SOIL

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December, 2006

SOIL SECTION OUTLINE

LEARNING OBJECTIVES

The objective of the soils section is to provide students with an understanding of the concepts of soil variability, suitability, limitations, and behavior as an integral part of ecosystems and the ability to apply this knowledge toward environmentally sound land management.

Team members will be able to:

- Recognize and identify various soil properties
- Understand how soil properties affect soil behavior
- Determine the suitability and limitations of soils for various land uses
- Gain an awareness of soil as an integral part of ecosystems
- Understand the environmental and economic importance of soils and soil information with regard to land use and management

KEY CONCEPTS

Soil Formation:
Parent Material, Soil Horizons: O, E, A, B, C, R

Soil Properties:
Texture, color, redoximorphic features, density, consistence, organic matter content, structure, drainage class, permeability, depth to bedrock or other impermeable layers, surface stoniness, rock fragment content, slope, propensity for flooding.

Interpretations:
Interpreting the soil is the process of recognizing characteristics and determining how the soil behaves. Examples are: Evaluating soil colors to determine the depth to a seasonal high water table and drainage class.
Estimate available water holding capacity for plant growth.
Identify the limitations for a basement, septic absorption field, agriculture, etc.
Determine how soil characteristics influence on-site and off-site affects of specific land management practices and land uses (application of pesticides, sub-division development with on-site sewage disposal systems, water quality, clear cutting etc.).

TEST FORMAT

Questions relating to soils are multiple choice with an occasional true/false question or fill in the blank. The test is interpretive and hands-on. Upon examining a soil pit or small hand dug hole and the surrounding landscape, the team answers questions about soil properties and characteristics specific to the site. Observations of the soil are applied to questions relative to soil formation and morphology, land uses and the environmental affects thereof, and the interrelationship of the soil to other ecosystem components. There may be questions that tie into the current topic. Sometimes included are questions involving the use of topographic maps, soil survey maps and soil survey information. Teams should be aware of this information.

RECOMMENDATIONS FOR PREPARING TEAMS

Read this manual. Concentrate on the sections manual that cover topics listed under Key Concepts. DIG HOLES!

Pick some areas in your locality that are accessible and undisturbed (athletic fields are often leveled and filled, plowed areas are OK). In highly urbanized areas this can be a challenge. Parks often have areas of undisturbed soils.

Obtain soil survey information for your sites. Read about the soils mapped there; this will tell you what to expect. Go out and examine the soils by digging a hole up to three feet in depth (water table/depth to bedrock permitting). Note the color, thickness and texture of each horizon. Try to identify the individual horizons. The soil survey information and this manual will guide you. Try to do this for soils having different drainage classes and parent materials. If there are adjacent areas that appear wetter or drier, examine the soils there and make comparisons. Complete the soil evaluation exercise included in this manual for each site visited. If a team does this successfully, it will do well on the day of the Envirothon.

I. SOIL DEFINITION

Soil is defined as the unconsolidated organic and mineral material on the surface of the earth that is capable of supporting plants. The upper limit of soil is air, or shallow water, the lower limit is either bedrock or the limit of biological activity. Most of us recognize the importance of soils within the context of food production. However, the use of soils is as varied as the use of land. Webster's Dictionary describes land as, ground or soil of a specific situation, nature, or quality. The soil can be thought of as the land itself and because soils are highly variable, their suitability for land use and ability to support plant communities and wildlife can differ greatly.

NOTE: When reading the information on soils you'll see lot's of 'weasel' words such as, usually and typically. Soils are natural, dynamic bodies on the landscape influenced by an infinite combination of factors. It is impractical and often inaccurate to make concrete, black and white statements about it. There are exceptions to every generalization. The information attempts to make fundamental concepts of pedology* comprehensible.

II. SOIL FORMATION

This section describes the five major factors of soil formation and the effect of each on the soils. Soils are formed through the action of climate, plants, animals and people (collectively referred to as organisms) on parent material in different topographic locations over time. The relative influence of each of these factors differs in different locations.

The five soil formation factors act in unison as the equation:
parent material x organisms x topography x climate x time = a specific type of SOIL.

PARENT MATERIAL

Parent material refers to that great variety of unconsolidated organic and mineral materials in which soils form. Fresh peat and unconsolidated mineral matter are included under this definition, but consolidated bedrock is not.

Much of the mineral matter in which soils form is derived in one way or another from hard rocks, such as granite, but the type of rock is not the same as parent material. Glaciers may grind the granite into rock fragments and earthy material and deposit a mixture of granite particles as glacial till; such parent material is identified as "till derived from granite." In contrast, granite may be weathered with great chemical and physical changes but not move from its place of origin; this altered material is called "residuum from granite."

Residuum is parent material produced by weathering of rock in place. The kinds of material produced by weathering of rock in place are related to the nature of the original rock. The parent material of a modern mineral soil is not necessarily residuum from the bedrock that is directly below. The term "residuum" is used when the properties of the soil indicate that it has been derived from the underlying rock and when evidence is lacking that movement modified it.

Alluvium - sediment deposited by streams and rivers. It may occur on older terraces well above present streams or in active flooded bottomland of existing streams.

Lacustrine deposits - material that has settled out of the still water of lakes.

Marine sediments - These sediments settled out of the sea and were reworked by currents and tides.

Beach deposits - Beach deposits mark the present or former shorelines of the sea or lakes. These deposits are low ridges of sorted material and are commonly sandy, gravely, cobbly or stony.

Eolian - earthy material deposited through wind action.
Loess deposits are a type of eolian material that is typically very silty but may contain significant amounts of very fine sand.

Colluvium - a mass of soil material or rock fragments at the base of slopes. It is largely material that has rolled, slid, or fallen down the slope under the influence of gravity. An accumulation of rock fragments is called talus.

Organic material – material dominantly derived from plants that accumulate in wet places where it is deposited more rapidly than it decomposes. These deposits are called peat and muck, which in turn may become parent material for soils. Soils formed in organic materials are common to marshes, swamps and bogs. For a soil to be considered to have developed in organic material, the organic deposits must be at least 16 inches thick. If not, the soil is considered to have developed in mineral material.

Parent Material Deposited by Glacial Processes
Pulverized and other rock material transported by glacial ice and deposited, either directly from the ice or from melt-water is collectively known as glacial drift. Glacial drift is further defined based on the mode of deposition.

Till - that part of the glacial deposition that is set down directly by the ice with little or no transportation by water. It is generally an unstratified, mixture of variable amounts of clay, silt, sand, gravel, and often stones and boulders. Some settled out as the ice melted with very little washing by water. Some was overridden by the glacial ice.

Two major types of till are recognized:

- Ablation till- Loose, permeable till deposited during the final downwasting (when melting exceeds forward flow) of glacial ice.
- Lodgement or Basal till is dense, compact, and relatively impermeable till deposited beneath the ice.

Glaciofluvial deposits –These deposits are material that had been picked up by glaciers and then carried, sorted and deposited by water that originated mainly from melting glacial ice. Glaciofluvial deposits are also collectively known as glacial outwash. It can be thought of as the material that washed out from the glacial ice as it melted. This broad term includes all of the material swept out, sorted, and deposited beyond the glacial ice front by streams and rivers of melt water.

Glaciolacustrine deposits - These deposits range from fine clay to sand. They are derived from glaciers but were reworked and laid down in glacial lakes. Many of them are stratified or laminated. Alternating strata of silt and clay each related to one year's deposition and one season's glacial ice melt are called varves.

Glaciomarine deposits – The accumulation of glacially eroded, terrestrially derived sediment in the marine environment. These deposits are usually high in silt and clay.

Glacial beach deposits - These consist of gravel and sand and mark the beach lines of former glacial lakes. Depending upon the character of the original drift, beach deposits may be sandy, gravelly, cobbly or stony.

MORE ABOUT SOIL PARENT MATERIAL AS IT RELATES TO MASSACHUSETTS

Massachusetts was covered with glacial ice 12 to 14,000 years ago. Consequently, the parent material of the most extensive soils is comprised of various types of glacial deposits. Major kinds of parent material in Massachusetts are; till, glaciofluvial deposits, lacustrine and marine sediments, recent alluvium, and organic deposits. By far the most extensive is till.

Till is dominantly unsorted and unstratified sediments deposited from glacial ice. It is a heterogeneous mixture that can include boulders, stones, gravel, sand, and with smaller amounts of clay (typically less than 10 clay, by weight). Two broad groups of till are in Massachusetts. Basal till, or lodgement till, was deposited beneath and within advancing or retreating glaciers. It has a dense, firm, substratum that can be sandy or loamy*. Ablation till was deposited from melting ice and dropped out on bedrock or other surficial* deposits. It is generally coarse-textured, being dominantly sand, gravel, cobbles and stones, and is loose and permeable.

Outwash or glaciofluvial deposits. These deposits consist of stratified sand and gravel. It is generally in major stream valleys. Because of the nature of deposition of this parent material, the soils are in complex patterns on the landscape.

Glaciolacustrine and glaciomarine deposits are deposits often stratified of very fine sand, silt, and clay that have settled out of water in glacial lakes or in the ocean. Glaciolacustrine sediments settled in freshwater that have since drained, leaving a nearly level plain with depressions and generally poor internal drainage.
The mass of the glacial ice caused the land to compress, changing land elevations and the shoreline. Material accumulated in estuarine* and coastal environments as glaciomarine deposits. When the land rebounded upon glacial downwasting, low plains were exposed along parts of the present coast. The sediments generally are at elevations as high as 50 feet above sea level and grade to sea level.

Recent alluvium consists of sediments deposited by streams and rivers. It occurs on terraces above streams, on bottomlands, and in basins that are normally periodically flooded. It consists of strata of, fine and very fine sand, silt, and organic material in all variations and mixtures. This material was deposited during recent history and does not have a well developed soil profile (see Section IV). Older alluvium is on higher stream and river terraces that are no longer subject to flooding. They may have weakly developed profiles.

Organic deposits are accumulations of plant material in various stages of decomposition. For a soil to be categorized as having organic parent material, the deposits must generally be more than 16 inches thick. This parent material is in inland and coastal wetlands. Thick organic deposits are formed when the rate of accumulation of plant material exceeds the rate of decomposition. Decomposition is slowed by saturated conditions.

Areas of post-glacial eolian deposits are believed to influence texture in the upper part of many Massachusetts soils. They are characterized by 1 to 2.5 feet of silt or very fine sand deposited by post-glacial winds over a substratum of till, glaciofluvial or glaciolacustrine sediment.

TOPOGRAPHY

The shape of the land surface, slope, and the position of the soil on the landscape are dominant factors in soil formation. Soils that formed in identical parent materials and under the same climatic conditions vary because of position on the landscape. This is largely the result of drainage conditions caused by differences in surface runoff or depth to the seasonal high water table. Low lying areas tend to receive runoff, erosional deposition and nutrients.

Soils formed at higher elevations and strongly sloping areas generally are excessively drained or well drained. Depth to ground water is typically more than 6 feet, and surface runoff is moderate or rapid. In these areas, soil colors are bright strong brown to yellowish brown in the subsoil grading to a lighter, grayer, unweathered substratum.

On soils at lower landscape positions, such as those in swales, adjacent to drainageways and water bodies, and in depressions, surface runoff typically flows down from higher elevations. The seasonal high water table is often at a shallow depth. In these areas the soils are moderately well and somewhat poorly drained and generally have a yellowish brown color with gray redoximorphic features (defined below) in the subsoil. Poorly and very poorly drained soils are often in the relatively deepest depressions or at the base of broad watersheds. The seasonal high water table is at or near the surface for prolonged periods. Also, the soil profile typically has a dark colored organic or organic-rich surface layer and a gray subsoil* and substratum*.

CLIMATE

The kind of climate under which a soil forms largely determines the nature and the rate of physical and chemical weathering of parent materials. Moisture and temperature are variables that influence chemical and physical weathering processes. Climate directly affects the type of vegetation in an area, which in turn affects those soil-forming processes related to plant life. Moderate temperatures in Massachusetts allow the accumulation of organic matter in the surface layer of most soils. Rainfall leaches water-soluble minerals down through the soil, resulting in acid soil throughout most of the state. In winter, cold temperatures and high moisture cause frost action, which is especially active in loamy soils not under forest vegetation. Frost action breaks apart rock fragments, and in some soils influences the development of soil structure (defined on page 112).

PLANT AND ANIMAL LIFE AND THE ACTIVITIES OF PEOPLE (ORGANISMS)

Living things influence the soil-forming process. Microorganisms, such as bacteria, fungi, algae, and protozoa, are active in the surface layer of most soils. They are constantly recycling organic materials and minerals, which in turn are used by plants. The dark brown color of the surface layer in most soils is attributable to the activities of these organisms breaking down organic material. Larger animals, such as earthworms, insects, woodchucks, and moles, mix the soil and change its physical characteristics. They help to make the soil more permeable to air and water. Their waste products help to aggregate soil particles, improve soil structure, and conserve nutrients in a less mobile state.

The mineral content of leaves and branches influences the soils that develop beneath the trees. In a very efficient cycle, hardwood trees, such as red oak, take up bases* (calcium, magnesium and potassium) from the soil and eventually return them to the soil surface as litter. Coniferous trees, such as white pine, take up smaller amounts of bases than hardwood trees; consequently, the soil beneath them is commonly more acid and bases are leached through the soil. Wind throw* is common in places where trees are shallow-rooted because of a seasonal high water table or an impermeable layer or bedrock. The result is deeper mixing of the soil and irregular boundaries between the surface layer and subsoil. Soils that have been in grass for long periods of time generally develop a thicker, darker surface layer. The surface layer of these soils also has a higher moisture-holding capacity and a higher cation exchange capacity* than similar soils developed under forest vegetation.

