Connecticut Envirothon

Soil Manual

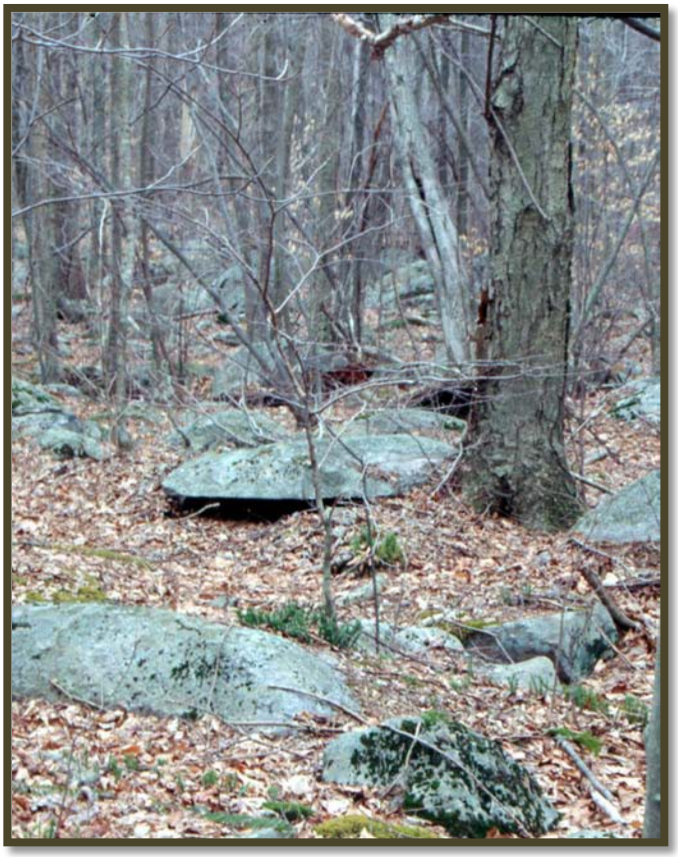


Table of Contents

United States Department of Agriculture
Natural Resources Conservation Service
Helping People Help the Land
USDA is an equal opportunity employer and provider.

Connecticut Envirothon
Take The Natural Challenge

This handbook is intended for use by students participating in the Connecticut Envirothon.

Introduction

The way we define and characterize soils depends on our background. For example, farmers view soils as a medium for plant growth, engineers view them as a resource to build on, while geologists may call all material above bedrock "overburden". Because soils are so variable across the Connecticut landscape, one parcel may have several types of soils with many potential uses. In this manual, land will be evaluated primarily from the agricultural, forestry, and engineering perspectives.

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. Organic matter can accumulate in all soils in Connecticut. For example, a darker color in the surface layer is an indication of organic matter accumulation. Organic matter usually decreases with soil depth except in floodplains and areas disturbed by humans. Although Connecticut soils are relatively young, chemical changes are important in layer or *horizon* differentiation.

Other important processes include chemical reactions such as oxidation, reduction, and hydration and physical weathering or the breakdown of particles into finer pieces. In some soils, iron compounds have moved down through the soil forming metal-organic oxides (rusts). These compounds 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. Mechanical breakdown is mainly a result of freezing and thawing.

Some processes modify, impede, or reverse the effects of soil forming processes. Examples are the mixing of soil by tree throw, animal movement (i.e. burrowing), and frost action, and the deposition of new material from flooding, landslides, or human activity.

All soils are constantly developing, or undergoing *pedogenesis*. Changes range from extremely gradual to drastic. To judge the land we must evaluate soil features according to intended uses. The evaluated features can then be used to determine if the intended use is ecologically and economically feasible. Land and soil judging requires careful attention to soil texture, color, drainage conditions, permeability, depth, stoniness or rockiness, slope and surface runoff.

Soil Forming Factors

Soil forms through the interaction of five major factors:

1) physical, chemical, and mineral composition of the <u>parent material</u>
2) <u>climate</u>
3) <u>biology</u> of the soil
4) <u>topography</u>
5) length of <u>time</u> the processes of soil formation have acted on parent material

Parent Material

Parent material is the unconsolidated material from which soils form. It determines the baseline chemical and physical composition of the soil. Most parent materials in Connecticut were deposited by glaciers that covered New England at least 15,000 years ago. Because of this properties can sometimes vary greatly within small areas. Some material was also affected by subsequent actions of wind and water, so some soils may have more than one parent material. General categories of Connecticut parent material are:

<u>Glacial till</u> was deposited directly by glaciers and contains a mix of particles varying in size and shape including silt, sand, gravel, cobbles, and stones that have not been worn smooth by water. Rock fragments have sharp, angular edges and corners. Chemistry varies depending on bedrock composition of the area. Till soils are usually loamy textured although they can be silty or sandy. Bedrock is near or at the surface in some glacial till soils.

