Envirothon Soil Guide

INTRODUCTION

Most of our daily activities and lives are related to and influenced by the soil around us. Life as we know it would not exist without soil. It is critical for us to understand the soil and it's importance, as well as how to manage soil and other natural resources in regards to soil properties and behavior.

What is soil? The answer depends on who you are asking. In engineering and construction, soil is the usual name for earth that can be excavated without blasting. Geologists commonly use the term soil for a layer of weathered, unconsolidated material on top of bedrock. To soil scientists, soil is unconsolidated mixture of mineral and organic material at the surface of the earth that serves as a natural medium for growing plants.

Most soils take a very long time to form. They may be millions of years old. They form from rocks and sediments (parent materials) that have disintegrated and decomposed through the action of weathering and organisms. The five factors that control the formation of soils are:

Climate
Organisms
Topography (slope, aspect, relief)
Parent Material
Time

Soils perform many functions that are important to all of us. A healthy soil performs five critical functions:

Filters and cleans our water
Acts as a medium for plant growth and habitat for organisms
Stores and regulates water flow
Is an engineering/structural medium
Helps recycle nutrients and organic materials

The Use of This Guide

The soil properties, soil conditions, and soil uses in this guide provide a brief overview. The definitions and information are not intended to be all encompassing – they simply provide a brief discussion of the subject covering most situations that will introduce participants to the idea of soil science. If more detailed information is needed, the County Conservation Districts have a list of professional soil scientists throughout the state who are available to serve as volunteer coaches for schools participating in the contest.

PHYSICAL FEATURES OF THE SOIL

Soil Profile and Soil Horizonss

When a pit is excavated in the soil, the soil profile is exposed on the sides of the pit. The profile is a vertical cross section through the horizon (layers) of soil that occur roughly parallel to the soil surface.

The **O horizon** (organic layer) is almost entirely composed of organic matter. This is the layer of old semi-decomposed leaves, pine needles, and other plant material.

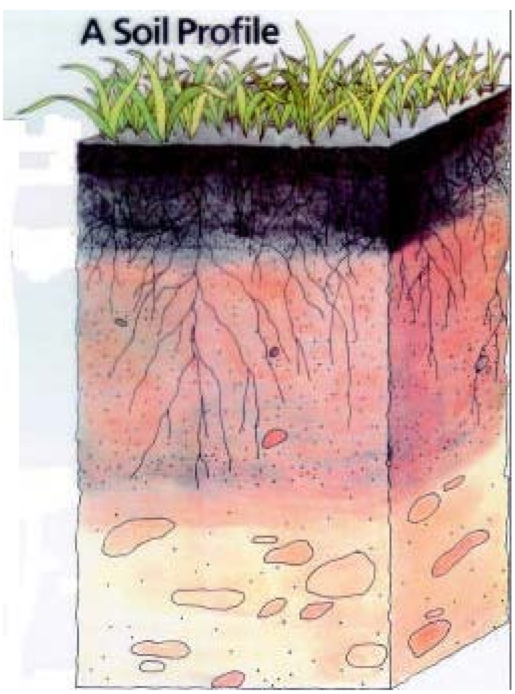
The **A horizon** (topsoil or surface layer) contains high amounts of organic matter and other nutrients and minerals. It furnishes the most favorable conditions for biologic and chemical activity. This layer is usually black, dark brown, gray brown, or a similar color. Roots are generally abundant. In many New Hampshire soils, it is usually only a few inches thick, except where the soil has been plowed, disturbed, or removed.

The **E horizon** (elluviation layer) is a layer where material has been removed (leached). Most of the minerals, organics, nutrients and color have been removed from this layer. This horizon is not present in many of our soils.

The **B horizon** (subsoil) starts at the bottom of either the E horizon or the surface layer and continues down to the parent material. It is a layer in which organic matter, nutrients, and chemicals that have leached down into the soil accumulate. This layer is usually yellowish brown, reddish brown, grayish brown, sometimes gray, or similar colors. Roots are generally common, but not nearly as abundant as in the surface layer.

The **C horizon** (substratum) typically starts at the bottom of the subsoil layer and extends down to the bedrock. This layer is also referred to as the parent material. This soil material contains little organic matter and, compared to the surface and subsoil layers, relatively few nutrients for plants. This layer is usually brownish gray, olive gray, or similar colors. Roots are not common in this layer. The parent material in most cases is the material from which the surface and subsoil layers developed.