Human activities have significantly altered soil in some areas. Many soils have a distinct plow layer formed by mechanical cultivation and additions of organic matter, lime, and fertilizer. Some naturally wet soils have been altered by artificial drainage and filling. In urban areas much of the natural soil has been covered, removed, or replaced.

TIME

The soil forming factors interact over time. In general, if all the other factors are similar, an older soil will have more defined development than a younger soil. The soils of Massachusetts formed in the period since glaciation. They have weathered little compared to soils in most non-glaciated areas and have developed relatively weak soil profiles.

III. SOIL PROFILE DEVELOPMENT

A soil profile is a vertical section of the soil extending from the surface through all its horizons, or layers, into the parent material. A soil horizon is a roughly horizontal layer of soil and has distinct characteristics. Some horizons are less than an inch thick; some are over 2 feet thick. The physical and chemical characteristics observed within the soil profile are the basis for differentiating one soil from another. Most unplowed (plowing mixes any organic surface into the topsoil) soil profiles have a surface layer of organic material and two or three layers of mineral materials.

HORIZONS

Horizons are the individual layers within the soil and are designated by symbols. Major horizons are symbolized by the capital letters O, A, E, B, C, and R and are identified in the field accordingly. Soils vary widely in the degree to which horizons are expressed. Relatively recent geologic formations such as active floodplains, sand dunes, or blankets of volcanic ash, may have no recognizable genetic horizons. As soil formation proceeds, horizons may be detected in their early stages only by very careful examination. As age increases and the soil weathers, horizons are generally more easily identified in the field.

O HORIZONS

O horizons are layers dominated by organic material (material that was once living tissue). Some O horizons consist of undecomposed or partially decomposed litter such as leaves, conifer needles, twigs and moss, that has been deposited on the surface. Other O layers, called peat, muck, or mucky peat, are organic material that was deposited under saturated conditions and has decomposed to various stages. The mineral part of O horizons, if any, is only a small percentage of the volume of the material.

Identifying features:

- at least 20% organic matter (by weight)
- dark color (never used by itself to categorize a horizon as O)
- low strength, light dry weight, may have a high plant fiber content
- usually a surface horizon

A HORIZONS

A horizons are layers composed mostly of mineral material that formed at the surface or below an O horizon and are characterized by an accumulation of organic matter intimately mixed with the mineral part. The organic accumulation in A horizons gives them their characteristic coffee brown or darker brown color.

Topsoil is an analogous term for A horizons.

Identifying features:

- dominantly mineral soil material
- mixed or well decomposed organic material and mineral material
  usually a surface horizon, or underlying the O horizon
- typically darker in color than underlying horizons, it takes very little organic matter to darken the predominantly mineral A horizon. Do not confuse the A with an O horizon.

E HORIZONS

E horizons are mineral layers where the dominant feature is a loss of clay, iron and aluminum. Through these horizons clay, iron and aluminum have been leached by the downward movement of weak organic acid solutions through the soil. Iron coatings are stripped from the soil particles and leached down into the underlying subsoil. As iron is the element that gives mineral soil much of its reddish or yellowish brown color, these horizons usually are lighter in color than the overlying A horizon and the underlying B horizon (described below). Also, they are usually coarser in texture because the fine clays have been removed through the leaching process leaving behind the coarser silts and sands.

Identifying features:

- zones of eluviation* – removal of clays, Fe, Al, and humus
- lighter in color (often interpreted as 'ashy' in appearance) than overlying and underlying layers
- usually below O or A horizons and above a B horizon

B HORIZONS

B horizons are mineral layers that have undergone weathering and soil formation processes. These are dominated by the obliteration of original rock structure, accumulation of clay and, or a concentration of iron or aluminum. There are many types of B horizons, but basically, these layers have characteristics indicative of change. Generally they have formed through the weathering of the underlying parent material and/or the accumulation of iron and aluminum. They usually have finer textures than the underlying material and are usually more brightly colored and often have developed structure. Subsoil is an analogous term to B and E horizons.

Identifying features:

- subsurface horizon formed below an A, E, or O, and above the C horizons (unless the topsoil is removed by erosion or excavation)
- developed as a result of soil forming processes
- color development (in aerated soils yellowish brown to strong brown)
- zone of illuviation* – zone of accumulation

C HORIZONS

C horizons - are layers excluding hard bedrock that are little affected by soil formation processes and lack properties of O, A, E, or B horizons. Generally the C horizons are comprised of the parent material from which the other horizons developed. Substratum is a term analogous to C horizons.

Identifying features:

- little affected by soil forming processes
- lack color development, color is that of the unweathered geologic material
- geologic layering or strata is often present
- often, but not always, is the geologic material from which the overlying soil developed.

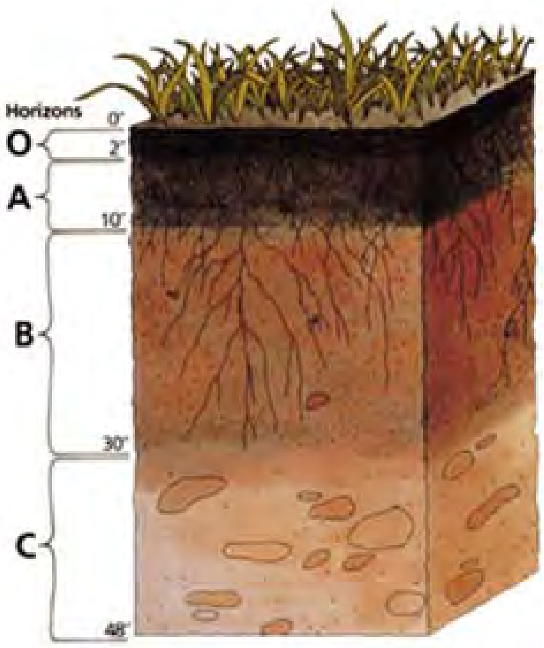
R LAYERS

R layers are the hard bedrock (ledge).

Identifying features:

- typically can not be excavated using a backhoe unless fractured and blasting is often needed to remove this material
- when highly fractured and/or weathered it can be difficult to differentiate from the overlying soil material
- may be difficult to differentiate between large boulders and depth to bedrock

PROFILE DEVELOPMENT



Soils develop through the physical and chemical weathering of parent material and the accumulation and/or decomposition of organic matter. Organic matter accumulates on the surface of soils as an O horizon that has undergone different degrees of decomposition. The dominant source of the organic matter is parts of dead plants such as leaves, branches and bark. In swamps, bogs and marshes, thick, mucky organic deposits resulted from very poor drainage. These soils form where organic material accumulates with a lack of oxygen and decomposes very slowly. Soils have an A horizon where humified organic material and the underlying mineral matter are naturally mixed.

Soil profile development is similar in many excessively drained, well drained, and moderately well drained soils. It is the result of movement and deposition of aluminum, iron, and humified organic matter and the weathering of iron compounds and other minerals within the soil profile. Weak organic acids generated by the decomposition of surface organic litter are percolated by rainwater downward through the soil. Aluminum and iron in the upper part of the soil profile are released into solution and leached downward, along with fine particles of humified organic matter. A light gray colored E horizon just below the surface horizon can result from this leaching.

The chemical environment within the soil changes with depth, and aluminum, iron, and organic material precipitate out. The greatest concentration of leached material accumulates just below the E horizon and commonly forms a B horizon. The color within the subsoil is caused primarily by iron oxide stains on the surfaces of individual soil particles and generally fades with depth to the relatively unweathered parent material of the C horizon.

In moderately well, somewhat poor and some poorly drained soils in which the water table is in the soil or fluctuates within the soil profile there are usually blotches of gray, reddish and or orange-like colors. These mottles are called redoximorphic features. When the soil is saturated for a while, the activity of microorganisms removes oxygen from the soil environment. This anaerobic condition causes the reduction of iron. In its reduced state iron does not adhere to soil particles and it is released into solution. Individual soil particles that are not coated with iron oxides (same as rust) tend to be gray, reflecting the soil's mineralogy. In soil where the water table seasonally drops, oxygen re-enters the environment and the newly oxidized iron precipitates out of solution and adheres to the soil. Redoximorphic features are produced in this oxidation-reduction process (alternating aerated-saturated conditions) principally when iron within soil aggregates migrate. In many poorly and very poorly drained soils gleying is a condition that develops when the soil is wet for most of the year and iron remains in a reduced state. The iron in the environment does not get a chance to oxidize. In a gleyed soil the matrix color is gray or bluish gray because of prolonged reducing conditions that leave the predominantly gray color of the soil minerals exposed.

Not all soils have all horizons. Most of the soils in Massachusetts have well-defined A, B, and C horizons. Thin O horizons are common in wooded areas. In agricultural land, the O horizons are usually non-existent due to plowing. E horizons can be found sporadically throughout woodlands in the state and are not as common as O, A, B, or C horizons.

IV. SOIL CHARACTERISTICS

TEXTURE

Soil texture refers to the relative proportions of sand, silt and clay in the soil. Sands are the largest, clays the smallest. Sand particles can be seen with the naked eye and feel gritty. They can be easily wiped clean from one's hands leaving no materials in the pores and fingerprints. They can be subdivided into size fractions.

Silt particles can be seen with a hand lens or light microscope. They have a smooth powdery feel when dry and a slick creamy feel when moist or wet. Some liken the feel to that of talcum powder. Silt is not sticky or plastic. After handling silty soil, a coating will be left on the hand, which for the most part can be brushed off when dry, leaving silt particles in the pores and grooves of your fingerprints.

Clay particles can be seen with an electron microscope only. Clay is sticky and plastic when wet. It is hard when dry. After handling clayey soils a film will be left on the hands, the removal of which requires vigorous washing.

SOIL SEPARATES

Soil separates are the individual size groups of mineral particles designated as:

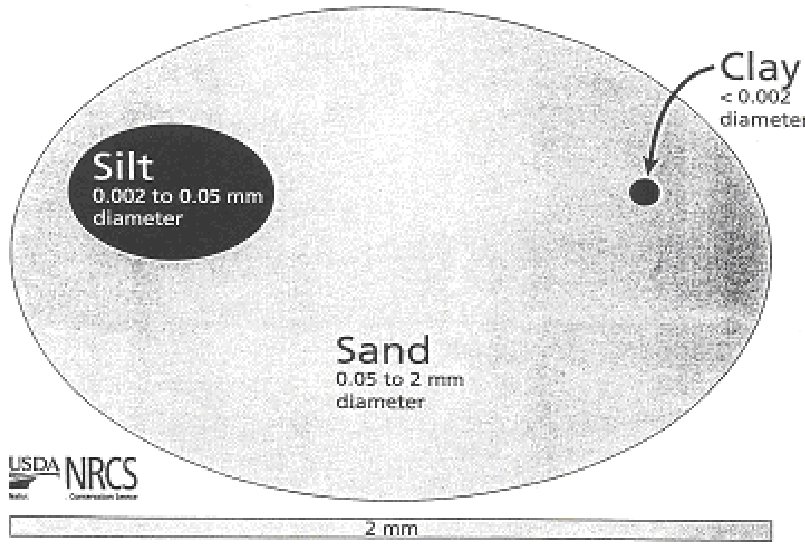
Very coarse sand	2.0 - 1.0 mm
Coarse sand	1.0 - 0.5 mm
Medium sand	0.5 - 0.25 mm
Fine sand	0.25 - 0.10 mm
Very fine sand	0.10 - 0.05 mm
Silt	0.05 - 0.002 mm
Clay	smaller than 0.002 mm

ROCK FRAGMENTS

Rock fragments are larger than sand size. They are classified by size as follows:

Gravel	2 mm to 3 inches
Cobbles	3 to 10 inches
Stones	10 inches to 2.5 feet
Boulders	greater than 2.5 feet

Relative Sizes of Clay, Silt and Sand



SOIL TEXTURAL CLASSES

Few, if any soils consist wholly of particles of one size class. Soils are usually comprised of combinations of different size particles. These different combinations are referred to as textural classes. There are many different textural classes. The basic textures in order of generally increasing proportions of finer particles are sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. The classes of sand are very coarse sand, coarse sand, sand, fine sand, and very fine sand. No modifier is used for medium sand.