<u>Glacial outwash</u> was deposited by flowing glacial melt water. These deposits are sandy or gravelly, especially in the lower part of the soil profile. Outwash generally consists of layers or *strata* of sand and gravel, depending on the speed of the water at the time of deposition.

<u>Alluvial deposits</u> are left by floodwaters of streams, so they are found adjacent to stream channels. Alluvium ranges in texture from silty to loamy to sandy, depending on the speed of the water that deposited the material. Alluvial deposits are typically stratified and may include buried surface layers, so they also have irregular organic matter content within the profile.

<u>Lacustrine deposits</u> were deposited in glacial lakes when the glacier blocked river and stream valleys. In these low-energy environments, finer soil particles such as silt and clay settle to the bottom. When the lakes eventually drained the lacustrine deposits remained. Soils that form in lacustrine deposits typically have layered clayey or silty textures with very few sand or gravel particles and are mainly found in the Central Valley of Connecticut.

<u>Organic material</u> consists of decomposed plant material. The degree of decomposition varies from slightly decomposed (fibric material/ peat) to moderately decomposed (hemic/ mucky peat) to highly decomposed (sapric material/muck). In most places soil saturation has aided in the build-up of these deposits by slowing the decomposition rate.

Climate

Climate influences the rate of chemical and biological activity in the soil through its effect on soil temperature and moisture. In colder and saturated soils, the level of biological and chemical activity is low and organic matter can accumulate, while these processes occur faster in warmer moist soils. Climate can also influence which plants and animals live in the soil.
The climate in Connecticut differs depending on elevation and topography. The two soil temperature regimes recognized in the state are the *mesic* regime which occurs in most of the state and the *frigid* regime which occurs in the hills of northwestern Connecticut, mainly above 1500’ (450m) in elevation.

Biology

Plants add organic matter and nutrients to the soil by decaying and becoming incorporated into the soil. Plant roots and macrofauna provide channels for water movement through the soil. Soil bacteria and fungi break down the organic matter and release plant nutrients as well as provide soil structure by exuding a substance called *glomalin*. The effects of soil biology are most notable in surface layers.

Topography

Topography effects soil formation through its influence on drainage, erosion, vegetation, and temperature. Local topography can be measured as percent slope, which is defined as the change in elevation across a distance. In Connecticut slopes range from nearly level (0%) to very steep (> 70%). Steeper slopes have higher runoff because water always travels downhill. In low-lying areas soils are often wetter than upslope positions. Water and air move more freely through soils that have better drainage.

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. 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.

Physical Soil Features

Soil Profile

Soils are made of distinct layers called horizons (see Figure 1). The mineral horizon closest to the soil surface is referred to as the A horizon or topsoil. There may or may not be an organic O horizon above it. The layer below is the B horizon or subsoil. The C horizon or substratum is relatively undeveloped parent material with few to no roots.

The layers of the soil profile can indicate a water table, depth to impervious layers or bedrock, and organic matter content.

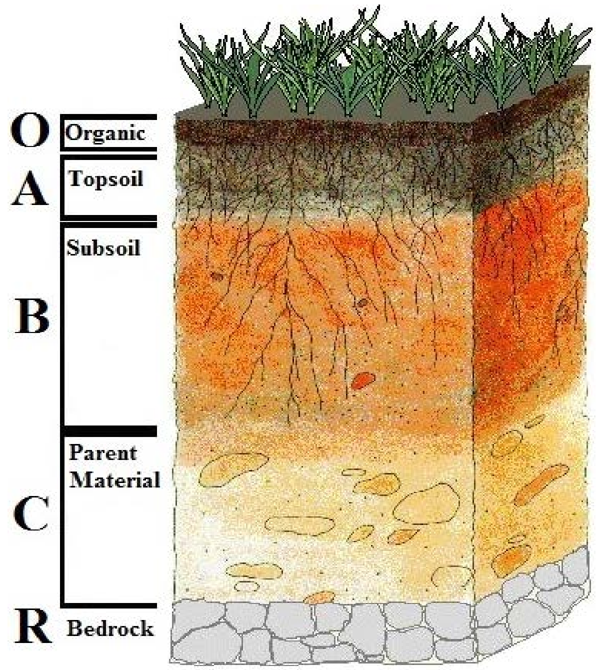


Figure 1: A soil profile from a forest showing the basic horizons. The O horizon is composed of organic matter. The A horizon in this unplowed soil is darker in color because of the high organic matter content. In a plowed soil (most of Connecticut), the O horizon is mixed with the A.

Soil Texture

Soil texture is the relative proportions of the various sizes of soil particles in a soil (Figure 2). Soil particles are small pieces of rocks and minerals. They are grouped by their size into sand, silt, and clay. Texture and soil structure influence moisture, fertility, permeability, and erosion potential.