The **R horizon** (rock layer) is bedrock, which often occurs below observation depth.



Texture

Soil is made up of about 50% mineral particles, 25% water and 25% air. The mineral particles are divided into three parts – sand, silt, and clay – depending on the size of the mineral particle. Texture is the relative proportion of the sand, silt, and clay in a given soil sample. The proportions are expressed in percent and the total is always 100 percent.

Texture is not based on other factors, such as how difficult the soil is to dig (most hardpans are not “clay”) or color (“blue clay” is seldom made up of clay mineral particles). Soil scientists, using the proportions of sand, silt and clay, and a textural triangle (see next page), divide soils into twelve different textures. The most common textures in New Hampshire are sandy loam and loamy sand, due to the high amounts of sand in the till and outwash. But the other textures are also present.

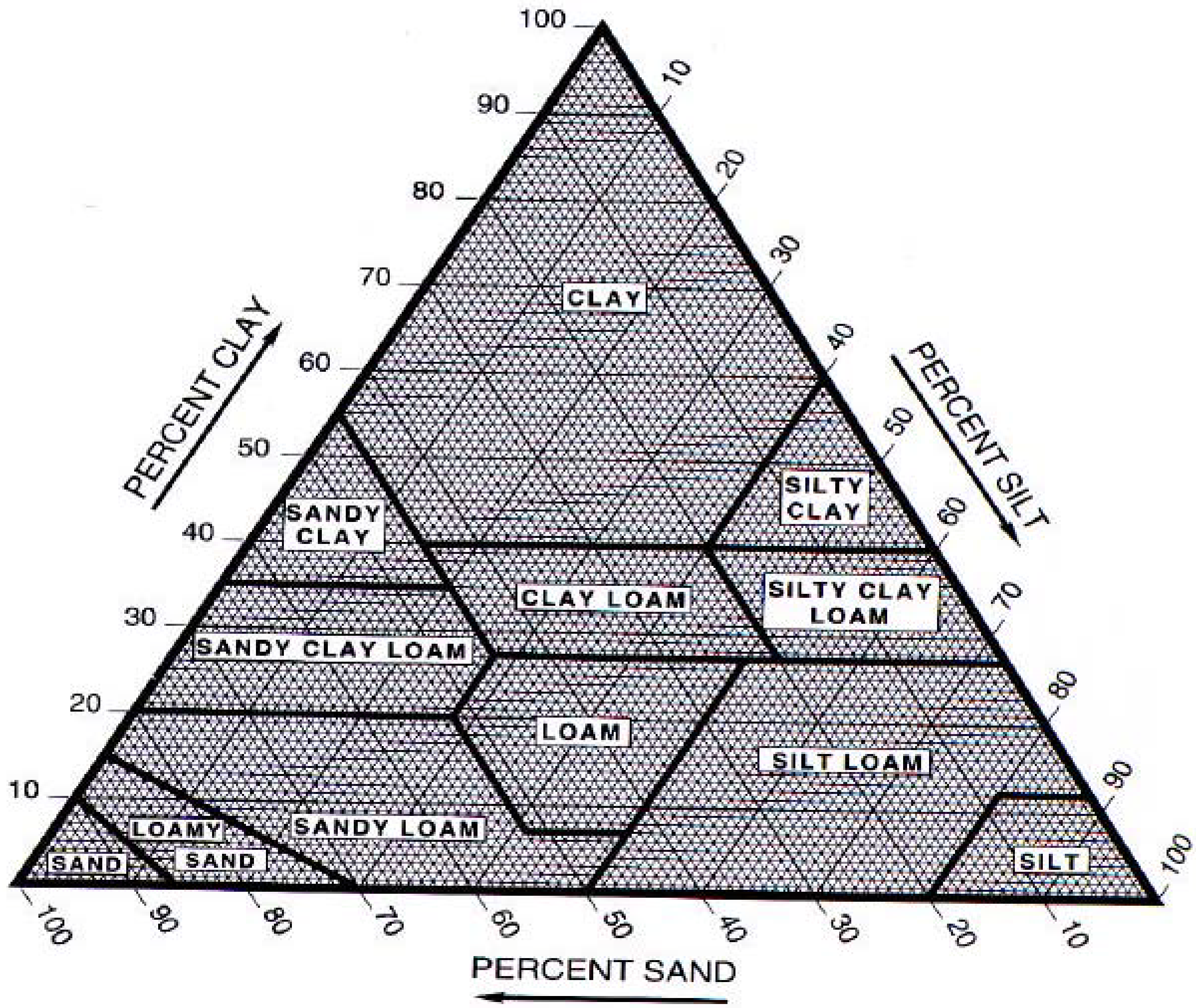
Texture is determined by taking a sample of soil (a ball about 1 inch in diameter), moistening it (if necessary), rubbing a small amount between the thumb and forefinger, and determining how it feels. The proper moisture content is important because it makes it easier to feel the mineral particles. The soil sample should be moist enough not to be dusty, but not so moist that water runs out when you squeeze it. Many soils are moist enough in spring of the year to be able to determine the texture, but in late summer and autumn, soils often need a small amount of water added to them in order for you to be able to determine the texture. The following is a brief description of what they feel and act like when rubbed between the thumb and forefinger:

Sand feels very gritty, not sticky, and when squeezed does not hold together in a ball. Sand will leave very little stain on the fingers, if any. Sand does not form a ribbon when squeezed between the thumb and forefinger.

Clay does not feel gritty. It is very sticky, and forms a ball when squeezed. A fingerprint will remain on the ball. Clay will stain the fingers. It will form a long ribbon when squeezed between the thumb and forefinger. The ribbon has a smooth surface. Clayey soil textures are usually found only in the Seacoast region of New Hampshire, where they are deposits of marine sediments.

Silt feels moderately gritty to smooth (butter-like), is not sticky, but forms a ball when squeezed. Loamy soils will stain the fingers. Silts may form a short (up to 1 inch long) ribbon when squeezed between the thumb and forefinger, and if so, the ribbon will have a flaky surface.

Loam is a term used to describe a mixture of all three particle sizes (sand, silt, and clay).



Hardpan

In New Hampshire, a hardpan occurs in the substratum layer of some glacial till soils. If a hardpan occurs, it always occurs in the substratum layer of glacial till soils. However, not all substratum layers in glacial till soils are hardpans.

Hardpans may have any soil texture, but are usually loamy. They occur in soils that have any natural soil drainage class.

To determine if a substratum layer is a hardpan, compare the firmness of the substratum and subsoil layers.

To perform this comparison, a small knife is recommended. Poke the knife into the subsoil and then the substratum in several different places. Compare the difficulty of inserting the knife. If the insertion of the knife into the substratum layer is significantly more difficult than the subsoil layer, then the substratum is hardpan.

If a knife is not available, this comparison can be done by squeezing a small clod from each of the layers between the thumb and forefinger to determine the firmness. If the clod crushes easily, when squeezed, the layer is not a hardpan; if the clod crushes suddenly when squeezed (like a small explosion) or if it takes a lot of pressure to crush the clod, the layer is a hardpan.

Permeability

The permeability of a soil layer is the rate at which air and water move downward through the layers. This rate is determined by two soil features: the soil texture and the presence of a hardpan in the substratum layer.

Soil layers with clay textures have slow permeability, those with loamy textures have moderate permeability, and those with sandy textures have rapid permeability. The only exception to this rule is if the substratum is a hardpan, in which case the permeability is slow regardless of the texture.

Natural Soil Drainage Class

Natural soil drainage classes are a means to summarize, in general terms, the internal drainage and water table relationships in a particular soil. In other words, it indicates where the water is situated during the wettest time of the year in that soil.

This soil characteristic may the most confusing feature of a soil to many people, but can be fairly easy to determine by having an understanding of soil colors.

Observations of the soil matrix color and the color of the redoximorphic features (mottles) will give you both the depth to the seasonal high water table and the natural soil drainage class.

Soil matrix color is the dominant color of each of the soil layers. Please refer to the section on “Soil Profile and Soil Layers” for common soil matrix colors.

Water tables in New Hampshire soils are generally highest in the spring (April) and lowest in the fall (late September). In some soils, the water table will fluctuate as much as 6 feet between spring and fall. It is in this zone of fluctuation that soil mottles are formed.