The basic textural classes typically occurring in Massachusetts in order of increasingly finer texture is sand, loamy sand, sandy loam, loam, silt loam, silt, silty clay loam, and silty clay. Textures coarser than loam are further subdivided based on the dominant sand size as follows:

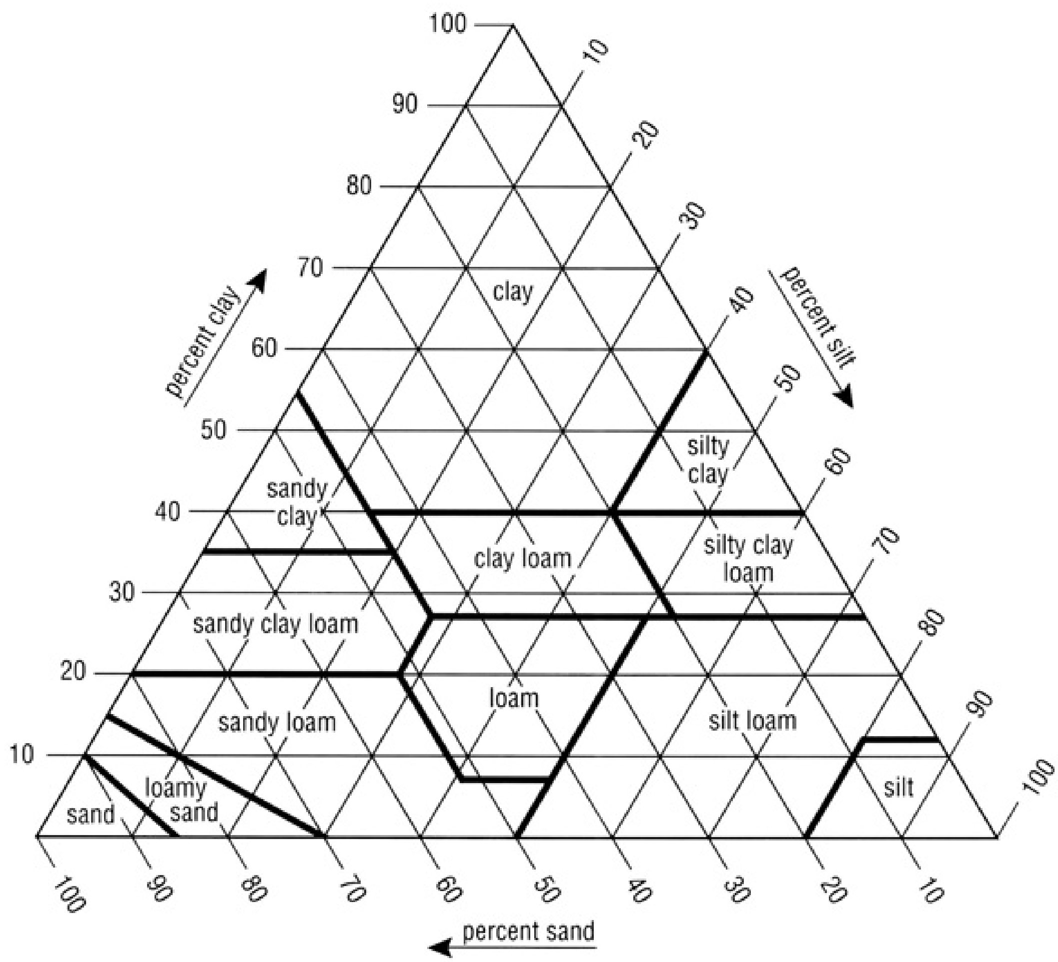
- sand; very coarse sand, coarse sand, fine sand, very fine sand (medium sand is referred to as sand),
- loamy sand; loamy very coarse sand, loamy coarse sand, loamy fine sand, loamy very fine sand,
- sandy loam; fine sandy loam, very fine sandy loam.

Loam is a term that has different, often conflicting meanings. The local meaning is dark topsoil. In the USDA textural classification loam refers to specific combinations of sand, silt and clay, having significant amounts of each.

Textural class name provides a basis for making prediction of soil behavior, and is a primary consideration for predicting hydraulic conductivity, bulk density, water holding capacity, shrink - swell potential, frost infiltration rate, erodibility, and more.

USDA Textural Classification Chart

The chart shows the basic soil textural classes and associated percentages of sand, silt and clay. The textural triangle is used primarily when lab data or sieve analysis is available, but it illustrates the ranges of proportions of soil separates within each class. The corners represent 100% sand, silt or clay, as indicated. (Gravel and organic soils are not included.) The triangle is divided into 10% portions of clay, silt and sand. Heavy lines show the divisions between the twelve basic textural classes. If the percent for any two of the soil separates are known, the correct textural class can be determined. The summation of the three percentages must total 100%.



FIELD METHODS FOR DETERMINING SOIL TEXTURAL CLASS

Below is a description of how various textural classes feel and behave when handled.

Mineral Soils

Sand is loose and single-grained. The individual grains can readily be seen or felt. Squeezed in the hand when dry, sand will fall apart when the pressure is released. Squeezed when moist, the sand will form a cast, but will crumble when touched.

Sand texture can be further subdivided according to the predominance of the type of sand, such as; very coarse sand, coarse sand, fine sand and very fine sand. If the predominant sand size is medium sand the texture is called sand.

Sandy loam is a soil containing much sand but which has enough silt and clay to make it somewhat coherent. The individual sand grains can readily be seen and felt. Squeezed when dry, it will fall apart when the pressure is released. Moist sandy loam will form a cast that will bear careful handling without breaking when squeezed. Sandy loam texture can be further subdivided according to the predominance of the type of sand, such as; very coarse sandy loam, coarse sandy loam, fine sandy loam and very fine sandy loam. If the predominant sand size is medium sand the texture is called sandy loam.

Loam is a soil with a relatively even mixture of different grades of sand, silt and clay. It has a somewhat gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, loam will form a cast that will bear handling. Squeezed when moist, loam will form a cast that can be handled quite freely without breaking.

Silt loam - is a soil having a moderate amount of the fine grades of sand and only a small amount of clay, over half of the particles being of the size called silt. When dry, silt loam may appear cloddy, but the lumps can be readily broken, and when crushed, the silt loam feels soft and floury. When this soil is wet, it readily runs together and puddles. Either dry or moist, it will form casts that can be freely handled without breaking. When moistened and squeezed between the thumb and forefinger, however, silt loam will not ribbon* (see page 111) but will give a broken appearance.

Clay loam is a fine-textured soil that usually breaks into clods or lumps that are hard when dry. The moist soil is plastic and will form a cast that will bear much handling. When kneaded in the hand, clay loam does not crumble readily, but tends to work into a heavy, compact mass.

Clay is a fine-textured soil that usually forms very hard lumps or clods when dry and is quite plastic and usually sticky when wet. When the moist soil is pinched out between the thumb and fingers, it will form a long, flexible ribbon.'

Organic Soils

The terms peat, muck and mucky peat are used for organic materials in a manner similar to the way in which mineral textural terms are used.

Muck is well-decomposed organic soil material.

Peat is raw, undecomposed organic material in which the original fibers constitute almost all of the material.

Mucky peat is material intermediate between muck and peat.

Following are three methods for determining texture. Try them all and compare the results. Use that which is most comfortable for you. The methods are good guides but are not absolutely definitive. They work well for samples having texture that fall in the middle of their respective classes. It's always difficult to make determinations of samples that are close to the boundary of two or more classes. Determining texture by feel takes practice, the only way to learn it is to do it. HINT: learn to texture the soil by feel using the hand with which you do not write. This is so you can keep your notes clean. Also, focus on methods that call for moist soil samples. It's most likely field conditions will be moist the day of the Envirothon, and if not, you'll be able to moisten your samples.

Method 1

Organic Soils vs. Mineral Soils

Soils that have a high amount of organic matter (20 to 30 percent by weight) are classified as organic soils. Depending upon the degree of decomposition, organic soils may have many fibers (peat) or have a very greasy, smooth feel (muck).

Field Test: Place a sample of very moist or wet soil material, about the size of a golf ball, in the palm of your hand and squeeze hard. If the sample contains a high percentage of well decomposed organic matter, it will have little strength and ooze through your fingers as if it were mashed potatoes. Mineral soil material will not. Organic material is light in weight when dry whereas, mineral material retains much of its weight. A dark soil color usually indicates the presence of organic matter, but it alone, will not determine if the soil is mineral or organic.

MINERAL SOILS

Sample Preparation:

1. Place about a tablespoon of representative soil sample in the palm of your hand.
2. Separate out and remove as many particles greater than 2 mm in size (about the diameter of lead in a wood pencil), as practical.
3. Moisten the sample and rub hard to break up any aggregates or clods of dry soil.

Soil samples that are comprised predominantly of sand size particles vs. soil samples that are predominantly silt and/or clay size particles:

1. With the wet soil sample in the palm of your hand, rub and stir with a finger from the opposite hand.
   - Soils with greater than 50 percent sand size fraction have a gritty to very gritty feel.
   - Soils that have a smooth creamy feel with little to no grittiness are high in silt and/or clay.

Soils with Greater than 50 percent Sand Size Particles:

Textural classes for soils with greater than 50 percent sand size particles include sands, loamy sand and sandy loam. The field test used to differentiate these three textural classes is to make a cast and estimate its durability. The sample should be moist, not wet or dry. The moisture condition of the sample is critical when doing this test. A dry sample will not form a cast, but a wet sample usually forms a cast.

1. Place a tablespoon size sample of moist soil in the palm of your hand and firmly press the sample together with the fingers of the opposite hand, creating a rough ball shaped soil cast.

- SAND TEXTURE (greater than 85% sand) will either not form a cast or will form a cast that crumbles with slight handling.
- LOAMY SAND TEXTURE (70 to 85% sand) will form a cast, which bears only slight to moderate handling before falling apart.
- SANDY LOAM TEXTURE (50 to 70% sand) will withstand moderate handling and retain its shape.

<u>Soils with Greater than 50 percent Silt and/or Clay Size Particles:</u>

The field test used for differentiating soils that are high in silt from those that have a significant clay content (greater than 30 percent) are the tests for stickiness and plasticity. Moisture content is critical when doing either test. The moisture content that makes the sample the most sticky or plastic is the one to use.

1. Gradually add moisture to a tablespoon size sample of soil, while mixing in the palm of one's hand is a good procedure.

2. Stickiness test: squeeze a very moist soil sample between your thumb and index finger and then pull apart. Soil material that is very high in silt is non-sticky and the sample will adhere to either the thumb or finger and separate cleanly from the other. A soil with a significant amount of clay (greater than 30 percent) will initially stretch between the thumb and finger and then pull apart with some soil adhering to both the thumb and the finger (silty clay).

3. Plasticity test: There are two procedures for doing this test, forming a ribbon or making a wire. The ribbon test is done by pinching and pushing a thin ribbon of sample out from beneath the thumb and over the top of the index finger. A soil sample high in silt and low in clay will form a short ribbon; typically less than 1.5 inches long before it breaks and falls off (silt loam). A soil significantly high in clay (greater than 30 percent) will form a ribbon longer than 2 inches (silty clay). Another test for plasticity is to form a wire. A soil sample is rolled out into a wire by placing a very moist sample between one's palms and then moving them back and forth over one another. If a wire cracks or breaks before it reaches 1/8 inch in diameter, this is an indication that the sample is high in silt with a small clay fraction (silt loam texture). If a wire less than 1/8 inch in diameter is formed, this indicates a relatively high percent of clay (silty clay texture).

NOTE: Very fine sandy loam and loam textural classes can have the feel of both sandy and silty soils. Loam, when dry, can be crushed under moderate pressure and when pulverized has a velvety feel. Loam when moist may have a very slight tendency to ribbon. Very fine sandy loam textures when thoroughly wetted will have a very slightly gritty sensation when rubbed in one's palm.

Method 2

Use moist samples when trying this method.
The following terms and definitions are used as part of this method.

Molded ball is the property of a soil that enables it to be molded into a spheroid under pressure and to retain that shape while being deformed.
Roll the soil material in the palms to form a ball. Observe the ball's resistance to breakage when a finger applies stress. Observations should be noted using the following terms:

- None – a ball cannot be formed
- Very weak – ball crumbles when touched by a finger
- Fragile – ball retains its shape when touched gently
- Strong – ball retains its shape when touched and handled freely
- Very strong – can be formed into any shape and will retain that shape even under rough handling and high finger pressure.

Ribboning is the property of a soil that allows the development of a flat ribbon under the influence of applied pressure and will retain that shape. Extrude the soil between thumb and forefinger. Definitions are expressed in the length of ribbons formed.

- None – No ribbon can be formed.
- Slight – less than 2.5 cm (1 inch)
- Medium – between 2.5 and 5 cm (1 to 2 inches)
- High – greater than 5 cm (2 inches)

Grittiness is the abrasive action felt by the thumb and forefinger or palm of the hand when kneading soils containing an appreciable amount of sand. Rub the soil between thumb and forefinger or palm of hand. Terms commonly used to describe grittiness are:

- None - no individual grains are felt
- Some gritty – some grains can be felt
- Gritty – abrasive feeling is easily felt
- Very gritty – most of the soil is individual grains that can easily be seen and felt.

Smoothness is a quality exhibited by some soils when kneading between the thumb and forefinger or palm of the hand. Soils are smoothest when they contain few, if any sand grains. Rub the soil between the thumb and forefinger or palm of the hand. Terms commonly used to describe smoothness are:

- Somewhat smooth – smooth feeling but some grittiness felt
- Smooth – very little grittiness
- Very smooth – no grittiness

GUIDE FOR ESTIMATED USDA TEXTURAL CLASSES

USDA Textural Class	Consistence			Other Test Evaluated at a Wet Consistence			
	Dry	Wet		Molded Ball	Ribboning	Grittiness	Smoothness[1]
		Stickiness	Plasticity				
Sand	Loose	Non-sticky	Non-plastic	None	None	Very gritty	---
Loamy Sand	Soft	Non-sticky	Non-plastic	Very weak	None	Very gritty	---
Sandy Loam	Soft[2] to slightly hard	Non-sticky/Slightly sticky	Non-plastic to slightly plastic	Very weak to fragile	Slight	Gritty	---
Sandy Clay Loam	Slightly hard to hard	Sticky	Plastic	Strong	Medium	Gritty	---
Sandy Clay	Hard to very hard	Very sticky	Very plastic	Very strong	High	Gritty	---
Loam	Slightly hard to soft	Slightly sticky to non-sticky	Slightly plastic to non-plastic	Strong to fragile	Slight to none	Somewhat gritty	Somewhat smooth
Clay Loam	Hard	Sticky	Plastic	Strong	Medium	Somewhat gritty	Somewhat smooth to smooth
Silt Loam	Slightly hard to soft	Slightly sticky to non-sticky	Slightly plastic to non-plastic	Strong	Slight	None	Very smooth to smooth
Silt	Soft to slightly hard	Non-sticky	Non-plastic	Fragile to very weak	Slight	None	Very smooth
Silty Clay Loam	Hard	Sticky	Plastic	Strong	Medium	None	Very smooth
Silty Clay	Very hard	Very sticky	Very plastic	Very strong	High	None	Very smooth
Clay	Very hard/ extremely hard	Very sticky	Very plastic	Very strong	High	None	Smooth to very smooth