The USDA Natural Resources Conservation Service (NRCS) uses a textural triangle (Figure 3) that illustrates how soil textures are determined by the percentages of each of the three mineral soil size classes. Soil texture is determined by moistening the soil and rubbing a small amount between the thumb and fingers so the relative proportions of sand, silt, and clay can be estimated. The textural groups used in this manual are as follows:

	FINE EARTH									ROCK FRAGMENTS				150	380	600 mm
										channers				flagst.	stones	boulders
USDA [1]	Clay [2]		Silt		Sand					Gravel			Cob-bles	Stones		Boulders
	fine	co.	fine	co.	v.fi.	fi.	med.	co.	v. co.	fine	medium	coarse				
millimeters:	0.0002	.002 mm		.02	.05	.1	.25	.5	1	2 mm	5	20	76	250		600 mm
U.S. Standard Sieve No. *(opening)*:					300 [3]	140	60	35	18	10	4	*(3/4")*	*(3")*	*(10")*		*(25")*

Figure 2: Particle Size (in mm) of NRCS Textures

Sandy: Sandy soils feel gritty and fall apart when moist. Textures are loamy sand and sand. They have low moisture holding capacity and permit water and air to move through rapidly.

Loamy and Silty: Loamy and silty soils contain a mix of sand, silt, and clay. Textures are loam, sandy loam, silt loam, and silt. Loamy soils feel slightly gritty but not sticky. Silty soils feel relatively smooth but not sticky. A ribbon does not form easily when a moistened sample is rubbed between the fingers and thumb. Loamy and silty textures have good moisture holding capacity and fertility. They are typically the most productive agricultural soils.

Clayey: Clayey soils contain at least 27% clay, with the exception of the sandy clay loam which contains only 20% clay. Textures are sandy clay, sandy clay loam, clay loam, silty clay, silty clay loam, and clay. 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. Because they contain finer pores, clayey soils do not normally allow water to move through as rapidly as silty, loamy, or sandy soils. These textures have good moisture holding capacity and high fertility levels.

