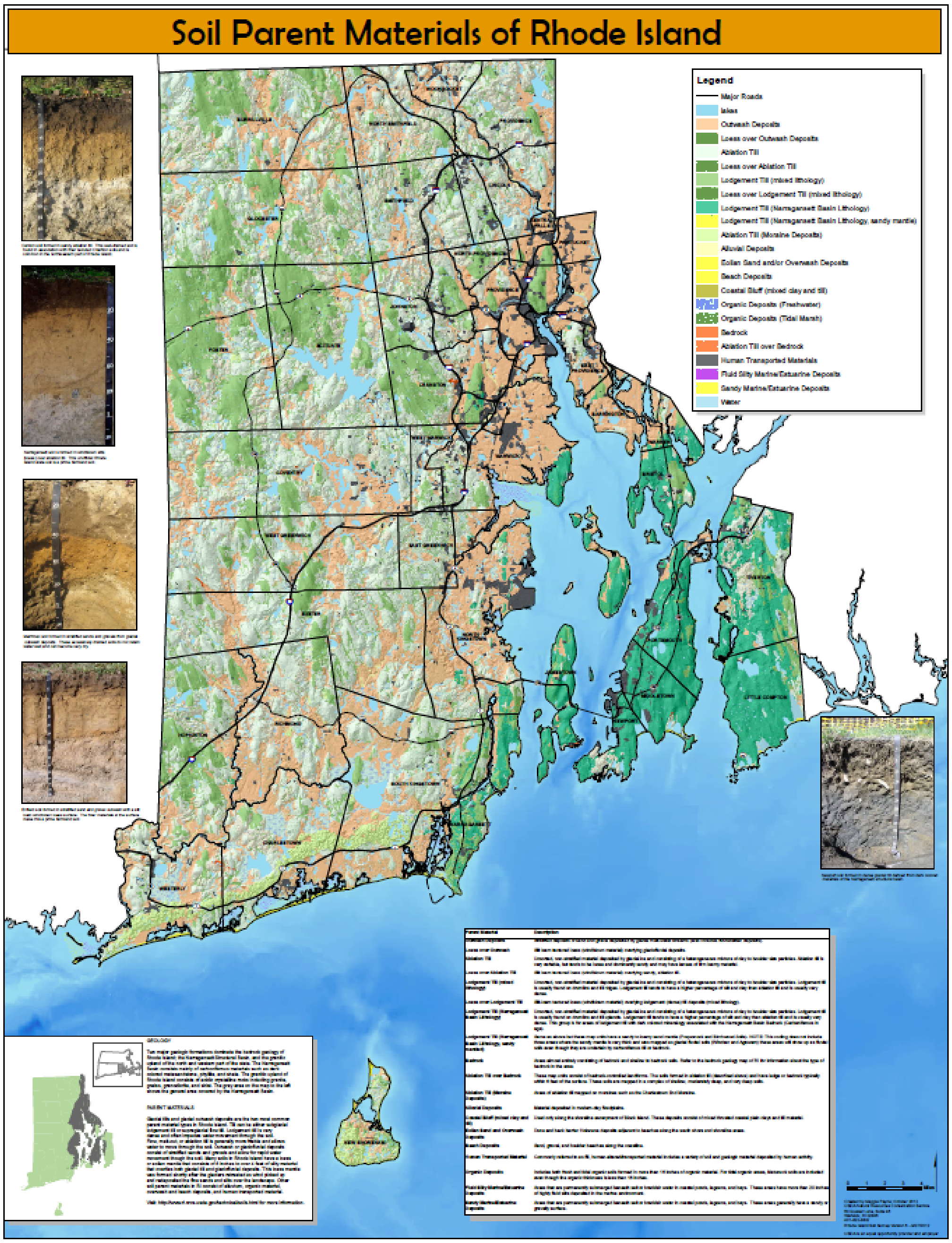
Rhode Island Envirothon Soil Manual



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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. 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 (Human Transported Soils). 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.

