing and thawing. Glacial till soils have angular coarse fragments, while outwash soils have rounded coarse fragments, due to their being tumbled down waterways during glacial melting.

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. Soil and land judging requires careful attention to soil texture, color, drainage conditions, depth, permeability, stoniness and 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 is referred to as the A horizon. It is turned over in a normal plowing operation, which is usually 6"-8" deep. In the Soil and Land Judging Contest, this layer is referred to as the topsoil. The horizon below the plow layer is referred to as the subsoil in the Contest. 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.

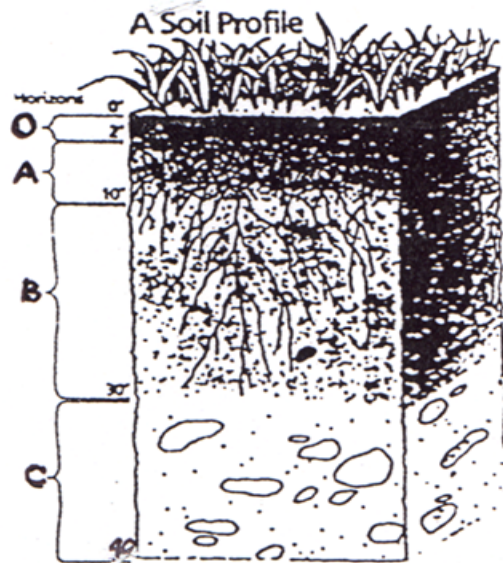


Figure 1: A soil profile, showing the basic horizons. The upper layers (O and A horizons) in this unplowed soil are darker in color because of their high organic matter content. In a plowed soil, the O horizon is mixed into the A horizon. The presence and variation of soil horizons are used to help differentiate 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." Texture is determined after taking out any larger rock fragments in the soil, such as stones, cobbles and gravel. The soil particles measured for texture are classified by their size: **sand** (largest), **silt** (intermediate), and **clay** (smallest size particle).

Texture influences the moisture holding capacity, nutrient availability and potential fertility, permeability, and erosion potential of a soil.

A lab test called a Particle Size Distribution Analysis (PSDA) 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) to determine soil textures by the percentages of sand, silt, and clay.

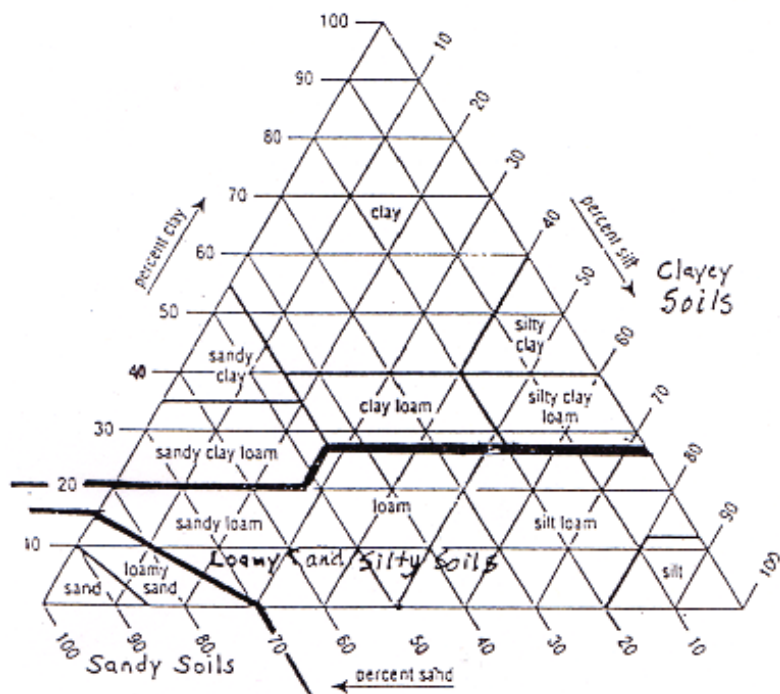


Figure 2: USDA NRCS Textural Triangle
 (bold lines show texture groups for Soil and Land Judging Contest)

In Soil and Land judging, texture is determined by feel - 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 their sense of feel. Many soil scientists are able to accurately determine texture with only a pinch of soil. Becoming adept at this technique requires practice using soils of known texture. This is one soil and land judging skill where experience counts.