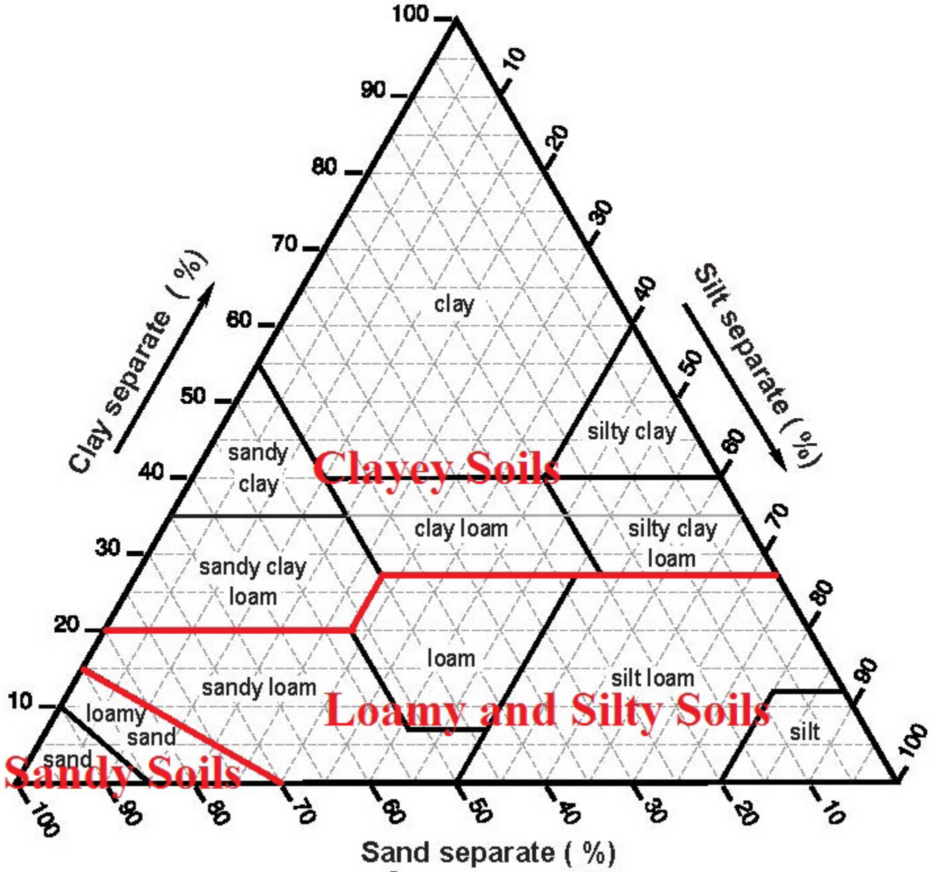
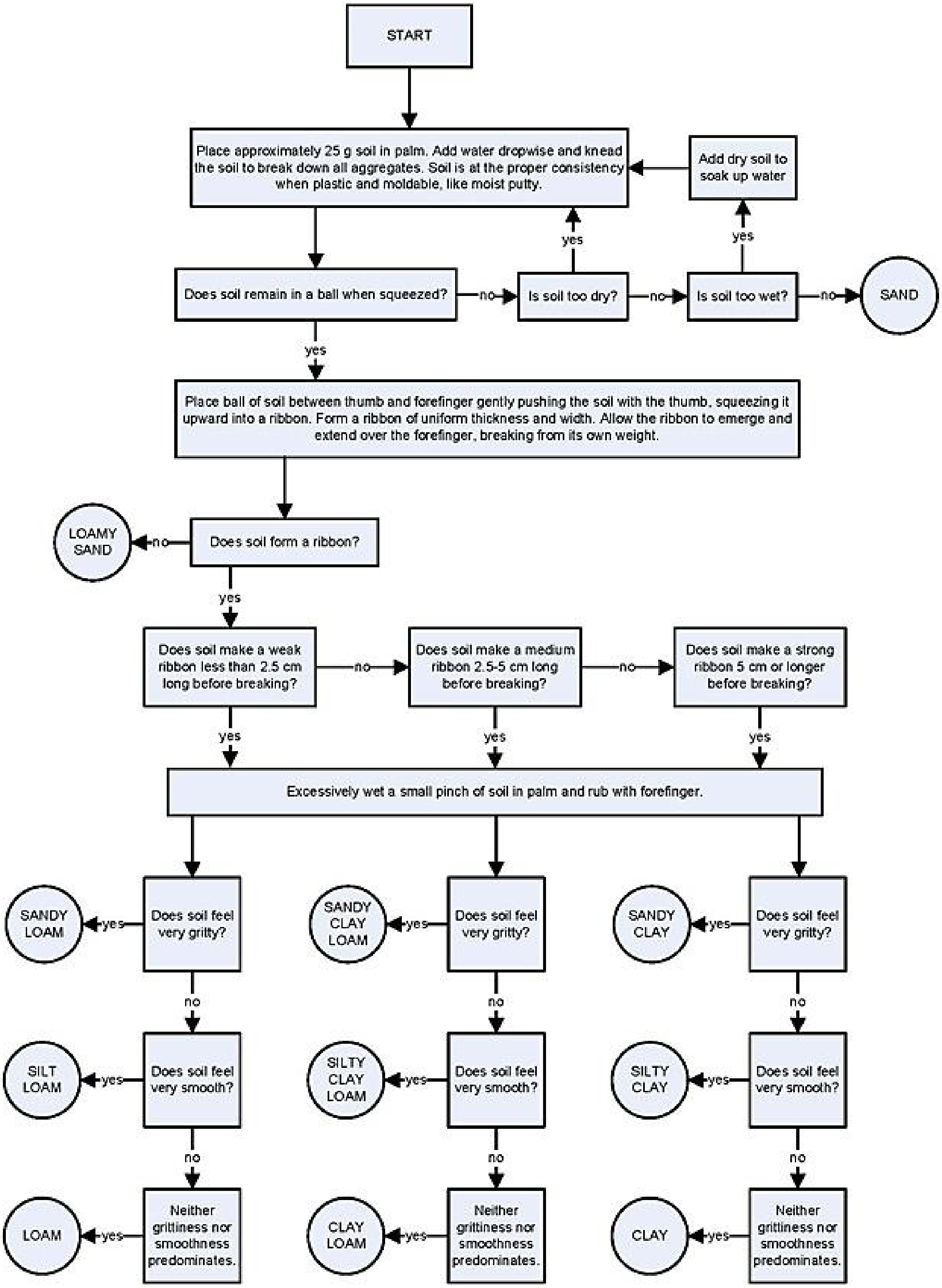


Figure 3: NRCS Textural Triangle; Red lines show texture groups for this manual. Please see next page for the texturing by feel worksheet.

Soil Texture by Feel



Seasonal High Water Table

A seasonal high water table is defined as the highest level at which water reaches during the year. Because of drought, heavy rain, plants, and other factors, no water table has a truly constant depth. The water table will fluctuate substantially during a normal year. Note that the seasonal high water table is not the same as groundwater. Groundwater wells typically go into bedrock and are often over 100' (30m) deep.

Redoximorphic Features

The presence of redoximorphic or *redox* features in a soil profile generally indicates a seasonal high water table. Redoximorphic features in Connecticut are typically red to yellow and gray areas which are distinguishable from the dominant soil color (Figure 4). Areas with distinctly gray colors or *depletions* indicate a seasonal high water table. Reddish-orange redox features are *concentrations* of oxidized minerals, primarily iron (rust). These are commonly formed at a depth where water levels fluctuate creating alternating periods of aerobic and anaerobic conditions.