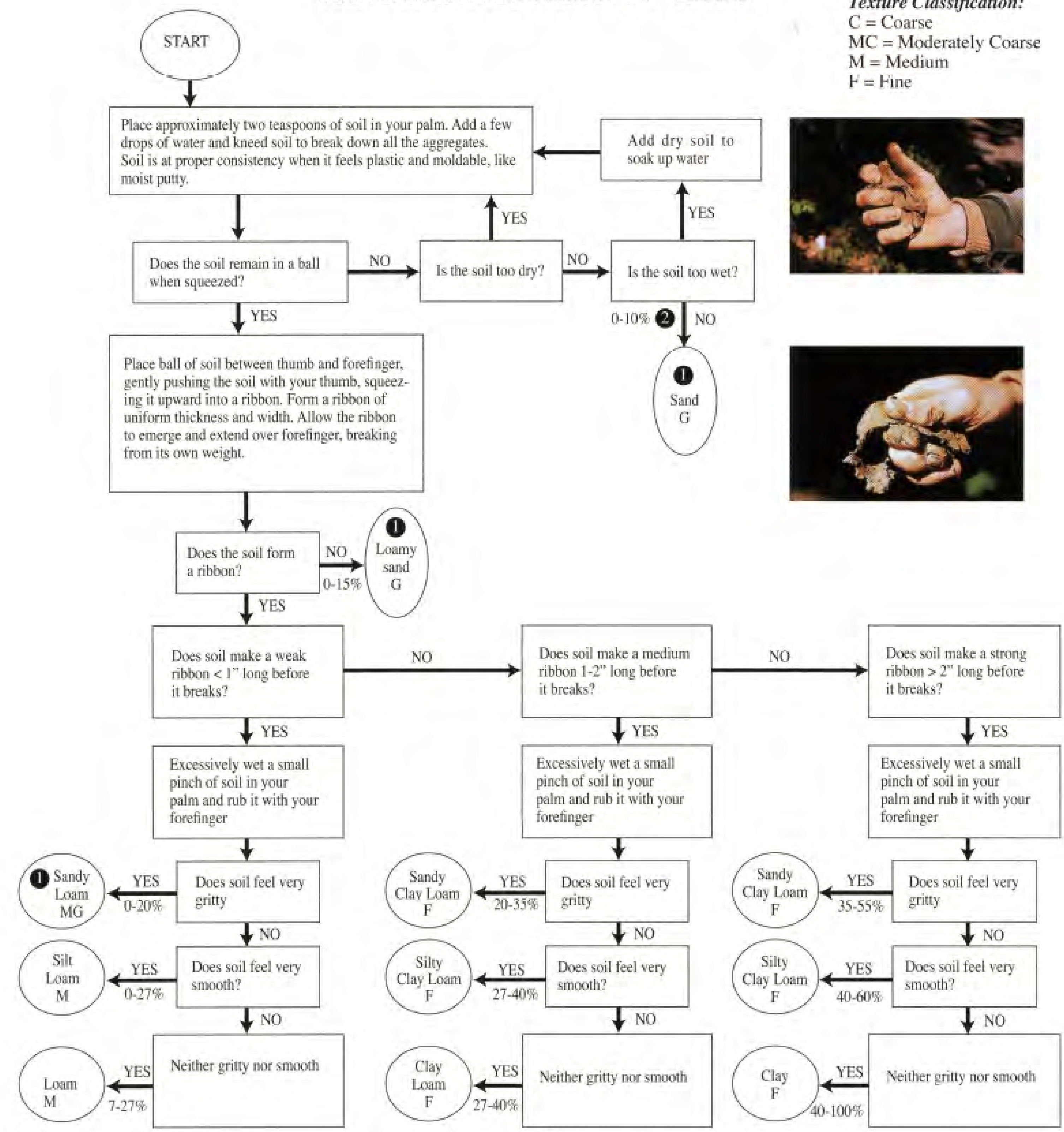
1. Smoothness is not evaluated for the textural classes of sand, loamy sand, sandy loam, sandy clay loam, and sandy clay because of their sand content.

2. The descriptive term listed first is generally the reaction most often observed

Method 3

Flow diagram for estimating soil texture by feel.

SOIL TEXTURE BY FEEL FLOW CHART [3]



[1] Sand particle size should be estimated (very fine, fine, medium, coarse) for these textures. Individual grains of very fine sand are not visible without magnification and there is a gritty feeling to a very small sample ground between teeth. Some find sand particles may be just visible. Medium sand particles are easily visible. Examples of sand size descriptions where one size is predominate are: very fine sand, fine sandy loam, and loamy coarse sand.

[2] Clay percentage range

[3] Modified from: Thien, Steve J., Kansas State University, 1979 Jour. Agronomy Education.

Photo Credit: R. Weil, University of Maryland

TEXTURAL CLASS MODIFIERS

Rock fragments: If a soil sample has between 15 to 35 percent by volume of rock fragments (>2 mm in diameter), a textural modifier is used, i.e. gravely sandy loam. If a soil sample has greater than 35 percent by volume of rock fragments, a textural modifier is used, i.e. very gravely sandy loam.

Organic matter: If a soil has a high percentage of sand, silt and/or clay and a significant volume of organic matter (8 to 12 percent by volume), a textural modifier is used i.e. mucky sandy loam.

SOIL STRUCTURE

Soil structure refers to the natural organization of soil particles into units. These units are separated by surfaces of weakness. An individual natural unit is called a ped. Peds are distinguished from:

- Clods which are caused by disturbances (for example, plowing which molds the soil into transient bodies).
- Soil fragments that form when the soil cracks or is broken and are bounded by ephemeral planes that do not reappear in the same place upon drying.
- Concretions or nodules which are local concentrations of substances binding grains of soil together into discrete units within the soil.

Some soils lack structure and are called structureless, while those soils that have structure are described in terms of shape, size, grade distinctness of the peds.

SOIL CONSISTENCE

Soil consistence is the tendency of the soil to maintain its cohesion and adhesion. It is the soil’s resistance to deformation or rupture under an applied stress. It’s a measure if how much pressure is required to cause a soil aggregate to collapse and break apart. It’s the property determined by how loose, dense, hard or soft the soil is.

SOIL COLOR

Soil color is the most obvious and easily determined soil characteristic. Although it has little known direct influence on the functioning of the soil, important soil characteristics can be inferred from color.

COLORING AGENTS IN THE SOIL

The two major coloring agents are organic matter and iron. Organic matter darkens the soil and as little as 2 to 5 percent can give the soil a dark brown to black color. It is a strong coloring agent and will mask all others in the soil. Organic matter is typically associated with the surface layers (O and A horizons).

Iron is the primary coloring agent in the subsoil (B horizons). The bright orange to yellowish brown colors associated with well-aerated upland soils is the result of iron oxide stains coating individual soil particles. Where soils lack color coatings, colors are generally gray due to the preponderance of quartz minerals.

Color Charts

Soil colors are conveniently measured by comparison with a color chart. The soil color charts consist of some 245 different colored chips, systematically arranged according to their Munsell notations according to hue, value and chroma. Hue refers to the wavelength of light (red, yellow, green, blue etc.). Value refers to the degree of lightness and darkness, and chroma is the relative purity of strength of the hue.

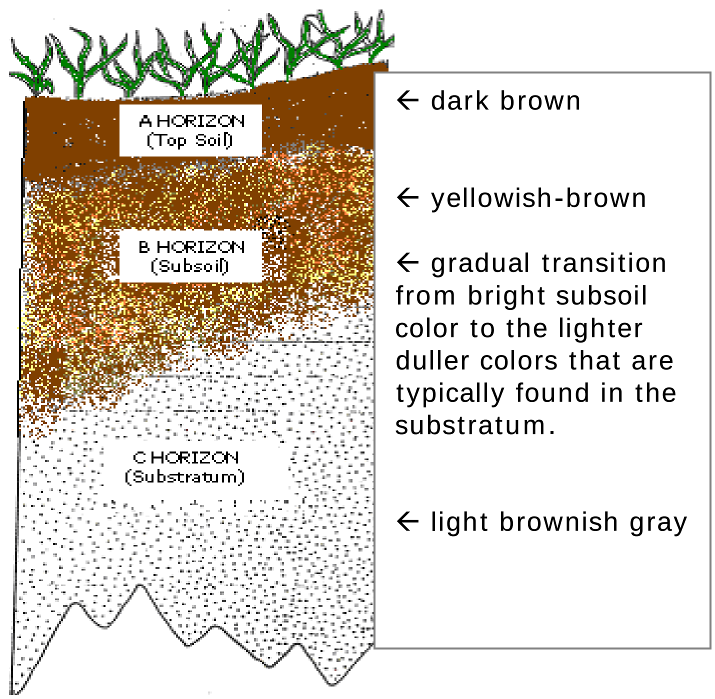
Soil Redoximorphic Features

In a soil with a fluctuating water table, there are two contrasting chemical environments. When the water table is high and the soil is saturated such as in wetlands, there is a reducing environment in the soil (lack of free oxygen). When the water table is lower, the soil is well aerated and oxygen moves freely through the open pore spaces. Within this zone of a fluctuating water table, iron, the main color agent in the subsoil, takes on two different forms.

When the soil is saturated, iron is reduced (ferrous state), is soluble and mobile, migrating from one place to another, leaving gray areas in the soil where the iron is depleted. When the water table recedes, air is reintroduced into the soil environment and iron is oxidized (ferric state) and becomes less mobile. This results in areas of relatively bright colors of orange, yellow, and or red where the iron had migrated and concentrated. The areas of bright color and the processes that form them are similar to the rusting of a nail.

Blotches of color form within this area of fluctuating water: gray where the iron was reduced, and orange, yellow, and or red where the iron accumulated. These blotchy areas of bright and dull colors due to the movement of water are referred to as redoximorphic features. The term is derived from “redox” referring to the oxidation-reduction process and “morphic” meaning form or the way something looks. These features are interpreted in the soil to determine the height and duration of the seasonal water table, soil drainage class, wetland determinations and delineation.

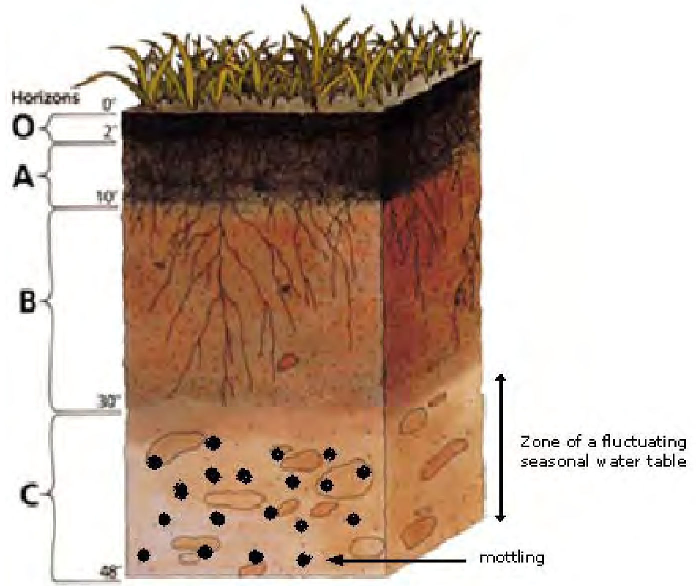
The orange and gray mottled colors are redoximorphic features resulting from a fluctuating water table.



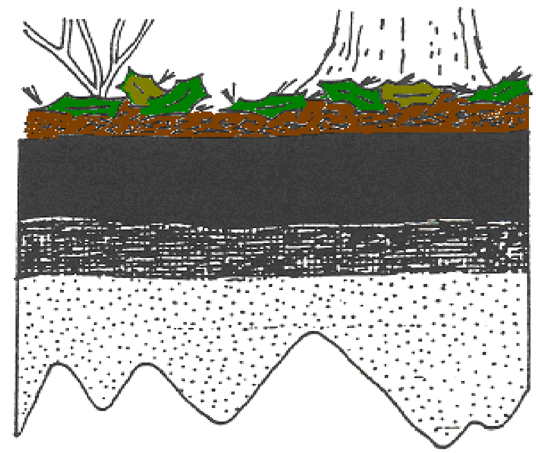
Typical morphology of a well drained soil.

In a well drained soil, the top soil is typically a dark brown color underlain by a weathered yellowish brown to strong brown subsoil. The bright colors of the subsoil are the result of iron oxide stains coating the individual sand grains. With depth, the color of the subsoil gradually fades to the substratum. The color of the substratum is dependent on the mineralogy of the individual soil particles and may range from a light brownish gray (soils high in quartz) to a dark grayish brown color (soils high in dark minerals).

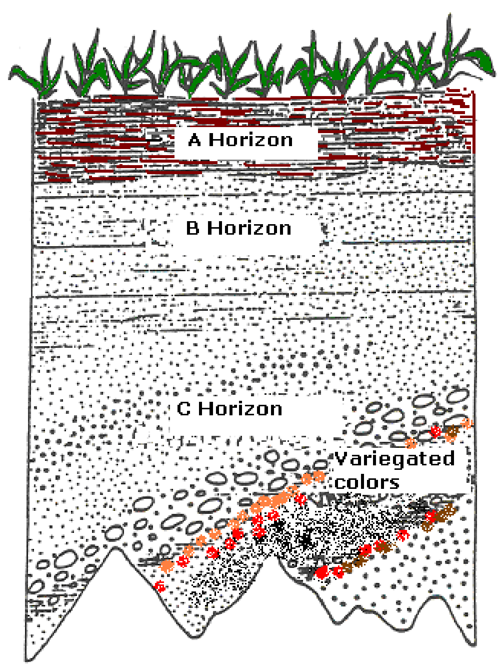
When the soil is saturated, iron is reduced (ferrous state) and is mobile in the soil, migrating from one area to another, developing gray areas in the soil where the iron has been depleted. When the water table recedes, in areas where the iron has migrated and is concentrated, iron is oxidized (ferric state) and is less mobile in the soil, developing brighter colors of red, orange and/or reddish orange. Within this zone of a fluctuating water table, spots or blotches of color are formed. The gray areas are where the iron has been reduced and flushed from the soils, and the yellow, orange or red areas are where the iron has accumulated. This blotchy pattern of both bright and dull colors is referred to as soil mottling and is interpreted by soil scientists as a zone in the soil with a fluctuating seasonal high water table.