The general soil textural classifications are shown in the textural triangle in Figure 2. In the Soil and Land Judging event, two textural determinations will be made: the **topsoil** texture and the **subsoil** texture - both determined by feel. The textural groups used on the scoresheet are 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, silty 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 Vermont soils are derived from different parent materials left behind after the last glacier. For the Soil and Land Judging contest, the contestant must determine the parent material category that best matches the soil at each site. The parent material determination will be based on the soil in the pit and surrounding landforms, unless otherwise stated. (At some pits, it's possible the proctor will instruct you to judge the parent material 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 in somewhat even proportions. 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. (Note: although this is true of natural soil profiles in glacial outwash, texture samples in the buckets may not always come from the same parent material as the site, so it is possible that a site could have loamy, silty or clayey textures even though the parent material is glacial outwash.) 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. (Note: although this is true of natural soil profiles in alluvial deposits, texture samples in the buckets may not always come from the same parent material as the site, so it is possible that a site could have clayey textures even though the parent material is alluvial deposits.) 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 water during part of the last ice age. The two main areas of this material are the Champlain Valley and the Connecticut River Valley, but it is also found along the Winooski River and the White River and many other areas.

Organic deposits are another type of parent material, but because they are typically found in very wet, water-logged soils, they are not included in the Soil and Land Judging contest for practical reasons.

Natural Soil Drainage Classes

a. Seasonal High Water Table

No water table in a soil 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 the groundwater table that water wells are bored into – groundwater wells typically go deep down into bedrock. They're often over a hundred feet deep.

For the Soil and Land Judging contest, 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. The depth of the seasonal high water table is based on the shallowest depth in which redoximorphic features occur in the soil profile.

The presence of redoximorphic features in a soil profile generally indicates that 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 strongly contrast with the dominant soil color are typical redoximorphic features in Vermont soils.

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

Completely grey-colored subsoil layers within 20 inches of the top of a dark topsoil layer are almost a sure sign of a seasonal high water table. Soils like this typically have long periods of total saturation that create anaerobic conditions and lead to the reduction of iron and other minerals. These poorly drained soils are almost always in depressional or low-lying landscape positions.

Note that many 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 lake sediments, silts, and clay). More sloping or more convex landscape position should help to separate these soils from 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. In these situations, 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

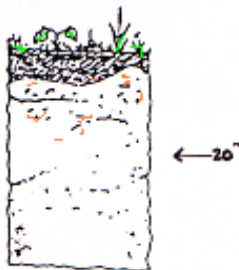
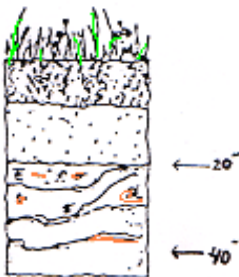
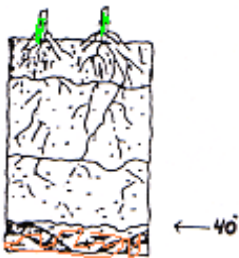
should cause one to observe the location of the test pit in the landscape and to look for other site characteristics, such as vegetation, that substantiate that the soil may be moderately well drained or poorly drained.

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.

b. 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 Guide:

- A well drained soil has no redoximorphic features within 40 inches of the soil surface.
- A moderately well drained soil has redoximorphic features between 20 and 40 inches of the soil surface.
- A poorly drained soil has redoximorphic features and/or dull grey soil horizons within 20 inches of the soil surface.



Well Drained: Redoximorphic features and gleying are not observed within 40 inches of the soil surface. Bright reddish 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 20 and 40 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 grey soil horizons are observable within 20 inches of the soil surface. Water-loving plants are usually present. Carefully managed agricultural uses are feasible in some poorly drained soils.