Soil mottles are small splotches of red and/or gray colors within the soil matrix color. They are usually 1/16 to 3/8 inch in size, and come in all shapes from long and narrow to round. Mottles are essentially rust in the soil, and are formed by the same process (oxidation and reduction of iron) as when a steel or iron tool is left out in the rain or dew, and splotches of rust form on it.

Just as wetting and drying form rusty colors on steel or iron tools, wetting and drying form rusty gray colors in the soil that we call mottles. The wetting and drying in the soil is caused by fluctuating seasonal water tables.

Soil mottles do not occur as an individual splotch or variations of color within a soil layer; there is always more than one splotch. Often times these individual splotches or variations are a result of other soil processes that are not caused by a fluctuation water table. When soil mottles that are caused by a fluctuating water table do occur, there is always more than one; they are separated from each other by distances of about ½ to 6 inches; and there may be upwards of 60 per square foot of soil profile.

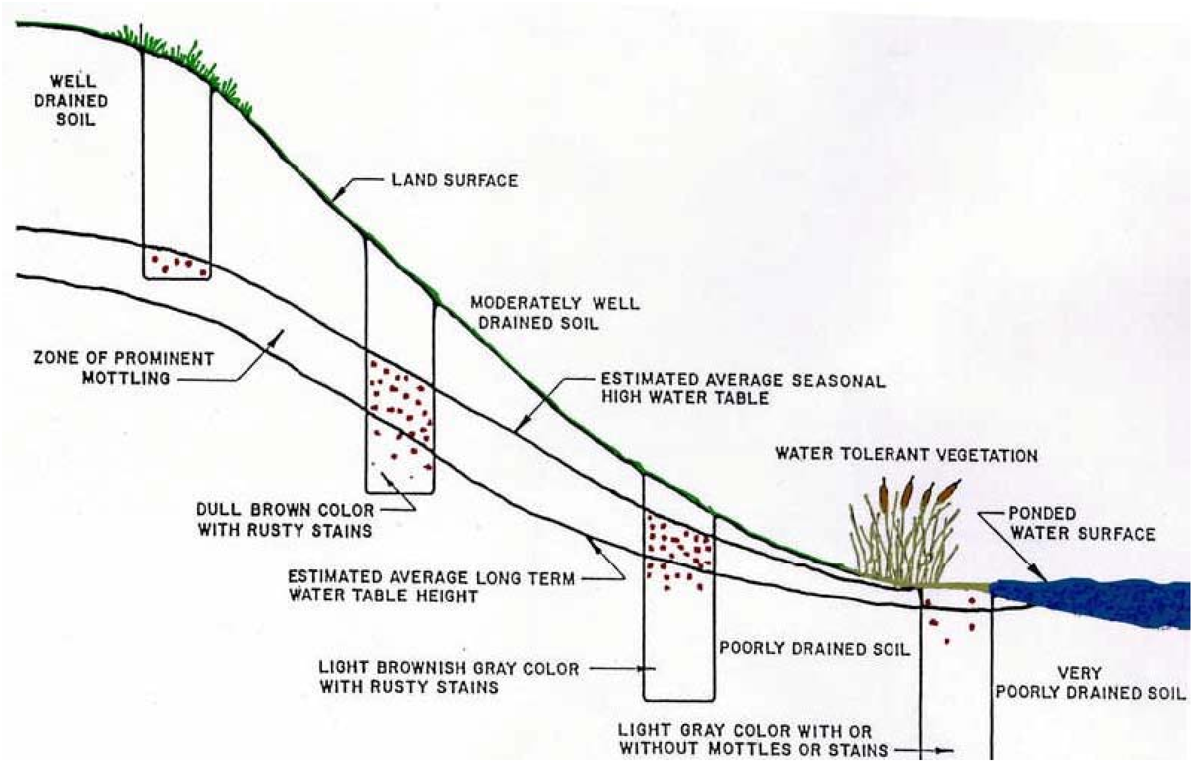
To determine the depth to the seasonal high water table at any time of the year, use the location of the mottles in the soil profile, not the location of the water table. For example, if you identify mottles between depths of 14 and 45 inches in the soil profile, and the observed water table is at 50 inches, the depth to the seasonal high water table is 14 inches.