Soil developed in wetland areas where the soil is saturated to the surface for prolonged periods of time, there is typically a black organic rich topsoil (O, A or Ap horizon) underlain by a light gray subsoil (gleyed) that may or may not have mottles. In these soils the iron has been reduced and flushed out of the soil and the color is the result of the stripped quartz sand grains.



A soil color pattern common to some stratified sands and gravels is variegated colors. These are typically bright streaks of color associated with the different textural breaks in the soil. They are often mistaken for redoximorphic features but are not the result of a fluctuating water table. Variegated colors are caused by momentary pauses in the downward movement of a wetting front at the different textural breaks in the soil. Over time, iron (ferric) precipitates in the soil causing bright red streaks. Iron is not reduced under these conditions and gray colors are absent.



SOIL DRAINAGE CLASSES

Soil drainage class, in general, refers to the relative depth of a seasonal high water table from the soil surface and the duration of saturation. Whether a soil is subject to saturation by seasonally fluctuating water is dependent on landscape position more than any other factor. Soils in low lying positions such as depressions and swales that receive a great deal of surface runoff from the surrounding areas will tend to be saturated with water for relatively long periods. Soils in landscape positions close to the higher levels of ground water aquifers will naturally tend to be wetter.

Following landscape position, the second most important factor determining drainage is permeability or the ease at which water moves through the pores in the soil. Dense, impermeable layers such as basal till can impede the downward movement of water resulting in a temporarily perched water table or zone of saturation above the dense layer.

It's important to understand that the presence of a dense layer does not automatically mean the soil will be poorly drained or wetter. For example, if the soil is on steep, convex slopes, free water will tend to drain out of the soil fairly rapidly. Also significant amounts of surface water will not move into these soils due to the shape of the slope. In contrast, a sandy, highly permeable soil can have poor drainage if it is in a landscape position that is close to the seasonal high water table.

Drainage class is determined in the field by observing landscape position and interpreting redoximorphic features. These blotchy colors resulting from the reduction and oxidation of iron tell the story of fluctuating water within the soil. You can think of them as sort of a bathtub ring in the soil profile. The higher and more pronounced the redoximorphic features in the soil profile, the more poorly drained is the soil. Also, thick deposits of organic matter are usually indicative of a high water table and poor drainage. The decomposition of organic matter is slowed under saturated conditions due to lack of activity by microorganisms. Vegetation is also a good clue, particularly on poorly and very poorly drained soils.

Seven drainage classes are recognized and refer to the frequency and duration of periods of saturation or partial saturation. The first two; excessively drained and somewhat excessively drained, describe soils that are dry longer than is typical for the dominant soils of an area. Well-drained soils are neither unusually dry nor unusually wet. Increasing degrees of wetness limit agricultural and other uses of moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained soils.

Excessively drained - Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky or shallow. Some are steep. Most are in higher landscape positions relative to their immediate surroundings. All lack redoximorphic features.

Somewhat excessively drained - Water is removed from the soil rapidly. Many are shallow to bedrock. Some are so steep that much of the water they receive is lost as runoff. All lack redoximorphic features.

Well drained - Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well-drained soils are commonly medium textured. Redoximorphic features, if any, are deep (typically deeper than 30 inches) in the soil profile.

Moderately well drained - Water is removed from the soil somewhat slowly during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They may have a slowly permeable layer within or directly below the B horizon. Landscape positions include broad nearly level areas, benches in slopes, and low areas relative to the immediate surroundings. Redoximorphic features can be common within 18 to 30 inches from the soil surface.

Somewhat poorly drained - Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils may have a slowly permeable layer, usually within a depth of 25 inches. They are usually in low landscape positions such as depressions and swales.

Redoximorphic features can be abundant within 18 inches of the soil surface.

Poorly drained - Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. Poor drainage results from a high water table, a slowly permeable layer within the profile, seepage, low landscape position or a combination of these. Redoximorphic features are common within one foot of the soil surface. Often the dominant color within the upper B horizon is gray due to the depletion of iron.

Very poorly drained - Water is removed from the soil so slowly that free water remains at or near the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic* plants cannot grow. Very poorly drained soils are on level or depressed parts of the landscape and some are commonly ponded. The high water table impedes the decomposition of organic matter so that often these soils have thick accumulations of muck or peat.

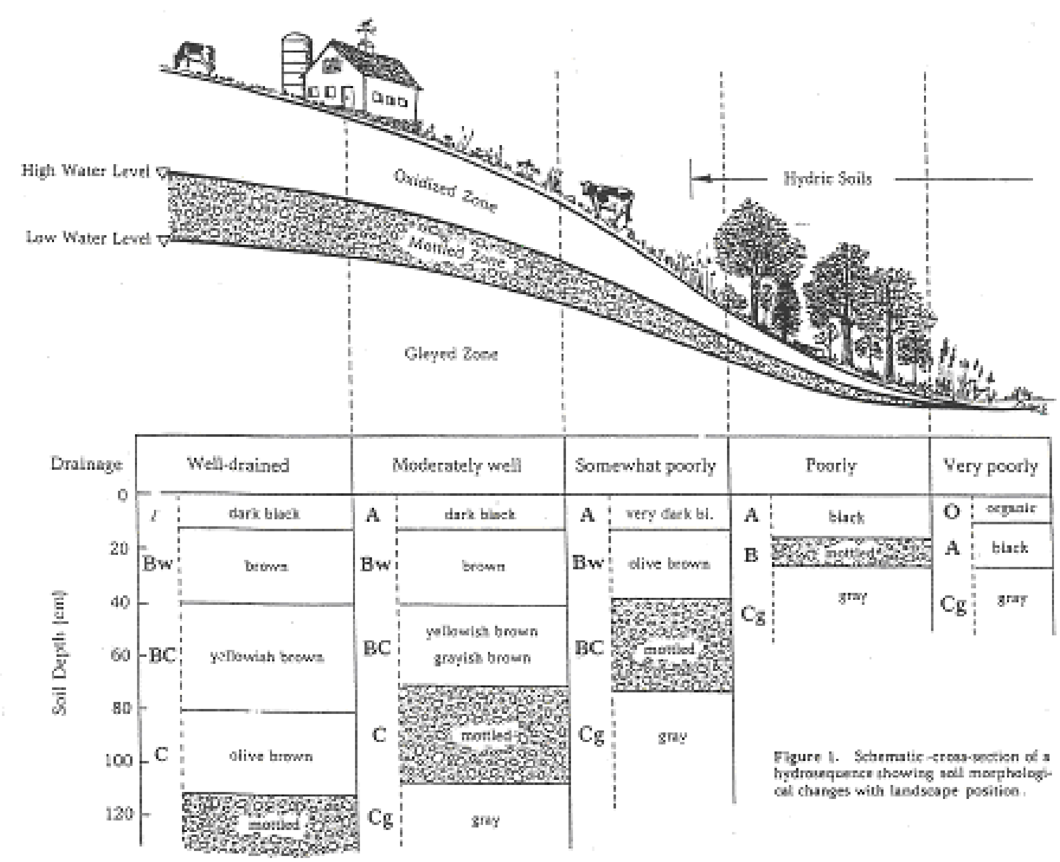


Figure 1. Schematic cross-section of a hydrosequence showing soil morphological changes with landscape position.

V. SOIL INTERPRETATIONS

There are many environmental concerns associated with various land uses. These include surface and groundwater quality, erosion and sediment control, non-point source pollution, stormwater management, forestland management, farmland conservation, and wetland conservation. Additionally, environmentally sound land management and land use planning requires knowledge of soils and their behavior and capability. The following information describes important soil characteristics as they relate to some environmental issues, and their intricate role in ecosystems.

SOILS AND PLANTS

The amount of open space between soil particles has a lot to do with how easily water moves through a soil and how much water it will hold. Too much clay, in proportion to silt and sand causes a soil to take in water very slowly. Such a soil also gives up its water to plants slowly.

Individual pore spaces are relatively large in coarse textured soils. Sandy soils do not retain moisture since there is less surface area for the water to cling to and the pores are so large that the weight of the water causes much of it to run down and out of the soil. Don't confuse this property with that of poorly drained sandy soils, which are situated within the depths of the seasonal high water table. These can be saturated during the wettest periods of the year. They are normally dry during the peak of the growing season. Soils dominated by medium and coarse sands and that are low in silt and clay are known as droughty soils. Crops cannot live long in them without very frequent rains or irrigation. In areas of sandy, well drained soils in woodland, the trees are dominated by drought tolerant species.

Finer textured soil can hold more water for plants because there is more surface area on which water adheres. Since the size of the pores is reduced, the weight of the water is less and it doesn't run out of the soil so readily. There is however, a fine line. Some soils high in clay hold a great deal of water but so tightly that many plants can not extract the moisture. In general, silt loam textures have the greatest available moisture holding capacity for plant growth.

Rate of water intake determines the amount of water that runs off. The more water that enters the soil the less there is to run off. But there are other advantages to soils that take in water readily. Much of the rain that falls during heavy rainstorms soaks into the soil and is available for plants later on. Plants need air in the soil for best root development and growth, as do many kinds of bacteria. Water movement in the soil brings better air circulation. When water enters the soil, air moves out and is replaced by fresher air as soon as the soil pores are again free of water. To a great degree, soils determine the type of natural vegetation within a given area. The soil is therefore an environmental parameter for many wildlife species dependent on specific vegetation for food and shelter.

EROSION

In its broad sense, erosion means the wearing away of the earth's surface by the forces of ice, water, and wind. The inevitable wearing down of high places and filling of low places of the earth's surface continues with or without assistance from people.

Natural erosion is the detachment and movement of material under conditions unaffected by the activities of people. Natural erosion may be very slow or very rapid, and it may fluctuate considerably depending on local conditions.

Accelerated erosion is the process of erosion influenced by people can be divided into two classes, water erosion and wind erosion, depending upon the moving agent.

Sheet erosion is the more or less uniform removal of soil from an area without the development of conspicuous water channels.

Rill erosion is the removal of soil through the cutting of many small but conspicuous channels where runoff concentrates. Rill erosion is intermediate between sheet and gully erosion. The channels are shallow enough that they are easily obliterated by tillage.

Gully erosion is conspicuous. Gullies form where water concentrates and flows as a stream, cutting down into the soil along the line of flow. Gullies form in exposed natural drainage ways, in plow furrows, in animal trails, in vehicle ruts, between rows of crop plants, and below broken people-made terraces. In contrast to rills, gullies cannot be obliterated by ordinary tillage. Deep gullies cannot be crossed with common types of farm equipment.

Erosion detaches individual soil grains from the soil mass and carries them away in raindrop splash or running water. Soil erodibility therefore is a combination of its detachability and transportability.

Soil texture has an effect on the rate of erosion. Sand particles are difficult to transport because of their relatively large size, even though they are easily detached from the soil mass. Clay particles tend to stick together and are difficult to detach. Silty soils are often well aggregated but the aggregates break down readily when wetted and the particles are easily detached and transported. Soils with high silt contents are therefore the most highly erodible, all other factors being equal.

Whenever vegetation is removed and the soil is bare or disturbed, such as on building site development, logging operations and farmland, there is potential for accelerated erosion. After the sediment leaves the farm or building site some of it gets into streams and begins to affect everyone.

Sediment from soil erosion is a national problem. The national sediment damage amounts to millions of dollars annually. Much of the sediment is topsoil, the most agriculturally productive. Pesticides can travel with soil particles through the process of soil erosion. More than 3,200 water-supply reservoirs are losing water-storage capacity each year to sediment. Water bills are higher because the water must be further treated. Many harbors must be dredged annually to allow ships to enter. Erosion that causes sediment deposition can be reduced up to 90 percent with soil and water conservation measures. The first step is to understand the nature of the soil.

WATER QUALITY

Water entering the soil moves downward to become groundwater unless taken up by plants, evaporated into the atmosphere, held within soil pores, or diverted by an impermeable layer. The downward movement of water through the soil is called percolation. If percolating water reaches the ground water, it is referred to as recharge. The quality and amounts of recharge are influenced by the characteristics of the soils through which the water travels.

There are many sources of potential pollutants to groundwater including pesticides from farms, lawns and gardens, runoff from roads, and septic system effluent*. The soil can act to reduce the pollutant levels in groundwater recharge. The extent of treatment the water receives is influenced by a variety of soil characteristics.

Soil texture affects the surface area available for the adsorption of pollutants (adsorption -not absorption- is the attraction between a chemical compound and a soil particle). Pollutants strongly adsorbed to soil particles are less likely to move through the soil with percolating water. As the amount of small particles in the soil increases, the total surface area in the soil increases. Therefore, soils having clayey textures remove pollutants from recharge more effectively than those having sandy textures would.

Soil texture influences pore space and therefore water holding capacity. There is more pore space in soils that have high contents of silt and clay than in sandy soils. In fine textured soils the individual pore spaces are small but there are a lot of them, particularly in clay soils. Water is held tightly in these soils. Sandy soils have less pore space, and the size of individual pores is large. Water readily percolates through sandy soils therefore if polluted there is a greater risk of groundwater contamination from recharge water through coarse textured, sandy soils.