Uniformly gray or *gleyed* colors in the subsoil form during long periods of wetness that create anaerobic conditions which cause microbes to reduce iron and other minerals. These poorly drained soils are usually in depressional landscape positions; however, redox features can also form between soil horizons that have strongly contrasting textures which can slow or "perch" water due to the change in size of soil pores. In these situations the redox features are found at only one depth, and should not necessarily be interpreted as an indication of a water table. Some soils can also have gray or red colors due to the parent material of the soil, so redox features can be difficult to detect. Some other ways to help determine drainage class are:

- Vegetation- water-loving or *hydrophilic* plants may be present
- Rooting Depth- shallow rooting depth may indicate a water table
- Soil Color- uniform bright colors indicate a well drained soil; gray colors near the surface generally indicate a poorly drained soil
- Landscape position- poorly drained soils are typically in depressions or footslopes

Figure 4: Images of Redox Features (top) and Gleyed Soil (bottom)

Soil Drainage Classes

The drainage class of a soil is based on the presence and depth of the seasonal high water table in the profile. The class is usually determined by redoximorphic features as follows:

Excessively drained- textures coarser than loamy fine sand, usually shallow to sand and gravel or bedrock; no redox features within 40" (100 cm)

Somewhat excessively drained- textures are commonly sandy and gravelly below 20" (50cm) and may be moderately deep to bedrock; no redoximorphic features within 40" (100 cm)

Well drained- textures finer than loamy fine sand in upper 20" (50cm); No redoximorphic features within 30" (76cm)

Moderately well drained- no redoximorphic features in upper B horizons; Redoximorphic features typically between 15 -30” with redox depletions usually present

Poorly drained- many prominent redox features below surface layer within 12” (30cm)

Very poorly drained- all organic soils, or mineral soils with chroma of matrix of subsoil <2 if redox concentrations are present and chroma < 1 if no concentrations

Soil Permeability

The permeability of a soil is defined as how easily gases, liquids, or roots can move through a layer of soil. Many things affect the permeability of a soil such as texture, density, structure (Figure 5), and impermeable layers. Look at these features in the subsoil to determine the permeability class below:

Rapid- Water moves through the soil at a rate of at least 6’ per hour. Subsoil textures are sandy and transmit water readily. Groundwater contamination can be a concern.

Moderate- Water moves through the soil at 0.6 -6.0” per hour. Textures are mostly loamy and silty.

Slow- Water moves through the soil at < 0.6” per hour. Textures are clayey or loamy and silty that with a dense layer (such as compact glacial till or hardpan).

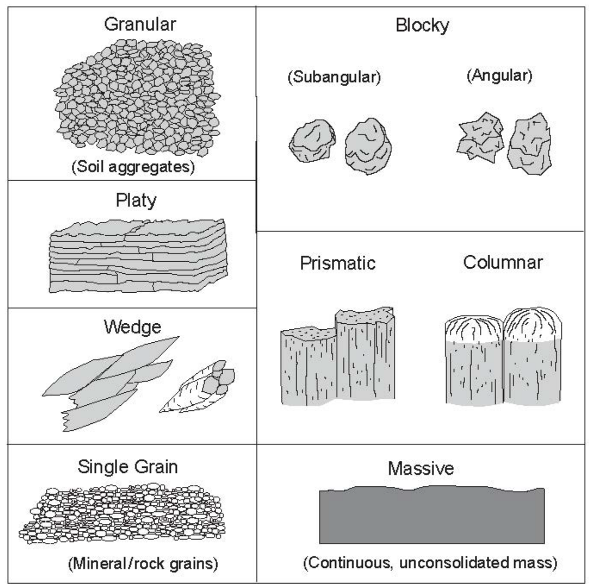


Figure 5: Examples of Soil Structure Types

Depth to Root Limiting Layer

Root limiting layers are features in the soil which limit most plant roots growth, including bedrock, seasonal high water table, dense layer. Dense layers are typically *massive* (structureless) or have *platy* structure, have very firm *consistence* or are difficult to break into pieces, or may have root penetration refusal to the bottom of the soil pit. The depth categories are:

Deep- >40” (100 cm) to bedrock or restrictive layer

Moderately Deep- 20 to 40” (50-100 cm) to bedrock or restrictive layer

Shallow- <20” (50cm) to bedrock or restrictive layer

Surface Stoniness and Rockiness

Stoniness refers to the amount of stones and boulders >10” (25 cm) in diameter in at least one direction. Rockiness refers to bedrock outcrops. The classes of stoniness and rockiness are as follows:

None or few– distance between stones and/or rock outcrops >25’

Stony– distance between stones and boulders <25’; there are no rock outcrops

Rocky– distance between rock outcrops < 25’; stoniness can range from none to extremely stony

Slope

The steepness and length of the slope influences runoff and potential of soil erosion. Steepness of slope is expressed in percent which indicates change in elevation in feet over a 100’ distance. For example, a 14% slope translates to a 14’ change in elevation over a 100’ length. Percent slope is determined by using a slope finder (attached), level, or clinometer. The classes are:

A- ≤ 3% slope
B- 4 to 8% slope
C- 9 to 15% slope
D- 16 to 35% slope
E- >35% slope

Surface Runoff

The runoff rate is how fast water moves over a soil. 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 percent slope, so it is helpful to determine the slope of the soil before deciding on the runoff class. The surface runoff classes are:

Slow- soils with slopes < 3%

Moderate- soils with slopes of 4 to 8%

Rapid- soils with slopes >8%

Soil permeability, which depends on structure, density, and texture, also influences the amount of runoff. As water moves downslope, a certain amount will infiltrate into the soil depending on its permeability. The condition of the soils and their land cover will also affect runoff. Saturated soils absorb much less water than dry soils. Forested soils have less runoff than similar vegetated soils, partly because bare soils can be *crusted* or sealed by raindrop impact.