Figure 3: Natural Soil Drainage Classes used in the Soil and Land Judging Contest

Redoximorphic features can be difficult to detect in some soils. Some 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 20 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)

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 within 40 inches of soil surface**
 - 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
- **strongly contrasting textural change**
 - defined as one of the two following topsoil/subsoil texture combinations:
 - sand over clay, or
 - clay over sand
 - textures are based on the samples in the two texture buckets at each soil pit (not on textures in the soil pit)
 - depth to a strongly contrasting textural change, when present, is arbitrarily set at 24 inches below the soil surface

If more than one root limiting layer is present in the soil, the root limiting layer is defined as the one at the shallowest depth in the soil profile. For example, if a soil is poorly drained (based on identifying redoximorphic features within the upper 20 inches of the soil profile), and there is a strongly contrasting textural change (arbitrarily set at 24 inches), then seasonal high water table is the limiting feature.

Soil Permeability

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." It is often assumed that soil permeability deals only with water movement, which is not true.

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

For this event, look at the textures of the soil and whether there is a strongly contrasting textural change to make your determination.

Three classes of soil permeability are defined as follows:

Rapid: Sandy subsoil textures with sandy, loamy and silty surface textures are in this group. Soils with these textures transmit water and gases readily and tend to be droughty. Water moves through the subsoil at a rate of at least 6 inches per hour.

Moderate: Loamy and silty subsoil textures with any surface texture fall into this group. Water moves through the subsoil at rates ranging from 0.6 to 6.0 inches per hour.

Slow: Clayey subsoils with any surface texture and sandy subsoils with a clayey surface texture (strongly contrasting textural change) are in this group. Water moves through the clayey subsoil at a rate of less than 0.6 inches per hour and water and root movement is slowed in soils with a strongly contrasting textural change.

Surface Stones and Rock Outcrops

The extent of surface stones and rock outcrops affects a soil's Prime Farmland rating because of their effect on the ease of tillage, cultivation, and mowing. **Surface stones** refer 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. It's not a permanent condition. **Rock outcrops** refer to bedrock outcrops – these outcrops are a permanent feature on the land. They can't be removed from a field. An area near each soil pit will be marked off as the test area. The classes of surface stones and rock outcrops 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. Surface stones 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 also the amount of soil erosion that could occur. On the Soil and Land Judging scoresheet, the steepness of slope is rated.

Steepness of slope is expressed in percent, as in "14 percent slope." The percent slope can be translated as the number of feet of rise or fall over a 100 foot horizontal 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 typically used in the Vermont Soil and Land Judging Contest to determine the slope percentage. Directions on the construction and use of a slope finder are included below.

In this event, slope stakes will be placed near the pit to be representative of the area around the test pit. Slope can be determined by measuring from the point marked on one stake to the point marked on the other stake with a slope finder. Note that measurements are not always made from the top of the stake, but from the point marked on the stake, which may be near the bottom of the stake sometimes. These markings are typically flagging tape wrapped around the slope stakes.

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, timber harvesting, 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. Logging is also more difficult on steep slopes.

The slope classes on the scoresheet 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 marked point on one stake to the marked point on the other stake.
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%
- **moderately rapid** - soils with slopes of 9 to 15%
- **rapid surface runoff** - soils with slopes greater than 15%

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 2-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. Evaluating Soil Physical Features to determine Land Use Potential

Agricultural Potential - *This information applies to parts B and C on the scoresheet.*

For rating Agricultural Potential, the soil will be placed into one of four categories: Prime Farmland, Good Potential, Low Potential, or No 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 or gently sloping)
- topsoil texture is loamy or silty
- surface has none or few stones or rock outcrops

Good Potential soils do not meet one or more of the Prime Farmland criteria, and 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
- all textures are allowed in this category

Low Potential soils 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

No Agricultural Potential is limited to soils that have the following combination of characteristics:

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

Limitations to Woodland Potential

This information applies to Part D on the scoresheet. Identification of limitations also requires application of management practices in Part F, Overcoming Site Limitations.

In general, the majority of Vermont's soils have good Woodland Potential. But one should be aware of the factors that can limit woodland potential-

1. Soil wetness - soils that are poorly drained can result in harvesting problems with heavy equipment, seeding mortality (frost heaving), and windthrow hazards.
2. Depth to bedrock - soils that are less than 20 inches (shallow) to bedrock have a windthrow hazard, seedling mortality, and problems with limited moisture holding capacity.
3. 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.

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

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

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

Site Suitability for Land Uses

This information applies to Part E on the scoresheet. Identification of limitations also requires application of management practices in Part F, Overcoming Site Limitations.