Soil Forming Factors

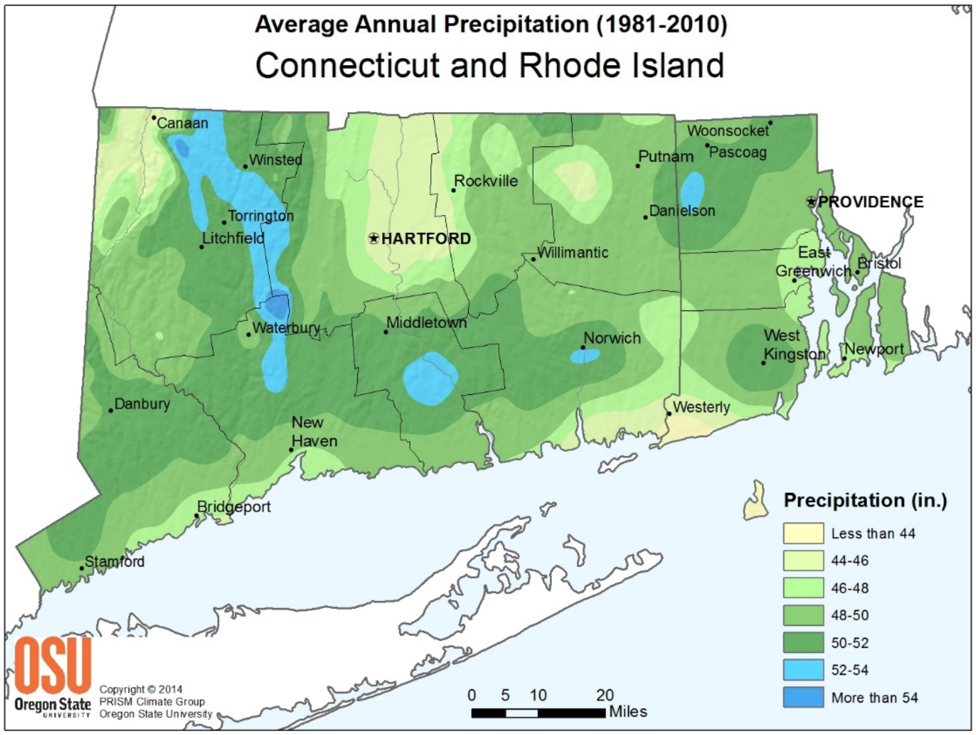
Soil forms through the interaction of five major factors: **CLORPT**

1) **cl**imate
2) **o**rganisms or biology of the soil
3) **r**elief or topography
4) physical, chemical, and mineral composition of the **p**arent material
5) length of **t**ime the processes of soil formation have acted on the parent material

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 Rhode Island differs depending on elevation and topography. All of Rhode Island is in the *mesic* soil temperature regime which means that the mean annual soil temperature is between 8C (47F) to 15C (59F) and rainfall ranges between 44 to 54 inches per year – see map below for the rainfall maps for RI and CT:



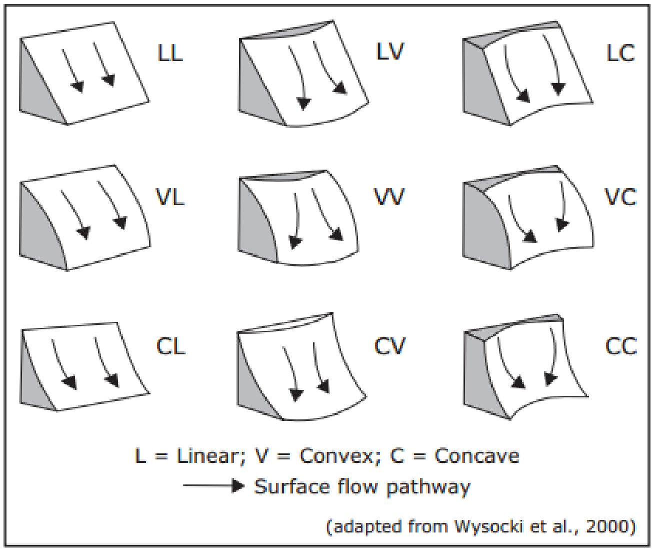
Organisms or Biology

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 (information on soil biology can be found at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/). Humans are also a major part of the organism factor – plowing soils, excavations, liming/fertilizing, filling land, and building on the soils all change the natural formation of the soils.

Relief or 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. Steep areas are subject to erosion and usually have shallower soil material, level land receives the erosion and the soils are typically deep. Relief and Topography also influences how water moves through and across the soil – convex landforms shed water and concave slopes receive water and are typically wetter (see figure below for slope shapes and how water moves through each).

Slope Shape—Slope shape is described in two directions: up and down slope (perpendicular to the elevation contour) and across slope (along the elevation contour); e.g., *Linear*, *Convex* or *LV*.