Applying Soil Features to Land Use

Agricultural Potential

Prime Farmland soils must have all of the following characteristics:

- depth to bedrock is >40” (100 cm) deep
- drainage class is well drained or moderately well drained
- slope ≤8% (nearly level to gently sloping)
- surface texture is loamy or silty and surface has none or few stones or rock outcrops

Soils with **high potential** do not meet the Prime Farmland criteria, and have the following:

- slope ≤15%
- depth to bedrock is ≥20” (50 cm), moderately deep or deep
- drainage class is well drained or moderately well drained
- surface has none or few stones or rock outcrops

Soils with **<u>low potential</u>** have one or more of the following characteristics, but do not qualify as a soil with no potential:

- slope >15%
- depth to bedrock <20" (50 cm), shallow
- drainage class is poorly drained
- surface is either very stony to extremely stony or very rocky to extremely rocky

Soils with **<u>no potential</u>** are limited to soils that have the following combination of:

- slope >35%
- surface is very rocky to extremely rocky

Forestry Potential

In general, most of Connecticut's soils have good forestry potential. The following are limitations to forestry practices:

- Slopes >35% limit harvesting, interfere with layout of wood roads and trails, and create severe erosion hazards during logging operations
- Soils <20" (50 cm;) deep to bedrock may have a wind throw hazard, seedling mortality, and limited moisture holding capacity
- Soils that are poorly drained can result in harvesting problems with heavy equipment, seeding mortality (frost heave), and wind throw hazards
- On sites with a very rocky to extremely rocky surface it can be difficult to establish roads and trails, there may be harvesting damage (felled trees can break on rock outcrops), and equipment limitations

Housing Potential

Any one of the following will make a site unsuitable for housing with on-site septic systems and basements:

- seasonal high water table within 15" (38 cm), poorly drained
- bedrock within 20" (50 cm), shallow to bedrock
- slope >35%
- areas that flood, parent material is alluvial deposits

Row Crop Potential

Row crops are annual crops grown continuously or in rotation with grasses and/or legumes. Any one of the following factors will make a site unsuitable for row crops:

- bedrock within 20" (50 cm), shallow to bedrock
- slope >15%
- very rocky to extremely rocky surface

Hay Land Potential

Hay land has continuous grass and/or legume cover. The combination of both of the following will make a site unsuitable for hay land:

- slope >35%
- very rocky to extremely rocky surface

Evaluating Limitations for Land Use

Limitations	*Land Use*			
	Home/Septic	**Row Crops**	**Hay Land**	**Forestry**
Texture	Clayey Subsoil	Clayey Topsoil	None	None
Permeability	Slow	Slow	Slow	Slow
Depth to Bedrock (or other restrictive layer)	<40 inches (100 cm)	<20 inches (50 cm)	<20 inches (50 cm)	<20 inches (50 cm)
Slope greater than:	15 percent	8 percent	15 percent	35 percent
Depth to Seasonal High Water Table	<40 inches (100 cm)	<20 inches (50 cm)	<20 inches (50 cm)	<20 inches (50 cm)
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

Some final thoughts on soil...
When you subtract the amount of the Earth's surface that is covered in water, ice, desert, mountains, buildings, or pavement, there is only about 3% of the planet available to farm. This area of soil must produce enough food to feed 7 billion people.

Worksheet for Evaluating Soil and Land

Part A. Physical Soil Features

Circle only one answer for each question.

1. Texture of soil surface

A. Sandy
B. Loamy or Silty
C. Clayey

2. Texture of subsoil

A. Sandy
B. Loamy or Silty
C. Clayey

3. Parent material

A. Glacial Till
B. Glacial Outwash
C. Alluvium
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 (> 40 in or 100 cm)
B. Moderately Deep (20-40 in or 50-100 cm)
C. Shallow (<20 in or <50 cm)

7. Root limiting layer

A. Bedrock
B. Seasonal High Water Table
C. Dense subsoil layer
D. None

8. Stoniness or rockiness

A. Not stony or rocky
B. Very Stony
C. Very Rocky

9. Slope

A. 0-3%
B. 4-8%
C. 9-15%
D. 16-35%
E. >35%

10. Surface Runoff

A. Slow
B. Moderate
C. Rapid

11 Agricultural Potential

A. Prime Farmland
B. Good potential
C. Low Potential
D. No Potential

***BONUS*: What is the...?**

Depth to Bedrock (cm): _______
Depth to Water Table (cm): _______

Part B: Prime Farmland Factors

Circle "L" for limiting and "N" for non-limiting at this site:

12.	Slope	L	N
13.	Depth to bedrock	L	N
14.	Drainage	L	N
15.	Rockiness	L	N
16.	Texture	L	N
17.	None	L	N

Part C: Forestry Potential

Judge the site for forestry potential even if it is cleared. Circle "L" for limiting and "N" for non-limiting at this site:

18.	Slope	L	N
19.	Depth to bedrock	L	N
20.	Drainage	L	N
21.	Rockiness	L	N
22.	None	L	N

Part D: **Land Use Limitations**

Judge the site for each land use. Circle "L" for limiting and "N" for non-limiting at this site.

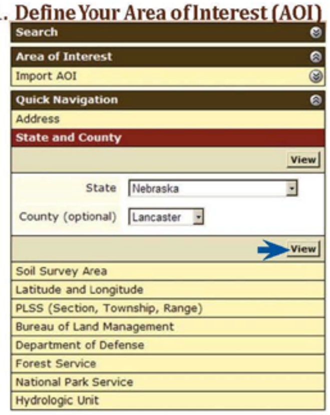
Limiting Soil Characteristic	**Land Use**											
	Houses with Basement & Septic Systems			**Crops**			**Hay Land**			**Forest**		
Texture	23	L	N	31.	L	N	39.	L	N	47.	L	N
Permeability	24	L	N	32.	L	N	40.	L	N	48.	L	N
Depth to Root Restrictive Layer	25	L	N	33.	L	N	41.	L	N	49.	L	N
Percent Slope	26	L	N	34.	L	N	42.	L	N	50.	L	N
Depth to Seasonal Water Table	27	L	N	35.	L	N	43.	L	N	51.	L	N
Flooding	28	L	N	36.	L	N	44.	L	N	52.	L	N
Stoniness and Rockiness	29	L	N	37	L	N	45.	L	N	53.	L	N
None	30	L	N	38	L	N	46.	L	N	54.	L	N

Web Soil Survey

Accessing Web Soil Survey

- Open the Web Soil Survey (WSS) site at: http://websoilsurvey.nrcs.usda.gov and click the "Start WSS" button.

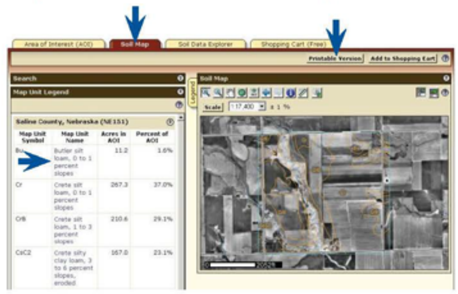
Step 1. Define Your Area of Interest (AOI)



- Several methods are available to zoom into a geographic area of interest. You can enter an address; select a state and county; enter section, township, and range information; or you can import a boundary file from your local computer to set the AOI.
- Click the "View" button to see the area.

- Use the zoom in tool (plus sign) to click and drag a rectangular box around a specific area. Repeat, as necessary, to zoom further.
- Select an AOI tool to draw a rectangular box or irregular polygon that defines the AOI and allows selection of associated soil data. Once the AOI has been defined, you can save it for use at a later date.

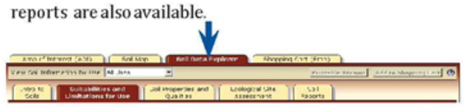
Step 2. View and Print Your Soil Map



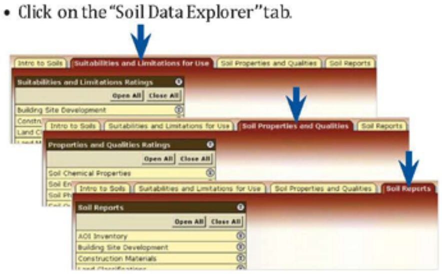
- Click on the "Soil Map" tab.
- Click on a map unit name to view a map unit description. Click the X to close the narrative.
- Print your soil map by clicking on the "Printable Version" button; then click the "View" button. On the browser menu bar, select File and Print; or click the print icon. Close the window.

Step 3. Explore Your Soil Information

WSS generates thematic maps of soil interpretations and chemical or physical properties. Tabular data reports are also available.



- Click on the "Soil Data Explorer" tab.



- Click on the tabs and explore available information (default tab is "Suitabilities and Limitations for Use").

Step 4. Add Items to the Free Shopping Cart and Check Out

WSS allows you to collect a variety of thematic maps and reports in the Shopping Cart, then print or download the content into one file or document.

- Soil map, map unit legend, and map unit descriptions are automatically added.

- Items viewed in Step 3 can be added by clicking the "Add to Shopping Cart" button.
- View your cart contents by clicking the "Shopping Cart (Free)" tab. Items checked on the Table of Contents are included.