Determine if any soil feature or combination of features makes the site not suitable for each land use. Rate each feature as to whether it has unsuitable characteristics 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:

- ~ areas that flood (parent material is alluvial deposits)
- ~ seasonal high water table within 20 inches (poorly drained soils)
- ~ bedrock within 20 inches (shallow to bedrock)
- ~ very rocky to extremely rocky surface
- ~ slope is greater than 35% (steep slopes)

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)
- ~ very rocky to extremely rocky surface
- ~ slope is greater than 15%

3. Hayland (continuous grasses and/or legumes)

The combination of **both** of the following two factors will make a site not suitable for hayland:

- ~ very rocky to extremely rocky surface, **and**
- ~ slope is greater than 35% (steep slopes)
- ~ if only one of the two factors is present, mark scoresheet # 34 False and consider the site suitable for hayland.

4. Woodland

There are no factors that make a site not suitable for woodland in Vermont.

Site is not suitable because of:	Land Use					
	House with Basement & Septic		Row Crops		Hayland	
Flooding hazard (Alluvial deposits)	21.	Alluvial deposit	26.	Not limiting	31.	Not limiting
Soil Wetness (Drainage class)	22.	Poorly drained	27.	Not limiting	32.	Not limiting
Depth to Bedrock	23.	<20"	28.	<20"	33.	Not limiting
Rock Outcrops	24.	Very to Extremely rocky	29.	Very to Extremely rocky	34.	Very to Extremely rocky - and - Slope >35%
Percent Slope	25.	>35%	30.	>15%		

Overcoming Site Limitations. Determine the appropriate management practice that can be used to overcome limitations determined in previous Parts of the Worksheet.

- If you identified any feature or combination of features that made the site not suitable in Part E, mark F for all of the management practices for that land use.
- Mark T to select the appropriate management practices for each land use. Mark T for all that are appropriate.
- Mark F for all practices that are not appropriate for that site's features.

Land Treatments and Management Practices to overcome Site 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. For housing 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% and 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 housing sites with slopes between 16 - 35% and 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 of whether they are wooded or not.

5. Omit basement in building plan - if bedrock is moderately deep (20-40 inches), it is often not practical to pour a basement under a house on that site. This practice should be applied on all housing sites with moderately deep bedrock between 20 and 40 inches.

6. Mound septic system needed - These septic systems are used on sites that are somewhat marginal for optimum performance. They are built on top of the existing soil to create a deeper treatment zone for effluent. They should be used on all housing sites that are moderately well drained or have moderately deep bedrock (20-40 inches).

7. Contour Farming – This practice, used only for row crops, 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 on sites used for row crops with slopes greater than 8%.

8. Irrigation for high-value crops - High value crops include truck crops like tomatoes, peppers, and other crops grown on small acreages and are typically seen for sale at farmer's markets. Irrigation should be used for these row crops if the topsoil texture or the subsoil texture is Sandy.

9. Maintain riparian buffers - For row crops and woodland sites, a vegetated riparian buffer along streams prevents streambank erosion and degraded water quality. These buffers should be maintained if the Parent Material is Alluvial Deposits on Floodplains.

10. Avoid deep-rooted legumes - Legumes like alfalfa have a deep taproot that can extend six feet or more into the soil under ideal conditions. When soils remain very wet over winter, excessive frost action from freezing and thawing can drive this taproot right up out of the soil and kill these valuable hay and pasture plants. If the Natural Soil Drainage class is poorly drained, these deep-rooted legumes should be avoided in seeding mixes for that site.

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

12. 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%.

13. Seasonal Harvesting - Limits 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.

III. Using the Scantron scorecard on the day of the Event

One Scantron scorecard will be filled out for each of the four sites and turned in to the proctor at the site. Be sure you have 4 blank scorecards when you start out at the beginning of the event.

The scorecard is divided into six parts.

Part A provides basic data by evaluating the physical features of the soil. In Part A, mark the one letter that best identifies the correct physical characteristic.

Parts B and C consider the physical features of the soil in relation to its agricultural potential. In Part B, mark the one letter that best identifies the agricultural potential. In Part C, mark correct answers "True" and mark all incorrect answers "False".

Part D consider the physical features of the soil in relation to its woodland potential. Mark correct answers "True" and mark all incorrect answers "False".