Not every soil will have mottles within the soil profile that you will observe (generally to a depth of 60 inches).

Every soil, however, will fall into one of the natural soil drainage classes. Observations of the soil matrix color and the depth to mottles will give you the natural soil drainage class.

The natural soil drainage classes used are:

- Excessively Drained (ED)
- Somewhat Excessively Drained (SWE)
- Well Drained (WD)
- Moderately Well Drained (MWD)
- Somewhat Poorly Drained (SWPD)
- Poorly Drained (PD)
- Very Poorly Drained (VPD)



Bedrock

Bedrock is commonly known as ledge. It is the rock that lies under the surface of the land everywhere. Average depth to ledge in New Hampshire is 20 feet, but in some places, bedrock is very near the surface (within 60 inches). When ledge is within 60 inches of the surface, it starts to have a negative effect on uses of the land.

If ledge occurs in the soil profile, measure at what depth it occurs below the surface.

Slope

The slope of the land is the vertical rise or fall of the surface in feet per 100 feet of horizontal distance. It is expressed in percent. For example, a 6 percent slope means that you would rise or fall six feet if you walked 100 feet from your starting point. Use a clinometer to determine the slope to the nearest percent.

Surface Stoniness

Stones are 10 to 24 inches in size (diameter). Not all soils have surface stones. Rocks smaller than ten inches are considered cobbles or gravels.

Parent Material

Parent material is the raw material from which a soil is developed, and is often named by the method in which that material was deposited on the landscape.

The most common types of parent material are: alluvium (flood plain sediments), glacial outwash, glacial till, lacustrine (glacial lake bed sediments), marine (seabed sediments), and residuum (material formed in place from bedrock). In New Hampshire, the glacial materials were deposited when the last continental glacier was melting 10,000 to 14, 000 years ago. The flood plain sediments were deposited since that period, and continue to be deposited every time a stream overflows its banks and floods the adjacent land.

Each type of parent material has certain physical soil features that serve as clues to its identification.

Alluvium - Soil profiles in this parent material generally have either loamy or sandy textures stratified throughout the profile. Gravelly layers may also occur in the substratum. There are no surface stones. The substratum layer is not a hardpan. Soil profiles in flood plain sediments may contain (1/4 to 3 inches thick) darker colored layers that are high in organic material. These soils are normally adjacent to streams on nearly level landscapes.

Alluvial sediments are, and continue to be, deposited by floodwaters from nearby streams. The age of these sediments ranges from a few hundred years to as recent as the last flood.

Outwash - Soil profiles in this parent material typically have sandy textures in the subsoil and substratum layers. Sometimes the surface and subsoil textures may be loamy. Gravelly layers may also occur in the subsoil and substratum. Gravel, if present, is usually round in shape. There are no surface stones. The substratum layer is not a hardpan. The sand and gravel in these profiles may be arranged in thin layers ranging in thickness from ¼ to 5 inches.

Outwash deposits were deposited by moving water that melted from glaciers. They were the floodplains of 10,000 to 14,000 years ago.

Lacustrine - Soil profiles in this parent material have silty or loamy textures in the surface, subsoil and substratum layers. Substratum layers do not contain gravel, and they are not a hardpan. There are no surface stones. The substratum layer usually has thinner (1/8 to ½ inch thick) horizontal layers within it.

Lacustrine sediments were deposited as the mud on the bottom of old lakes that existed when the last continental glacier was melting 10,000 to 14,000 years ago.

Marine - Soil profiles in this parent material have clayey textures in the surface, subsoil and substratum layers; the surface and subsoil occasionally have loamy textures. Substratum layers do not contain gravel, and they are not a hardpan. There are no surface stones.

Marine (seabed) sediments were deposited as mud in the tidal flats that existed about 12,000 to 14,000 years ago.

Residuum – This is material that formed in place. Soil profiles in this parent material take on the characteristics of the bedrock they form from and will be the same texture as the rock. Typically, sandstone and granite will develop into sands, siltstone and phyllite will develop into silt, and shale and slate will develop into clay. Since all of New Hampshire was scoured and modified by glaciers, most residual material here has been removed.