- Get your Custom Soil Resource report.
  - -- Click the "Check Out" button
  - -- Select a delivery option and click OK

NOTE: At any time during Steps 2, 3, or 4, you can redefine the soil map location by clicking on the "Area of Interest" tab and clicking the "Clear AOI" button. Repeat Step 1.

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. ½” plywood or ¾” lumber may be used.

2. Place three nails at the points indicated on the slope finder. Attach a large weight or nut 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.

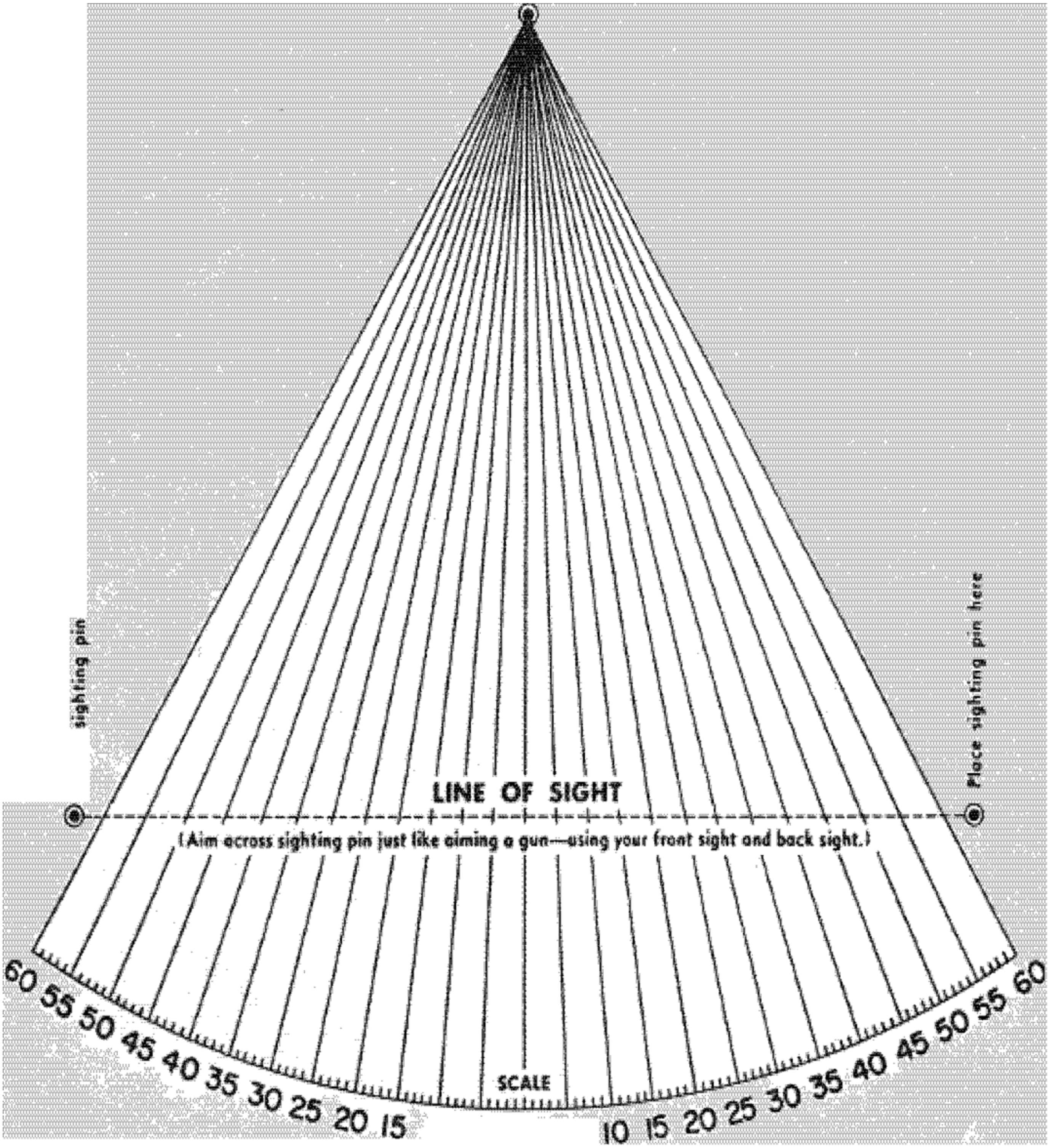
How to use a slope finder

1. The percent slope may be determined by either looking up or down the slope. It is not necessary to know the distance between the stakes.

2. Looking 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. The string and weight should swing free. On breezy days, guard against the wind.

3. When the weight has stopped swinging pinch the string against the board and read the percent slope. It can help to tilt the board at a slight forward angle and when the weight stops swinging.

SLOPE FINDER



Hang a weight on a string from this point

Read percent slope directly at the point where the string rests on the scale.