Part E identifies the site suitability for the following land uses: construction of a home, with basement and septic system, and production agriculture, including row crops and hay. Mark correct answers "True" and mark all incorrect answers "False".

Part F identifies management practices needed to overcome site limitations. Mark correct answers "True" and mark all incorrect answers "False".

Vermont Soil and Land Judging Contest
Scoresheet for Evaluating Soil and Land – revised Oct. 5, 2012

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

1. Texture of Topsoil

- A Sandy
- B Loamy and Silty
- C Clayey

7. Soil Permeability

- A Rapid
- B Moderate
- C Slow

2. Texture of Subsoil

- A Sandy
- B Loamy and Silty
- C Clayey

8. Surface Stones and Rock Outcrops

- A None or Few
- B Very Stony to Extremely Stony
- C Very Rocky to Extremely Rocky

3. Parent Material

- A Glacial Till
- B Glacial Outwash
- C Alluvial Deposits on Floodplain
- D Lacustrine Deposits

9. Slope Class

- A Nearly Level
- B Gently Sloping
- C Sloping
- D Moderately Steep
- E Steep

4. Natural Soil Drainage Class

- A Well Drained
- B Moderately Well Drained
- C Poorly Drained

10. Surface Runoff

- A Slow
- B Moderate
- C Moderately Rapid
- D Rapid

5. Depth to Bedrock

- A Deep
- B Moderately Deep
- C Shallow

6. Root Limiting Layer

- A Depth to Bedrock
- B Seasonal High Water Table
- C Strongly Contrasting Textural Change
- D None

11. Part B. Agricultural Potential. Select 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 (for Yes) to select those factors that keep site out of Prime. Mark all other answers F (for No).

12. Texture of Topsoil T F

13. Drainage Class T F

14. Depth to Bedrock T F

15. Stones/Rock Outcrops T F

16. Slope Class T F

Part D. Limitations to Woodland Potential

Judge all sites for their limitations to woodland potential, even if they are not wooded. Check as many answers T as are correct. Mark all other answers F. Limitations to woodland potential at this site are:

- 17. T F Soil wetness
- 18. T F Depth to bedrock
- 19. T F Rock outcrops
- 20. T F Steep slopes

Part E. Site Suitability for Land Uses. Based on Part A, determine if any soil features makes the site not suitable for each land use. Rate each feature as to whether it has unsuitable characteristics for that land use. Note that there are no soil features that make a site not suitable for Woodland in Vermont.

- Mark T for any feature or combination of features that makes the site unsuitable for housing, row crops or hayland. If any feature or combination of features is marked T, the site is not suitable for that land use.
- Mark F if the soil feature does not have unsuitable characteristics for that land use.

Site is not suitable because of:	Land Use								
	House with Basement & Septic			Row Crops			Hayland		
Flooding hazard (Alluvial deposits)	21.	T	F	26.	T	F	31.	T	F
Soil Wetness (Drainage class)	22.	T	F	27.	T	F	32.	T	F
Depth to Bedrock	23.	T	F	28.	T	F	33.	T	F
Rock Outcrops	24.	T	F	29.	T	F	34.	T	F
Slope Class	25.	T	F	30.	T	F			

Part F. Overcoming Site Limitations. Determine the appropriate management practices that can be used to overcome site limitations determined in previous Parts of the Worksheet.

- If you identified any features that made the site not suitable in Part E, mark F for all of the management practices for that Land Use.
- Mark T to select the appropriate management practices for each Land Use. Mark T for all that are appropriate.
- Mark F for all practices that are not appropriate for that site's features.