Texture also influences infiltration rate. The greater the rate at which water enters the soil, the less amount of water will be available for surface runoff. The large pores between sand particles permit rapid infiltration. The tiny pores in fine-textured soils such as clay and clay loam resist water movement. A moderate storm often produces more runoff and erosion from the finer textured soils than sandy ones.

Organic matter increases the ability of the soil to adsorb chemicals by providing more surface area for adsorption. It also increases water-holding capacity. Organic matter is beneficial to microorganisms in the soil. Reactions involving soil microorganisms can help degrade many pollutants before they reach groundwater. Soil structure improves and the individual aggregates become more stable as organic matter content increases.

Soil structure, the way the soil particles are held together, will affect water movement. Well aggregated, non-compacted soils allow for more rapid movement of water than massive, compacted soils. Improved structure is accompanied by increased infiltration and by decreased runoff and erosion. Sometimes large openings (macropores) occur as a result of animal bores, freeze/thaw action, root penetration, or drying. Under certain conditions, macropores can cause rapid pesticide movement.

Soil drainage in general refers to the relative distance from the soil surface to groundwater. The depth to groundwater represents the distance water must percolate and therefore the time it will take pollutants to reach groundwater. When the water table is close to the surface, groundwater can be more easily contaminated.

Additionally, areas of poorly drained and very poorly drained soils are usually wetlands and therefore important resources.

The type of parent material in which the soils formed influences the movement of water. Large deposits of sandy, gravelly outwash are good areas for groundwater recharge because water moves through them readily. In New England, these soils are usually found at the lower elevations of the watersheds and often receive water from the surrounding uplands. They are often good places for public well water supplies. Quite often, these are also areas where there is a demand for building sites for homes, commerce and industry. These soils can be identified as high priority resource areas and protected accordingly.

SOIL DEPTH

The depth from the surface, to layers that are impermeable to water such as bedrock and hardpan*, varies. Compared to deeper soils, shallow soils are a smaller filter through which water percolates. Contaminated water percolating through shallow soil will have less contact with soil material resulting in less effective treatment.

In areas where land is developed for building sites, the management of storm water is a concern. Water contained within a watershed must be managed to minimize erosion and pollution. Soils act like a sponge in containing precipitation. Shallow soils retain relatively small amounts of water. In general, a watershed that is comprised mostly of shallow soils will have greater stormwater runoff than one consisting of very deep soils. The soil depth therefore is an important planning consideration when managing runoff in developed areas within a watershed.

Degree of slope is considered to be a soil characteristic. Precipitation on steep slopes results in faster surface runoff and less contact time in the soil.

FARMLAND

The conservation and preservation of open space is a function of wise land use planning and management. Soils information, particularly that provided in soil survey reports, is an invaluable tool in assessing potential land use and identifying those areas most suitable for preservation. One important consideration in targeting land for open space is its suitability for agricultural use. Farmland, in addition to its basic value of crop and fiber production, is highly valued for aesthetic qualities.

Soil surveys provide information to identify areas that are prime, or important farmland. Prime farmland soils are those that have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and are also available for these uses (the soil's use could be cropland, pasture, forestland, or other land, but not urban built up land or water). In general, prime farmland soils have the following traits: adequate and dependable precipitation; a favorable temperature and growing season; suitable acidity or alkalinity; level or nearly level slopes; permeability that allows the uninhibited movement of air and water in the root zone; adequate drainage; acceptable rates of erosion; adequate moisture holding capacity (not droughty); adequate depth to impermeable layers; and few or no surface stones. Prime farmland soils are not excessively erodible or saturated with water for a long time, and they either do not flood frequently or are protected from flooding.

HYDRIC SOIL AND WETLANDS

Wetlands provide important benefits, in the form of water quality, wildlife habitat, species diversity, flood control, and control of surface runoff and erosion, that are well documented. Proper identification and delineation of wetlands are essential to preserve the important values and functions they provide. The interpretation of soil morphology and soil survey information are tools used extensively for this purpose.

This may seem simplistic but the thing that causes a landform to be a wetland is water. Places in the landscape that are subject to a high water table at or near the surface of the soil for significant periods of time is land that is wet. Wetlands are therefore driven by hydrology*. How does one determine whether the ground meets this definition? There are several methods, one of which is to examine and interpret the soils. As discussed earlier, the seasonal high water table influences the soil morphologies of color and organic matter accumulations.

Soils in a suspected wetland area can be described and interpreted to see if they meet the classification criteria of a hydric soil. Hydric soils are define as soils that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, July 13, 1994). Hydric soils are those that have thick accumulations of organic matter due to long periods of saturation, or have dominantly gray colors in the upper B horizons due to the loss of iron from individual soil particles. These morphologies are indicative of an environment without oxygen (anaerobic conditions). For further information, see the section on soil drainage class.

The soil survey maps identify those areas mapped poorly and very poorly drained as predominantly hydric soils. To get an idea of where wetlands are, one can simply consult soil maps, and look for soils defined as being poorly and very poorly drained.

VI. EVALUATING SOILS

Evaluating soils is the process of recognizing and describing soil properties and characteristics. This information is then applied to land use and environmental issues and concerns. The soil evaluation exercise that follows is designed to encourage "hands-on" learning and provides an opportunity to develop skills in interpreting maps, researching, making and documenting observations, applying observed facts in responding to questions, problem solving and teamwork. It also requires being outdoors! Teams can perform this exercise by visiting a site, digging a hole with an ordinary shovel or post hole digger to a depth of about 30 to 40 inches, and recording their observations on the form. The performance of this exercise requires skill in observation. Students will examine the surrounding landscape to see how it relates to the environment and the soil. They will note changes in soil characteristics through the process of excavating and describing soil layers. They will apply what's been observed to questions about soil behavior and suitability for various land uses.

Research skills can be applied to this exercise. Topographic maps and aerial imagery can be evaluated prior to a trip to the field to help identify landscapes and predict drainage characteristics. It is strongly recommended that USDA Natural Resources Conservation Service (formerly Soil Conservation Service) soil maps and accompanying information be used in conjunction with this process. The team members can locate the site on the soil map, read about the soils, and use the information to help them complete the soil evaluation form.

The Envirothon team members are expected to be familiar with the soil survey maps and information as well as the soil characteristics and land use interpretations referred to in this exercise.

The text following the soil evaluation form provides guidelines. It augments but does not replace related subject information in the manual. Teams should read the manual, review the evaluation form and then read the interpretation of the soil evaluation form prior to conducting an on-site visit to describe and evaluate soil.

Teams familiar and successful with this soil evaluation process will be successful with the soils aspect of the Envirothon.

SOIL EVALUATION EXERCISE

Massachusetts Envirothon

NAME/SCHOOL/GROUP ________________________

site number__________

A. LANDSCAPE FEATURES

1. Landform

_____________ Bog/Swamp/Marsh

_____________ Glacial lake

_____________ Escarpment

_____________ Floodplain

_____________ Drumlin

_____________ Moraine

_____________ Ground Moraine/Till Plain

_____________ Ground moraine/bedrock-controlled upland/ridge

_____________ Glaciofluvial: outwash plain, outwash terrace, esker

_____________ Other

2. Slope

_____________Nearly level 0-3%

_____________Gently sloping 3-8%

_____________Moderately sloping 8-15%

_____________Strongly sloping 8-25%

_____________Steep > 25%

3. Stoniness

_____________Non-stony

_____________Very stony

_____________Extremely stony

B. SOIL FEATURES

1. Soil Profile Description

Depth	Horizon	Color (moist)	Texture	RMF's Volume	RMF's Color	Consistence

Estimated depth to seasonal high water table:	

2. Parent Material

_____________Till

_____________GlaciofluviaL

_____________ Eolian

_____________Alluvium

_____________Glaciolacustrine

_____________Organic

3. Drainage

______Excessively

______Well

______Moderately

______Somewhat Poorly

______Poorly

______Very Poorly

4. Permeability

______Rapid

______Moderate

______Slow

5. Depth

_____Very Deep ______Deep ______Moderately Deep ______Shallow

C. LAND ASSESSMENT

1. Prime farmland

_______Yes

_______No

Major limiting factor for agriculture

______________Depth

______________Drainage

______________Slope

______________Moisture holding capacity

______________Stoniness

______________None

2. Limitations for residential homes with basements

Limitation

_______None to slight

_______Moderate

_______Severe

Major limiting factor

_______Drainage class

_______Slope

_______Flooding

_______Stoniness

_______None

3. Limitations for septic tank absorption fields

Limitations

_______None to slight

_______Moderate

________Severe

Major limiting factor

_______Drainage class

_______Slope

_______Flooding

_______Permeability

_______Stoniness

_______None

INTERPRETATION OF SOIL EVALUATION EXERCISE

Soil or land evaluation involves learning how to interpret a soil for its best use through an examination of its properties. With only a brief introduction to soil science, you can make several basic evaluations of a soil and at least limited predictions about its behavior under various types of management and use. The following provides explanations of the features presented on the soil evaluation exercise. For more in-depth information refer to your Envirothon manual.

A. LANDSCAPE FEATURES

1. LANDFORM

The landform can be identified by observing the soil and the surrounding area. Topographic maps are helpful in providing an inclusive picture of larger landforms and the surrounding area. The following list may not be all-inclusive but most landforms in Massachusetts can reasonably be placed into these categories.

Marsh/swamp/bog – A low lying area of saturated ground intermittently, partially or permanently covered by shallow water and supporting vegetation dominated with hydrophytic plants.

Glacial Lake – An area formally occupied by a glacial lake. Usually in a relatively low lying, level area characterized by soil parent material having thin strata of silt, clay and or very fine sand.

Escarpment - A relatively continuous and steep slope or cliff produced by erosion or faulting and that topographically interrupts or breaks the general continuity of more gently sloping land surfaces. The term is most commonly applied to cliffs produced by differential erosion.

Floodplain- The nearly level plain that borders a stream or river and is subject to inundation under flood stage conditions unless protected artificially. It is a landform built of sediment deposited during overflow and lateral migration of the streams or rivers.

Drumlin - A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It usually has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longest axis is parallel to the general direction of glacier flow. Drumlins are products of streamline flow of glaciers, which molded the sub-glacial floor through a combination of erosion and deposition.

Moraine - A mound, ridge, or other topographically distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited primarily by the direct action of glacier ice, in a variety of landforms. It is also a general term for a landform composed mainly of till that has been deposited by a glacier. Types of moraine include: disintegration, end, ground, kame, lateral, recessional, and terminal. For this exercise, moraine refers to a distinct landform deposited at the end or edges of an ice sheet as compared to the more extensive till plain and bedrock controlled upland described below.

Ground Moraine/Till Plain - Commonly an extensive, low relief area of till, having an uneven or undulating surface, and commonly bounded by a recessional or end moraine; its comprised of poorly sorted rock and mineral debris dragged along, in, on, or beneath a glacier and deposited by processes including basal lodgement and release from melting stagnant ice by ablation.

Ground moraine/bedrock-controlled upland/ridge – upland areas characterized by soils developed in a veneer of till varying in depth to within 6 feet of bedrock. Bedrock outcrop is a typical feature.

Glaciofluvial - Material moved by glaciers and subsequently sorted and deposited by streams and rivers flowing from the melting ice. The deposits are stratified and may occur in the form of various types of landforms such as outwash plains, outwash terraces, valley trains, deltas, kames, eskers, kettles, and kame terraces. These landforms are referred to collectively as glaciofluvial landforms in this exercise for the sake of simplicity. Glaciofluvial also refers to the soil parent material derived by the same processes as the landform. The key to recognizing glaciofluvial landforms is to read the soil profile and the position in the landscape. These land forms occur where water flowed as glacial ice melted: lower in elevation relative to the surrounding landscape and often near rivers.

Other – in Massachusetts, landforms not previously listed include beach, barrier beach, tidal flat and marine terrace.

2. SLOPE

The slope or gradient is generally expressed as a percentage that is calculated by dividing the difference in elevation between two points by the horizontal distance and multiplying by 100. For example, a 10% slope would have a 10 foot drop per every 100 feet.

3. STONINESS

Non-stony - less than .01% of the surface is covered with stones.

Stony - .1% to less than .1% of the surface is covered with stones.

Very stony - .1% to 3% of the surface is covered with stones.

Extremely stony – 3% to less than 15% of the surface is covered with stones.

Rubbly- 15% or more of the surface is covered with stones.

B. SOIL FEATURES

1. SOIL PROFILE DESCRIPTION

When excavating, pay attention! How difficult is the digging? Is the soil firm, and if so at what depths? Are there many stones? How about gravel? Is the gravel angular or rounded or something in between? Clean the face of the pit with a knife or trowel to remove smearing, smoothing or mixing caused by excavating. Sit back and look for the most obvious differences in the layers. Contrasts in color and rock fragment content are often most obvious. It's helpful to mark the layers by inserting nails, twigs or golf tees into the pit where you think the layers are distinct from each other. Then look for more subtle differences. Horizons can be separated based on any observable differences in color, root content, structure, gravel content, consistence, presence and abundance of redoximorphic features, etc. Subdivide the horizons further as you deem warranted. Some people tend to split out lots of layers (folks referred to as splitters); others tend to be more prone to generalize (lumpers). Describe the characteristics of layer as depicted on the exercise description form. Some soil scientists prefer to assign a designation (O, A, B, C, E) to the horizons as the last step because at that point each layer has been closely examined leading to a better understanding of the formation and morphology of the soil. And remember, not all soils have all types of horizons. Don't look for what is not there.

Depth – measure down from the surface, the surface being the zero point i.e., 0 to 3 inches, 3 to 12 inches, etc.