Till - Soil profiles in this parent material generally have loamy textures in the subsoil layer (sometimes sandy), and either loamy or sandy textures in the substratum layer. Gravelly layers do not occur in the substratum. There are surface stones; if they have been picked so that the land could be used for agriculture, there are usually stone walls or stone piles nearby. The substratum layer may be a hardpan; if so, this hardpan may consists of thin (1/6 to ¼ inch) plates with a horizontal orientation. There is usually a mixture of gravel, stones and boulders in various proportions throughout the soil profile.

Till is material deposited under the glacial ice during the advance and retreat of the last continental glaciation.

LIMITATIONS and USES

Uses

Building site development, including homesites, requires a thorough knowledge of the soil properties prior to construction. A homesite with a basement is a one to three story structure intended for year round use by a single family. The foundation is reinforced concrete built on undisturbed soil at a depth of five feet. The soil conditions that would adversely affect the excavation, construction, and maintenance cost of the house are important considerations.

Septic system and other waste disposal systems need to be placed in an appropriate site. A septic system consists of a tank and a subsurface system of tile or perforated pipe that distributes the waste into the natural soil at a depth of 24 to 60 inches. In any on-site investigation for a septic, it is important to know the soil conditions that would adversely affect the absorption of the waste into the soil, as well as the construction and maintenance of the septic system.

Agricultural crops are annual crops grown either continuously or in rotation with grasses and/or legumes. Understanding the soil conditions that would adversely affect the operation of all equipment necessary to obtain the crop, and soil conditions that would result in excessive erosion, poor crop yields, and limit the choice of row crop species is essential for any farm plan.

Woodland is hardwood and/or softwood tree species grown for timber and pulpwood. Important soil conditions to consider are ones that have an adverse affect on seedling conditions that have an adverse affect on seedling mortality, erosion hazard, windthrow hazard, and the operation of rubber tired skidders for harvesting.

Soil Conditions

Flooding occurs only on those soils developed in floodplain sediments. Flooding is a severe limitation for building site development and the operation of a septic system. It is not feasible to attempt to overcome the flooding problem for these uses. Flooding does not affect the use of the soil for hayland crops, or woodland. Flooding usually does not occur during the growing or harvest season of row crops and hayland crops, but if flooding occurs in harvested row crop fields that have been left bare, erosion may occur. Flooding is usually of short duration, so its affect on woodland management and harvesting activities is minimal.

Depth to Bedrock (ledge): Ledge within 60 inches of the soil surface affects the ease of construction of a homesite with a basement, and within 40 inches becomes a severe restriction. Ledge within 60 inches of the soil surface affects the thickness of the soil available for purifying the waste water from a septic system; ledge within 40 inches is a severe problem that is difficult to overcome. Ledge within 20 inches of the soil surface affects the rooting depth and available water capacity of the soil for row crops, hayland crops and woodland, resulting in decreased yields. Ledge affects the choice of crops and tree species and is a windthrow hazard in woodlands. Ledge within 10 inches is a severe problem.
Depth to seasonal high water table: A water table within 60 inches of the soil surface affects the ease of excavation, construction of, and maintenance cost of a homesite with a basement, and within 30 inches becomes a severe restriction. Water tables within 60 inches of the soil surface affect the thickness of unsaturated soil available for purifying wastewater from a septic system leach field. Water tables within 48 inches of the soil surface are a severe problem. Water tables within 24 inches of the soil surface affect the rooting depth, choice of row and hayland crops, reduce yields, and reduce the ease of operation of planting and harvesting equipment for agriculture and forestry. Water tables within 20 inches of the soil surface are a severe limitation for woodland harvesting equipment.

A permeability of slow or rapid in the substratum layer is a severe limitation to the operation of a septic system leach field. The slow permeability results in wastewater moving too slowly, restricting its downward movement into the soil. A rapid permeability results in wastewater moving too quickly downward, which may allow unpurified wastewater to pollute the ground water or nearby surface waters. A slow permeability in the subsoil layer is a severe limitation for row and hayland crops. The slow permeability results in poor internal drainage, causing decreased crop yields, restricted crop choices and increased crop choices and increased costs associated with tillage.