Housing (with basement and septic system)

- 35. T F Subsoil drainage
- 36. T F Diversions
- 37. T F Benching
- 38. T F Land clearing
- 39. T F Omit basement in build plan
- 40. T F Mound septic system needed

Hayland

- 47. T F Subsoil drainage
- 48. T F Diversions
- 49. T F Land clearing
- 50. T F Avoid deep-rooted legumes

Row Crops

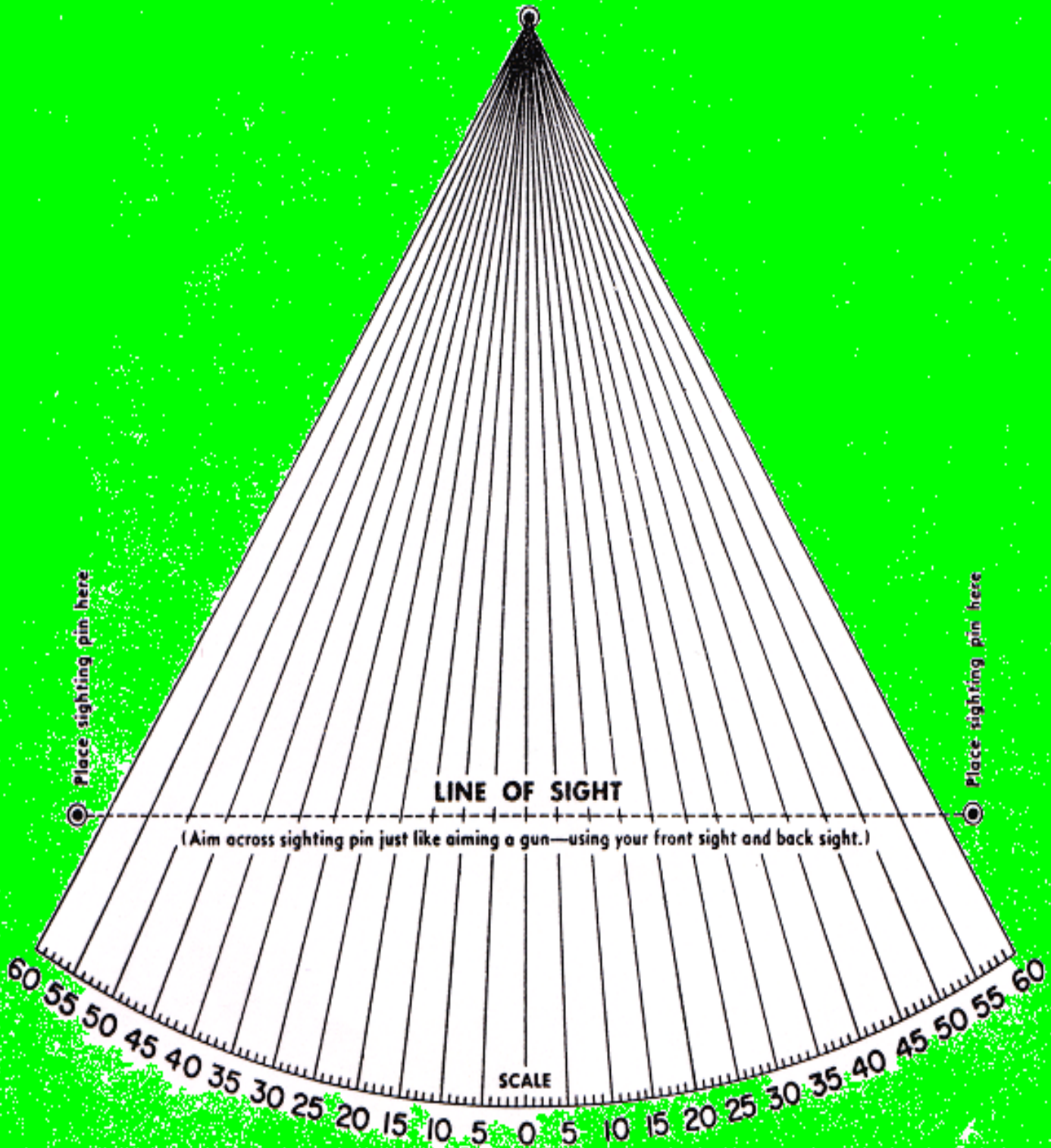
- 41. T F Subsoil drainage
- 42. T F Diversions
- 43. T F Land clearing
- 44. T F Contour farming
- 45. T F Irrigation for high-value crops
- 46. T F Maintain riparian buffers

Woodland

- 51. T F Specialized harvesting equipment
- 52. T F Erosion control
- 53. T F Seasonal harvesting
- 54. T F Maintain riparian buffers

SLOPE FINDER

Hang weight on a string from
this point



(Aim across sighting pin just like aiming a gun—using your front sight and back sight.)

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.