Color – If a soil color book is available, match a sample from each horizon to the closest color book chip. If a soil color book is not available, determine the best color descriptors for each horizon by group consensus.

Horizons

- O horizons: dominated by organic material. Usually dark, feels smeary when wet. Can be slightly to well decomposed.

- A horizon(s) or topsoil: Black or very dark colors are indicative of relatively high organic matter contents. Generally, the darker the A horizon, the higher its organic matter content. Pale colors indicate that the horizon has relatively low organic matter content. Don't confuse A horizons with O horizons. It does not require very much organic material to darken a mineral layer.

- B horizon(s) or subsoil: colors are not greatly influenced by organic matter. Usually the iron compounds coating the mineral particles are largely responsible for the color of this horizon. Soils formed under well-drained conditions have subsoil with relatively bright colors, usually yellowish brown or reddish brown. These colors can be interpreted as indicating good natural drainage. Septic systems should work well in these soils, and they should provide good, dry locations for houses with basements. When these colors are mixed with spots of gray, the soil has developed under conditions of imperfect drainage. The mixed color pattern is termed redoximorphic features (*RMF's is the abbreviation for redoximorphic features*) and indicates that the soil is saturated with water for long periods during the year. Basements may be wet and septic systems are subject to periodic failure when installed in these soils. When gray colors predominate, the soil has usually formed under poorly or very poorly drained conditions. This situation indicates that the water table is at or near the surface for long periods during the year. Artificial drainage is necessary for crop production, and the soil is not suited for building sites, especially where septic systems are needed.

- C horizon(s) or substratum: generally, the original condition of parent material. Colors are dull and relatively unaffected by organic matter or chemical weathering. It may have RMF's under conditions of imperfect drainage.

- E horizons: occur sporadically in Massachusetts. They are an ashy gray layer between the A and B horizons that form as humus, iron and aluminum are stripped from the layer by downward percolating water.

- R layers: are hard, contiguous bedrock

Texture

The mineral grains in soils can vary in size from coarse gravel and sands to fine silts and clays. The size of the individual mineral grains and their relative proportion in the soil mass is referred to as soil texture. Check out the manual for methods of determining texture. TIP: When texturing soils use the hand opposite your writing hand. This will help keep your papers clean!

RMF's (Redoximorphic features) – if these features are present, indicate the percentage by volume covering the horizon and describe the color. There may be more than one or two colors. Describe the major ones, or as many as practical. If there are none, indicate as such on the form.

Consistence - How resistant is the horizon to excavating? How much pressure is required to cause an aggregate of the soil to be crushed between thumb and forefinger? Consistence is determined because it may be important in influencing permeability and drainage. It is described using the following terms:
Loose- an intact specimen is not obtainable (usually very coarse textured soils)
Very friable – will rupture under very slight force between the fingers
Friable – will rupture under slight force between the fingers
Firm - will rupture under moderate force between the fingers
Very firm - will rupture under strong force between the fingers
Extremely firm - will rupture under moderate force between the hands

Estimated depth to seasonal water table: the depth at which redoximorphic features are observed

2. PARENT MATERIAL

Parent material is the stuff from which the soil developed. There is an extensive section describing soil parent material in the manual.

3. DRAINAGE CLASS

Drainage class reflects the depth to a seasonal high water table that is indicated by the presence of redoximorphic features of reddish orange and or gray colors. Drainage class also reflects the duration of the seasonal high water table.
Soil redoximorphic features are irregular spots of different colors that vary in number and size. Redoximorphic features generally indicate poor aeration and impeded drainage.

Excessively drained - Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, or shallow. Some are steep. Most are in higher landscape positions relative to their immediate surroundings. All are free of redoximorphic features.

Well drained - Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well-drained soils are commonly medium textured. Redoximorphic features, if any, are deep in the soil profile.

Moderately well drained - Redoximorphic features at 18+ inches. These soils may retard crop growth in wet years. Septic systems may experience periodic failure.

Somewhat poorly drained - Redoximorphic features at 8 to 18 inches. Unless artificial drainage is provided, crop production is restricted and septic systems commonly fail.

Poorly drained - Redoximorphic features at 0 to 8 inches, and or the subsoil immediately below the A horizon is dominantly gray (E horizons excluded, they are the result of a different process). These soils are productive only if they are artificially drained. Development of these soils for home sites should be avoided.

Very poorly drained – These soils often have thick accumulations of organic material at the surface. They are usually saturated so that the accumulation of organic material exceeds the rate of decomposition. They are associated with swamps, bogs and marshes.

Hint: When determining drainage class, think: is the landscape position conducive to receiving water or close to the actual ground water table (ground water elevations are generally expressed by the presence of surface water: lakes, ponds and streams)? Does the soil have a dense layer? If there are RMF's at what depth are they, and what is there abundance. Are they mostly gray or reddish-orange? Generally, grayer means wetter.

4. PERMEABILITY

This soil property is defined as the rate at which air and water move in the soil. Permeability is dependent upon soil structure, texture, porosity, cracking, and the presence or absence of dense, compact subsoil layers.
For each soil, permeability is determined for the least permeable horizon.

Rapid - Water moves through the soil at a rate of at least 6 inches per hour. Coarse-textured soils such as sands, loamy sands, and gravel are included in this category. These soils tend to be droughty.

Moderate - Water moves through the soil at rates ranging between 0.6 inches to 6 inches per hour. Most of the medium-textured soils fall into this class if no impervious layers are present.

Slow - Water moves through the soil at a rate of less than 0.6 inches per hour. Fine-textured soils or those with impervious layers are included in this category.
Note: You are not expected to be able to figure the rate in inches per hour that water moves through the soil. The information is provided to help explain the concept.

5. DEPTH

Very deep - Greater than 60 inches to hard bedrock

Deep - 40 to 60 inches to hard bedrock

Moderately deep - 20 to 40 inches to hard bedrock

Shallow - Less than 20 inches to hard bedrock

C. LAND ASSESSMENT

1. PRIME FARMLAND

Soils that have few limitations that restrict their use of crop production in Massachusetts and that are:

- deep or moderately deep
- well drained or moderately well drained
- on slopes less than 8%
- medium to high available moisture holding capacity. Soils having textures of loamy sand or sand have low moisture holding capacities. Consider the upper

two feet of the soil when making this evaluation.

- non-stony

2. LIMITATIONS FOR RESIDENTIAL HOMES WITH BASEMENTS

None to slight - Deep, well drained, non-stony soils with slopes less than 8% are considered suitable for home sites.

Moderate - Deep or moderately deep, moderately well drained soils, stony soils, or slopes of 8-15% would have moderate limitations.

Severe - Where soils possess serious hazards or have excessive construction costs, the site is rated as severe. These limitations include poorly and very poorly drained soils, extremely stony soils, areas subject to flooding, slopes greater than 15% and shallow depth to bedrock.

3. LIMITATIONS FOR SEPTIC TANK ABSORPTION FIELDS

None to slight – Very deep (greater that 60 inches to bedrock), well drained soils with moderate to rapid permeability and slopes of less than 8% are preferred for septic systems.

Moderate - Deep (40 to 60 inches to bedrock), well-drained soils with slopes of 8 to 15%, which may be stony will have moderate limitations.

Severe - Where soils possess serious hazards or where excessive construction costs would result, the site is rated severe. These hazards include imperfectly drained soils, extremely stony soils, areas subject to flooding, slow permeability, slopes greater than 15%, and moderately deep or shallow to bedrock.

VII. SOIL SURVEYS

A great way to learn about the soils of an area is to consult a soil survey report. Soil surveys are made and published by the Natural Resources Conservation Service (formerly Soil Conservation Service) of the United States Department of Agriculture. They are usually completed on a county basis. They show soil types delineated on an aerial photo base and have accompanying information about the soils. The soil survey is the most intensive resource inventory of land ever made in the United States. It is an extremely useful tool for people to examine the intricate relationships between ecosystems, humans and the world around them. Envirothon teams are expected to be familiar with the use of soil survey reports. A good way to start is to obtain the soil maps of an area, your school for example, and determine what the soil types are. Read about the soil and check out the interpretive tables that tell you what the limitation of the soil is for various land uses. You may begin to have an understanding of how soil conditions effect our environment. Information on obtaining soils information is in the beginning of this section.

The usefulness of soil survey maps becomes evident as you explore different land uses and their effects on the quality of life and the environment. A soil map displays the types of soils found in any locations of interest. You can use these maps and text to determine which land uses are best suited to each soil landscape. The information in a soil survey report identifies the limitations and potential of the land for various uses. It provides a database that can help people make economical and environmentally sound land management decisions.

Soil surveys help in planning the layout and maintenance of open space, parks, campsites, ski areas, and golf courses. They can be used to identify prime and important farmland and to locate environmentally sensitive places such as ground water recharge areas and wetland soils. Your county's survey can help you decide where to buy property or where to build your house.

Soil surveys are a valuable tool for exploring our environment. The following questions and issues can be addressed using soil survey information.

- How is soil formed? What is the geologic connection to soil type and properties?
- Did the ancient glaciers affect the soils in your area? How?

- Study the relationships between soil, climate and native plants.
- What role does wetland soil play in the ecosystem?
- Discuss which is the best use of a level, well-drained soil - homes or farms? What is the best use of hilly land?
- If you could rebuild your town, how would you change it based on the information in the soil survey?
- Which soils are subject to erosion? What types of soils carry pollutants quicker more readily than other types?
- Which soils can support endangered species? Why?
- What landscapes do the soil maps represent? How do soils relate to the ecosystems on each type of and landscape?
- How have land use patterns developed historically in relation to soil types? Where is future development likely to occur?

VIII. RESOURCES and ACKNOWLEDGEMENTS

RESOURCES

For soil survey information:

USDA Natural Resources Conservation Service Web Soil Survey. It provides soil mapping and related information. It also provides information about soils in general. http://websoilsurvey.nrcs.usda.gov/app/

Another source of soil maps and descriptive information is your local USDA, Natural Resources Conservation Service (formerly Soil Conservation Service) office.

Office Location	Service Area (By County)	Telephone
Barnstable	Barnstable, Dukes and Nantucket	508-771-6476
Greenfield	Franklin	413-772-0384
Holden	Worcester	508-829-4477
Hadley	Hampden and Hampshire	413-586-1000
Pittsfield	Berkshire	413-443-1776
Westford	Essex, Middlesex and Suffolk	978-692-1904
West Wareham	Bristol, Norfolk and Plymouth	508-295-5151
State Office	Amherst	413-253-4350

Another useful website is that provides educational information about soils is:

http://www.soil-net.com/

NRCS soil scientist, Jim Turenne maintains a website that provides soil profile images with accompanying information at:

http://nesoil.com/

Additional links can be found at http://www.maenvirothon.org/soils.htm

ACKNOWLEDGEMENTS

Much of the information in this section was compiled from various references developed by the NRCS Soil Survey program including, the Soil Survey Manual, the Soil Mechanics training course material and published soil survey information. Special thanks to Peter Fletcher, NRCS soil scientist, retired, for information on method 1 for field determination of soil texture, for the section on soil color, soil horizons and for sketches of soil profiles.

Hydric Soils of New England by R.W. Tiner, Jr. and P.L.M. Veneman. 1987. University of Massachusetts Cooperative Extension, Amherst, MA. Bulletin C-183

Delineating Bordering Vegetated Wetlands produced by Massachusetts Department of Environmental Protection, Division of Wetlands and Waterways. 1995 Written by Scott Jackson University of Massachusetts, Department of Forestry and Wildlife Management

Soil Survey Manual, by Soil Survey Staff, Chapter 4, Examination and Description of Soils in the Field, 1981 United States Department of Agriculture, Soil Conservation Service

IX. GLOSSARY

ABC soil - A soil having an A, B, and a C horizon.

Ablation till - Loose, permeable till deposited during the final down wasting of glacial ice. Lenses of crudely sorted sand and gravel are common.

AC soil - A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep rocky slopes.

Aeolian soil material - Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to silty loess.

Aeration, soil - The exchange of air in soil with air from the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil - Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium – Material usually dominated by silt and very fine and fine sand deposited on land by streams and rivers.

Aspect, slope - The direction towards which the surface of the soil or land faces.

Basalt - Igneous rock formed by rapid cooling of magma.

Base saturation - The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K) expressed as a percentage of the total cation-exchange capacity.

Bedding planes - Fine stratifications, less than 5 millimeters thick in unconsolidated alluvial, aeolian, lacustrine, or marine sediments.

Bedrock - The solid rock that underlies the soil and other unconsolidated material, or that is exposed at the surface.

Bottom land - The normal floodplain of a stream or river, subject to flooding.

Boulders - Rock fragments larger than 2 feet (60 centimeters) in diameter. As compared to stones which are about 10 inches to 2 feet in diameter.

Bulk density – the weight of a given volume of soil. It is usually expressed in grams per cubic centimeter. It is a measure of how compact the soil and therefore permeability, porosity and root restriction.

Calcareous soil - A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilate hydrochloric acid.

Capillary water - Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena - A sequence or chain of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation - An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity - The total amount of exchangeable cations that can be held by the soil, expressed in millequivalents per 100 grams of soil at neutrality (pH 7) or at some other stated pH value. The term, as applied to soils, is synonymous with base exchange capacity but is more precise in meaning.

Clay - As a soil separate: the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class: soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film - A thin coating or oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Claypan - A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard and dry and plastic or stiff when wet. Claypans are not recognized in Massachusetts soils.

Coarse fragments – Mineral fragments larger than coarse sand (2mm) including gravel, channers, cobbles, stones, flagstones and boulders

Coarse textured soil - Sand or loamy sand.

Cobblestone (or cobble) - A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium - Soil material, rock fragments, or both, moved by creep, slide or local wash, and deposited at the base of steep slopes. Colluvium is a soil parent material.