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 New England were deposited by glaciers that covered the area at least 15,000 years ago. Because of this properties can sometimes vary greatly within small areas. Most upland soil material was also affected by subsequent actions of wind and water, so some soils may have more than one parent material (eolian over till for example). General categories of parent material in New England are:

Glacial till 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 typically 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.

Material carried in different parts of the glacier produces till with different characteristics. Materials deposited directly beneath the glacier under enormous pressure are referred to lodgment till (dense till). Lodgment till is compact and contains a greater amount of fine-grained sediment. The compact or dense layer reduces the flow of air and water movement, producing a slowly permeable zone which supports perched water tables. Material deposited as the ice beneath slowly melts away is referred to as ablation or melt-out till, which is less consolidated and friable.

Glacial outwash (Glacial Fluvial) 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. It has very high air and water movement throughout, but very low available water making it very droughty. The materials are important for ground water and aquifer recharge.

Alluvial deposits 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. These water transported materials are generally very rich in nutrients and stone free.

Lacustrine deposits 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.

Organic material 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.

Human-altered material is soil that has undergone anthroturbation (soil mixing or disturbance) by humans. These soils may be composed of either mineral or organic soil material and may contain artifacts. The majority of the material has no evidence that it was transported from outside the pedons.

Human-transported material is soil that has been moved horizontally onto a pedon from a source area outside of that pedon by purposefully human activity, usually with the aid of machinery. These soils may be composed of either organic or mineral soil material and may contain artifacts.

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.

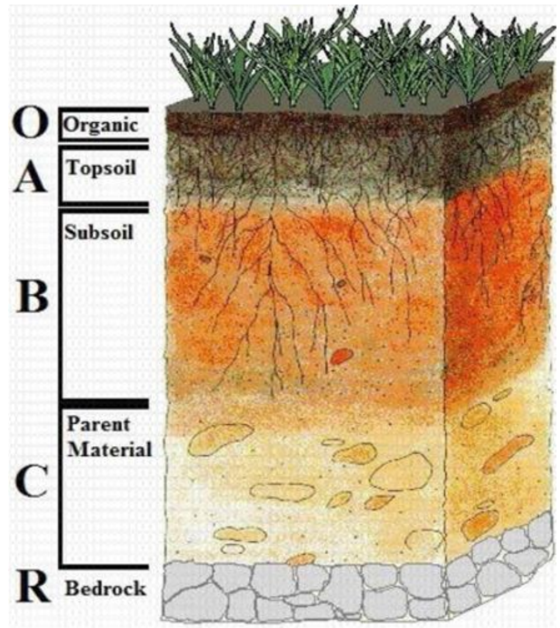


Figure 1: A soil profile from a forest showing the basic horizons. The O horizon is composed of organic matter. The A horizon in this unplowed soil is darker in color because of the high organic matter content. In a plowed soil, the O horizon is mixed with the A.

Horizons and Layers

The capital letters **O**, **A**, **B**, **C**, **E**, **L**, **W**, **M**, and **R** are used to identify master horizons. Lowercase letters are used to designate subordinate distinctions within master horizons.

Soil Color

Color helps us to differentiate between types of horizons of the same profile or different soil profiles. It is a physical property that allows us to know important characteristics, such as mineral composition, age and soil processes (chemical alteration, carbonate accumulation, the presence of humified organic matter, presence of a water table, etc.).

Three descriptive elements are used to describe the soil color: hue (a specific color), value (lightness and darkness), and chroma (color intensity). Using a Munsell Color Book, moist soil is held behind the chips to find a visual match and assigned the corresponding Munsell notation. For a good quality soil color reading, the sun should be over your shoulder (behind you) and you should not wear sunglasses. Pages in the Munsell Book are prearranged from most red to most yellow.

Color contrast is the degree of visual distinction that is evident between one soil color compared with another in close proximity. It is a visual impression of the prominence between a minor color component (mottle or concentration) and an associated major color component (matrix). The Soil Survey Manual provides three categories of soil color contrast:

1. faint for contrasts that are evident only on close examination,
2. distinct for contrasts that are readily seen but are only moderately expressed, and
3. prominent for contrasts that are strongly expressed.

Use the chart on page 2-15 in the Field Book for Describing and Sampling Soils to record the contrast or color difference between redoximorphic features and the dominant matrix color.