A slope of 8 to 15 percent affects the ease of excavation and construction of a homesite with a basement and a septic system. Slopes greater than 15 percent are a severe limitation. For row crops, slopes of 3 to 15 percent result in an increased erosion hazard, and affect the ease and safety of planting, tillage, and harvesting equipment. Slopes greater than 15 percent are a severe limitation for row crops. For hayland crops, slopes of 8 to 15 percent affect the ease and safety of operating farm equipment. Slopes of greater than 25 percent are a severe limitation. For woodland, slopes of 15 to 35 percent result in an increased erosion hazard during planting and harvesting activities and affect the ease and safety of operating equipment. Slopes of greater than 35 percent are a severe limitation for woodland use.

Surface Stones have a severe impact on the ease of operating equipment for the construction of a homesite or a septic system if the stones are less than 1.5 feet apart. For now crops and hayland crops, surface stones 25 to 80 feet apart are a moderate limitation for the ease of equipment operation. Surface stones less than 25 feet apart are a severe limitation. Surface stones less than 1.5 feet apart are a severe limitation for the operation of woodland equipment.

Surface textures that are sandy or clayey have adverse affects on plant growth and/or ease of operation of equipment. For row crops and hayland crops, sandy surface textures reduce the water holding capacity of the soil, which affects the choice of crop species and reduces yields. Clayey surface textures become hard when dry and form clods if cultivated when too wet. This also results in reduced row crop yields. For woodland, sandy surface textures reduce the water holding capacity of the soil. This results in high seedling mortality. Sandy and clayey surface textures both adversely affect the operation of woodland equipment.

PRIME FARMLAND

Prime farmland is the land best suited for producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply necessary to produce sustained high yields of crops at a minimum cost when treated and managed according to modern farming methods.

The physical features of the soil used in this contest to determine whether a soil is prime farmland are: (a soil must have all these features to be considered prime farmland).

Loamy texture – in both the surface and subsurface layers.
Moderate permeability in both the surface and subsoil layers.
Depth to seasonal high water table that is greater than 30 inches.
Natural soil drainage class of well drained or moderately well drained.
Depth to bedrock that is greater than 60 inches.
Slopes less than 5 percent.
Surface stones greater than 80 feet apart.

SOIL MAPS and INTERPRETATIONS

Soils maps and the soil interpretations are valuable tools in natural resource planning and site assessment. Each individual soil identified on the soil map will have its own unique set of properties and each horizon (layer) will be described.

A soil map is a representation of areas which have similar soil properties (such as: drainage class, depth to bedrock, parent material, etc). The delineated areas may show one dominant soil or may be a group of several soils (called a soil complex or association). Soil maps are typically shown with an aerial photograph background and includes a description of the properties and landscape (map unit description) found within the delineation and a description of the use and management (interpretations).

Soil interpretations are based on the various soil properties found for each soil series in each Map Unit.

Soil maps may be made at different scales and will have small inclusions of other soils within each delineation. An example of this is when a well drained soil is mapped next to a poorly drained soil. Both map units will typically have some inclusions of moderately well drained and somewhat poorly drained soils within their boundaries. As you go from one delineation to another the properties will grade from one to another. The soil line does not mean that the soils suddenly change there, but represents a transitional zone. If the scale of the map was increased, it may be possible to separate each drainage class. But at virtually any scale some inclusions will be present.

Example of a Map unit Description:

26B - Windsor loamy sand, 3 to 8 percent slopes

Setting

Elevation: 0 to 1000 feet
Mean annual precipitation: 28 to 55 inches
Mean annual air temperature: 45 to 52 degrees F
Frost-free period: 120 to 200 days

Composition

Windsor and similar soils: 85 percent
Minor components: 15 percent

Description of Windsor

Landform: Outwash terraces
Parent Material: Sandy outwash
Slope: 3 to 8 percent
Depth to restrictive feature: None
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High or very high
Depth to water table: Greater than 60 inches
Frequency of flooding: None
Frequency of Ponding: None
Available water capacity: Low (about 4.8 inches)

Typical Profile

0 to 12 inches: loamy sand
12 to 21 inches: loamy sand
21 to 60 inches: stratified coarse sand to sand to fine sand

For more information or to obtain a soil map, visit Web Soil Survey at: http://websoilsurvey.nrcs.usda.gov