Complex slope - Irregular or variable slope.

Complex, soil - A map unit in a soil survey of two or more kinds of soil that occur in such an intricate pattern or so small in area that is not practical to map them separately at the selected scale of mapping.

Concretions - Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conglomerate - Sedimentary rock formed from gravel and sand.

Consistence, soil - The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence for *moist* soil samples are:

Loose – noncoherent, does not hold together in a mass
Very friable – sample crushes under very slight force between fingers
Friable - crushes easily under gentle pressure between thumb and forefinger but resistance is distinctly noticeable
Firm – crushes under moderate force, resistant to pressure, can be broken with difficulty between thumb and forefinger
Very firm - crushes under strong force between thumb and forefinger

Dense layer - A very firm, layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging, is resistance to root growth, has slow permeability and can affect filling and compacting. In the glaciated northeast, soils developed in lodgement till parent material are underlain by a dense later substratum.

Drainage class - Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blockage of drainage outlets.

Drumlin - A low, smooth, elongated oval hill, mound, or ridge of compact glacial till. The longer axis is parallel to the path of the glacier and commonly has a blunt nose pointing in the direction from which the ice approached.

Effluent – Outflow from a sewer, sewage system or factory.

Eluviation - The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Erosion - The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic) - Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features and flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated) - Erosion particularly as pertains to soil movement much more rapid than geologic erosion. It is mainly as a result of the activities of people such as some agricultural and site development practices or of a catastrophe in nature, for instance, fire that exposes the surface.

Esker - A narrow, winding ridge of stratified gravelly and sandy drift deposited by a stream flowing in a tunnel beneath a glacier.

Estuarine – Pertaining to the widened tidal mouth of a river valley where fresh and sea water come in contact or a partially enclosed coastal body of water where the tide meets the current of a stream or river.

Fibric soil material (peat) - The least decomposed of all organic soil material. It combines a large amount of well preserved fiber that is readily identifiable according to a botanical origin such as sphagnum moss. It has the lowest bulk density and the highest water content at saturation of all organic soil material. The term 'fibric' can refer to both material formed in wet conditions and that which accumulates on the surface of forest soils in aerated conditions. The term 'peat' is applied to organic material that has accumulated under the saturated conditions that define very poorly and poorly drained soils.

Field moisture capacity - The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational or free water has drained away; the field moisture content 2 or 3 days after a soaking rain.

Fine textured soil - Sandy clay, silty clay and clay.

Flagstone - A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist, 6 to 15 inches (15 to 38 centimeters) long.

Floodplain - A nearly level alluvial plain that borders a stream or river and is subject to flooding unless protected artificially.

Foot slope - The inclined surface at the base of a hill.

Fragipan - A loamy brittle subsurface horizon, developed as a result of soil weathering processes, low in porosity and organic matter content and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard, and has a higher density than the horizon or horizons above. When moist it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil - The mode of origin of the soil. Refers especially to the processes or soil forming factors responsible for the solum or true soil from the unconsolidated parent material.

Glacial drift - Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by glacial meltwater.

Glacial till - Unsorted, non stratified glacial drift consisting of clay, silt, sand and boulders transported by glacial ice and deposited by force of gravity.

Glaciofluvial deposits - Material carried and deposited by glacial melt water. It is usually well sorted and stratified. Also referred to as glacial outwash.

Gleyed soil - Soil affected by prolonged saturated conditions, resulting in the reduction of iron and other elements in the profile as displayed by dominantly gray colors.

Gneiss - Metamorphic rock formed from granites and similar rock types.

Granite - Igneous rock formed by slow cooling of magma.

Gravel - Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. Gravel is a collection of pebbles.

Groundwater - Water filling all the unblocked pores of the regolith below the water table.

Hardpan - A hardened or cemented soil horizon or layer. The soil material is sandy, loamy, or clayey, and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Hemic soil material (mucky peat) - Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the most decomposed sapric material. The term 'hemic' can refer to both material formed in wet conditions and that which accumulates on the surface of forest soils in aerated conditions. The term 'mucky peat' is applied to organic material that has accumulated under the saturated conditions that define very poorly and poorly drained soils.

Horizon, soil - A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons.

Hydraulic conductivity – the rate of water movement through soil.

Hydrology – the nature of the movement, distribution and quality of water.

Humus – the well decomposed, more or less stable part of the organic matter in mineral soils.

Igneous rock - Rock originating from the fast (basalt, tephra) or slow (granite) cooling of molten magma at the earth surface or below the surface respectively.

Illuviation - The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil - A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration - The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity - The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate - The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied to the surface.

Kame - An irregular, short ridge or hill of stratified glacial drift.

Karst topography - The relief of an area underlain by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins.

Lacustrine deposit - Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Leaching - The removal of soluble material from soil or other material by percolating water.

Limestone - Sedimentary rock formed from soft masses of calcium and magnesium carbonate.

Liquid limit - The moisture content at which the soil passes from a plastic to a liquid state.

Loam - Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess - Fine grained material, dominantly of silt-sized particles, deposited by wind.

Lodgement till – Compact glacial till deposited beneath the ice. It is also known as a basal till.

Marble - Metamorphic rock formed by alteration of limestone under increased heat and pressure.

Medium textured soil - sandy loam, loam, silt loam, or silt.

Metamorphic rock - Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline. Examples: gneiss, schist.

Moderately fine textured soil - Clay loam, sandy clay loam, and silty clay loam.

Moraine - An accumulation of earth, stones, and other debris deposited by glacier. Some types are terminal, lateral, medial and ground.

Morphology, soil - The physical makeup of the soil, including the color, texture, structure, consistence, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil - Irregular spots of different colors that vary in number and size. Redoximorphic features are a type of mottling that generally indicates seasonal poor aeration and impeded drainage. Other types of mottling include worm casts and other organic stains. Descriptive terms are as follows:

Abundance; few, common, and many.
Size; fine indicates less than 5 millimeters (about 0.2 inch);
medium from 5 to 1-5 millimeters (about 0.2 to 0.6 inch); and coarse more than 15 millimeters (about 0.6 inch.)
Contrast; faint, distinct and prominent.

Muck (sapric material) - Dark colored, well decomposed organic soil material. The term ‘muck’ is applied to organic material that has accumulated under the saturated conditions that define very poorly and poorly drained soils. The term ‘sapric’ can refer to both material formed in wet conditions and that which accumulates on the surface of forest soils in aerated conditions.

Mucky peat (hemic material) - Organic soil material intermediate in degree of decomposition between the less decomposed peat and the most decomposed muck. The term ‘mucky peat’ is applied to organic material that has accumulated under the saturated conditions that define very poorly and poorly drained soils. The term ‘hemic’ can refer to both material formed in wet conditions and that which accumulates on the surface of forest soils in aerated conditions.

Munsell notation - A designation of color by degrees of three simple variables: hue, value, and chroma. For example a notation of 10YR 6/4 indicates a color hue of 10Y, a value of 6, and a chroma of 4.

Neutral soil - A soil having a pH value between 6.6 and 7.3.

Organic matter - Plant and animal residue in the soil in various stages of decomposition.

Outwash, glacial - Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial meltwater. Also referred to as glaciofluvial deposition

Outwash plain - A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Pan - A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, hardpan, fragipan, claypan, plowpan, and traffic pan.

Parent material - The unconsolidated organic and mineral material in which soil forms.

Peat (fibric material) - Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the most decomposed sapric material. The term ‘peat’ is applied to organic material that has accumulated under the saturated conditions that define very poorly and poorly drained soils. The term ‘fibric’ can refer to both material formed in wet conditions and that which accumulates on the surface of forest soils in aerated conditions.

Ped - An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedology – the branch of soil science that focuses on soil genesis, morphology and classification.

Pedon - The smallest volume that can be called an individual soil profile. A pedon is three dimensional and large enough to permit study of all horizons. Its area can range from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation - The downward movement of water through the soil.

Permeability - The quality of the soil that enables water to move downward through the profile. Permeability is often expressed in inches per hour reflecting the amount of water moving downward through the saturated soil.

Phase, soil - A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value - A numerical designation of acidity and alkalinity in soil.

Pitting - Pits caused by melting chunks of ground ice.

Plasticity index - the numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit - The moisture content at which a soil changes from semisolid to plastic.

Plowpan - A compacted layer formed in the soil directly below the plowed depth.

Ponding - Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poor filter – Refers to a soil that may not adequately filter effluent from a wastewater system, typically due to rapid permeability.

Poorly (or uniformly) graded - Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size, density can be increased only slightly by compaction.

Profile, soil - A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil - A measure of acidity or alkalinity of a soil, express in pH values. A soil that tests to pH 7.0 is described as neutral in reaction because it is neither acid nor alkaline. Acid soils have pH values less than 7, while soils with pH values above 7 are alkaline.

Regolith - The unconsolidated mantle of weathered rock and soil material on the earth's surface; the loose material above the solid rock.

Relief - The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil parent material) - Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rock fragments - Rock or mineral fragments having a diameter of 2 millimeters or more, for example pebbles, cobbles, stones and boulders.

Root zone - The part of the soil penetrated by the bulk of the plant roots.

Runoff - The precipitation discharged into stream channels from an area. The water that flows off the land surface without sinking into the soil before reaching surface streams is called groundwater runoff or seepage flow from ground water.

Sand - As a soil separate: individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains in southern New England consist of quartz. As a soil textural class: a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone - Sedimentary rock containing dominantly sand-size particles.

Sapric soil material (muck) - The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material. The term ‘sapric’ can refer to both material formed in wet conditions and that which accumulates on the surface of forest soils in aerated conditions. The term ‘muck’ is applied to organic material that has accumulated under the saturated conditions that define very poorly and poorly drained soils.

Saprolite - Unconsolidated residual material underlying the soil and grading to hard bedrock below. Weathered, decomposed bedrock.

Schist - Metamorphic rock formed from granites and similar rock types.

Sedimentary rock - Rock made up of particles deposited from suspension in water. The principal kinds of sedimentary rock are:

conglomerate, formed from gravel and sand.
sandstone, formed from sand.
shale, formed from clay.
limestone, formed from soft masses of calcium carbonate.

There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage - The movement of water through the soil. Seepage may adversely affect certain land uses.

Sequum - A sequence consisting of an illuvial horizon and the overlying eluvial horizon.

Series, soil - A group of soils that have profiles which are almost alike the characteristics of which are bounded by an established range which maintains placement in the same taxonomic classification. All the soils of a series have horizons that are similar in composition, thickness, and arrangement. The series is the most narrowly defined level of the soil classification system.

Shale - Sedimentary rock formed by the hardening of a clay deposit.

Shrink-swell - The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica - A combination of silicon and oxygen. One of the major mineral forms is quartz.

Silt - As a soil separate: individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class: soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone - Sedimentary rock made up of predominantly silt-sized particles.

Sinkhole - A depression in the landscape where limestone has been dissolved.

Slate - Metamorphic rock formed by alteration of shale under increased heat and pressure.

Slope - The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by the horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet or horizontal distance.

Small stones (gravel) - Rock fragments less than 3 inches (7.6 centimeters) in diameter. If rounded they a commonly referred to as pebbles. Small stones may adversely affect specific uses of the soil.

Soil - A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates - Mineral particles less than 2 millimeters in diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

medium sand - 0.5 to 0.25 millimeters
fine sand - 0.25 to 0.10 millimeters
very fine sand - 0.10 to 0.05 millimeters
silt - 0.05 to 0.002 millimeters
clay - less than 0.002 millimeters

Solum - The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the O, A, E and B horizons or a combination thereof. It is the part of the profile that excludes C layers and is the result of soil forming processes. (Not all soils have a solum consisting of all horizons.) Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stone line - A concentration of coarse fragments in a soil. Generally, it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones - Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Structure, soil - The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy; laminated
Prismatic; vertical axis of aggregates longer than horizontal

Columnar; prisms with rounded tops
Blocky; angular or subangular
Granular; rounded grains

Some soils lack structure and are referred to as structureless as follows:

Single grained; each grain by itself, as in dune sand
Massive; the particles adhering without any regular cleavage, as in many hardpans

Subsoil - Technically, the B horizon; roughly, the part of the solum beneath plow depth or the A horizon.

Substratum - The part of the soil below the solum.

Subsurface layer - Any surface soil horizon below the surface layer. Usually applied to situations where an A horizon underlies a thin O horizon. The A in this case would be referred to as the subsurface layer.

Surface layer - The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 4 to 10 inches (10 to 25 centimeters). It is frequently designated as the plow layer or the Ap horizon.

Swale – A shallow, open depression lacking a defined channel but can funnel overland and subsurface water flow.

Terminal moraine - A belt of thick glacial drift that generally marks the termination of important glacial advances.

Terrace - An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil - The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles are: sand, loamy sand, sandy loam, loam, silt, sandy clay loam, clay loam, sandy clay, silty clay and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying coarse, fine, or very fine.

Till plain - An extensive flat to undulating area underlain by glacial till.

Tilth, soil - The physical condition of the soil as related to tillage, seedbed preparation, seedling mergence, and root penetration.

Toe slope - The outermost inclined surface at the base of a hill, part of a foot slope.

Topsoil - The upper part of the soil which is the most favorable part for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace Elements - Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Upland (geology) - Land at a higher elevation in general than the alluvial plain or stream terrace; land above the lowlands along streams.

Upland (wetland delineations) - Non-wetland areas at higher elevations than the adjacent wetland.

Variegation - Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve - A sedimentary layer of a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Weathering - All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded (unsorted or poorly sorted) - Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. It contrasts with poorly graded soil.

Wilting point (or permanent wilting point) - The moisture content of soil, on an oven dry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Wind-throw – trees uprooted by excessive wind.