Color basics:

1. Dark color (brown and black) indicate high amount of organic material (A or O horizons).
2. Yellowish to reddish colors indicate oxidized iron and good drainage (no high water table).
3. Gray and patterns of gray and yellow colors below the top layer (not deep in the C horizon) indicate soil wetness and high water tables.
4. Color does not have any bearing on the type of soil texture – clays can be red or gray

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:

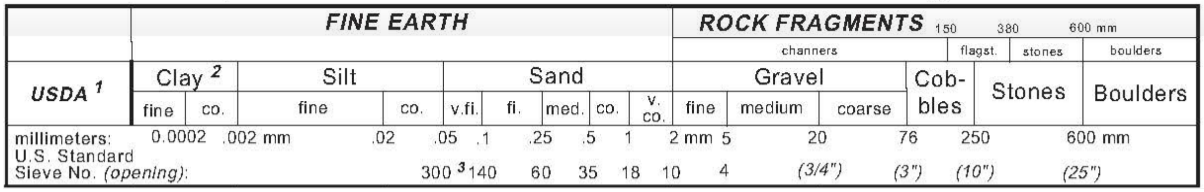


Figure 2: Particle size (in mm) of NRCS textures

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.

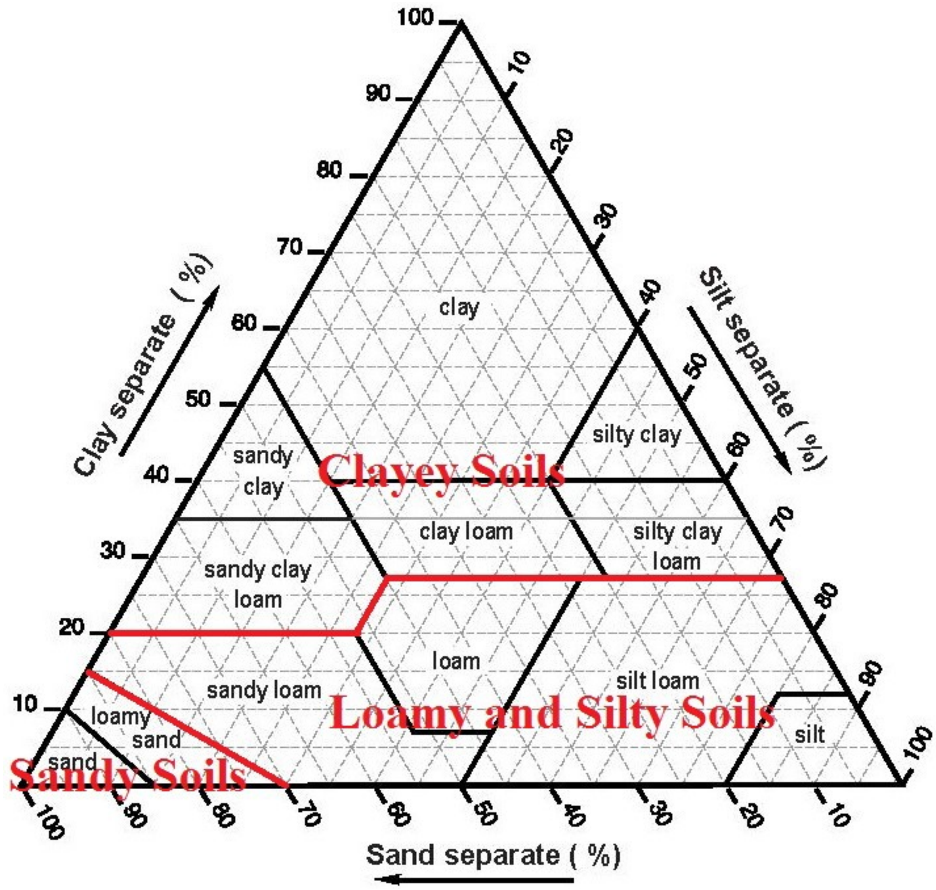
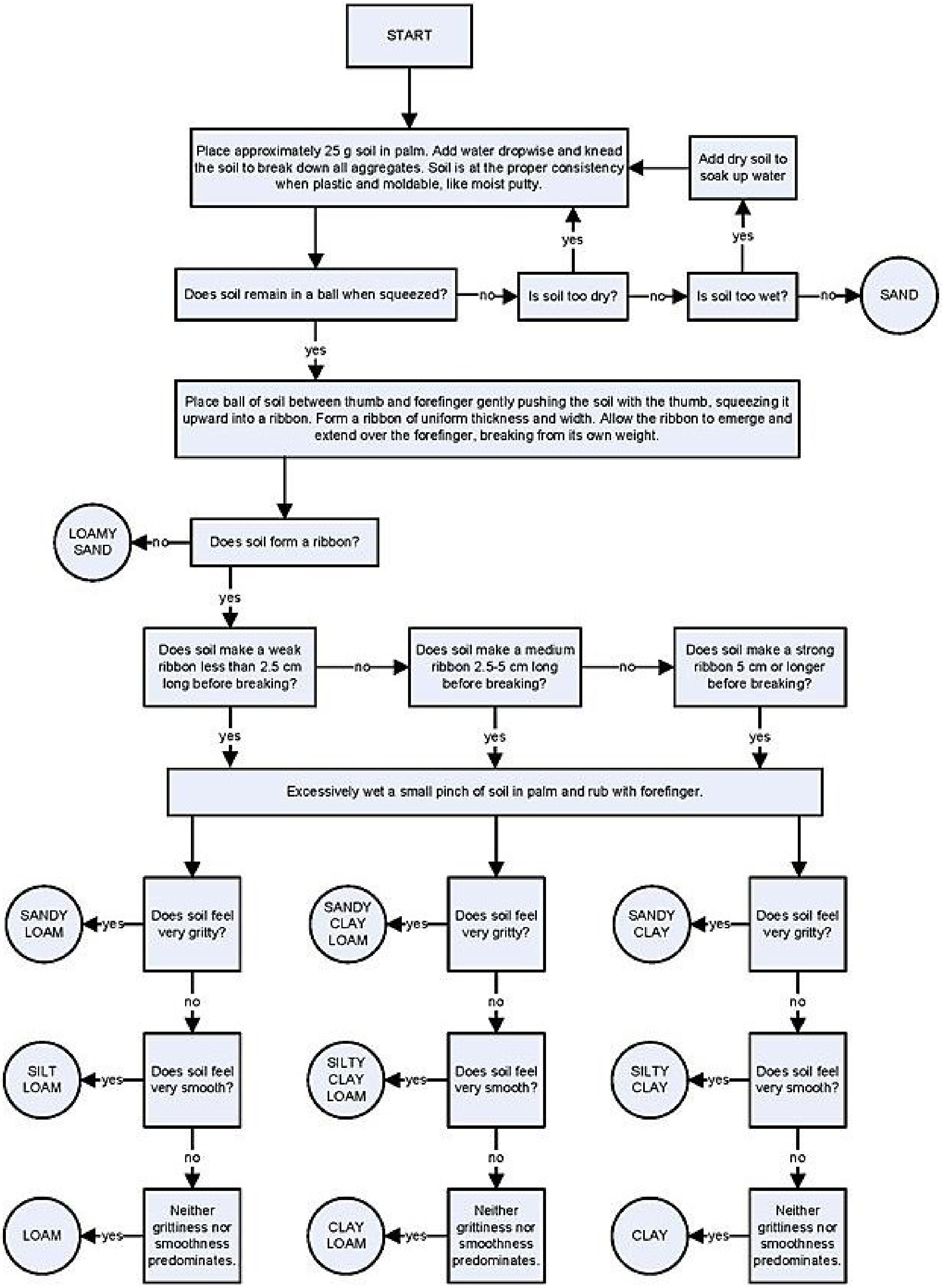


Figure 3: NRCS Textural Triangle; red lines show texture groups for this manual. Please see next page for the texturing by feel worksheet.

Soil Texture by Feel



Soil Structure

Soil structure is defined by the way individual particles of sand, silt, and clay are assembled. These are called aggregates. Aggregation of soil particles can occur in different patterns, resulting in different soil structures. The circulation of water in the soil varies greatly according to structure. Soil structure is described in terms of grade (degree of aggregation), size, and type of aggregates (form).

Use pages 2-53 to 2-61 in the Field Book for Describing and Sampling Soils to record the grade, size, and type of soil structure.

Soil Consistence

Soil consistency is the strength with which soil materials are held together or the resistance of soils to deformation and rupture. Soil consistency is measured for wet, moist and dry soil samples. Soil consistency may be estimated in the field using simple tests or may be measured more accurately in the laboratory.

Use pages 2-62 to 2-69 in the Field Book for Describing and Sampling Soils to record the consistence.

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.

Figure 4: Images of redoximorphic features (top) and gleyed soil (bottom).

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

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

Depth to Restrictive Layer

Restrictive layers are features in the soil which limit most plant roots growth, including bedrock, seasonal high water table, and 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