SOIL

DEFINITION

The collection of natural bodies on the earth's surface, in places modified or even made by man, of earthy materials, containing living matter and supporting or capable of supporting plants out-of-doors. The upper limit of soil is air or shallow water. The lower limit of soil is normally the point of contact with bedrock. A soils ability to support plants is considered the most important function of soil by the people of the world.

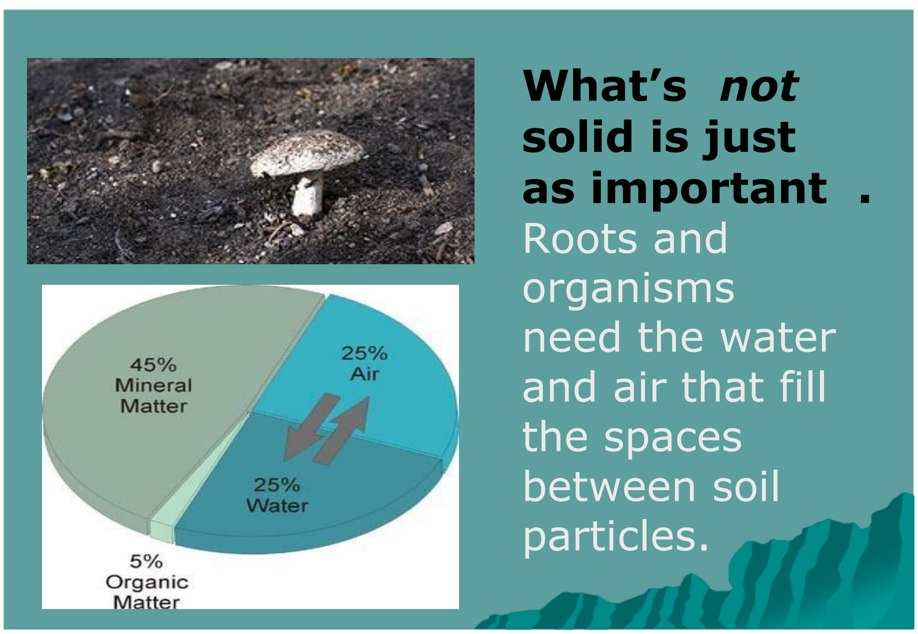
This definition focuses on soils ability to support plants because it is considered the most important function of soil by the people of the world.

SOIL COMPONENTS

The average surface mineral soil horizon (topsoil) contains more than just mineral material. Equally important for a soils ability to support plants are three other major components. The major soil components and their average percentages are:

1. **Mineral Material** (soil particles and small rock fragments less than 2mm dia.) - Approximately 45%
2. **Air** (air filled pores) - 20 to 30%
3. **Water** (water filled pores) - 20 to 30%
4. **Organic Matter** (includes living organisms) - 5%

It is important to understand that soil is not just a random assortment of mineral particles. A healthy soil is actually a dynamic material that is constantly undergoing change and which also contains millions of living organisms, air and water. If any of these components are lacking or out of balance it has a profound effect upon what, if any, plant life can grow on or in the soil.



SOIL AIR - Air in the soil is as important to plants as air in the atmosphere is to people. That is because plant roots and soil micro-organisms (microbes) need to breath. If a soil is compacted (compressed) so that no pore space exists, plants could not survive because the roots would not have room to grow and they would not have enough air to breathe. It would also be very hard for plant roots to penetrate the hard soil or for microbes to find a place to live or get air to breathe.

SOIL WATER - Water is essential for all living organisms, as we all know. Not only does soil water satisfy living organisms need for moisture but it serves several other functions. It is the primary means by which nutrients are removed from the soil and transported to plants. Soil water acts as a solvent, dissolving certain nutrients, making them available to be taken up by plants. It also is responsible for moving materials into and out of soil horizons, resulting in the development of distinct soil profiles. Without soil moisture, micro-organisms could not breakdown organic matter and return the nutrients for recycling. It is also one of the primary agents for weathering (breaking down) rocks into soil particles.

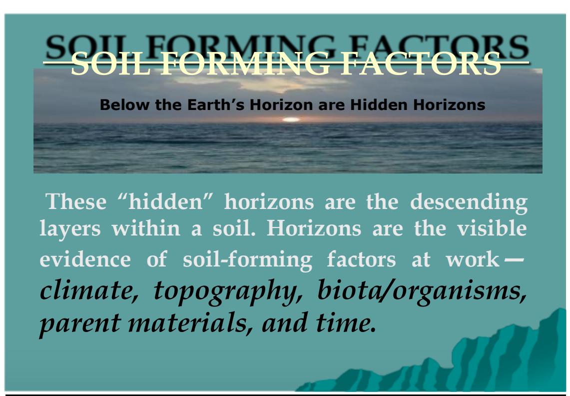
SOIL ORGANIC MATTER - Soil organic matter has strong influences on the physical and chemical properties of soil which are far out of proportion to the small quantities present in a soil. Soil organic matter acts like a "magnet" to hold the nutrients in the rooting zone so they are available to be used by plants. Clay particles also hold nutrients to a lesser extent than organic matter does. Organic matter acts as glue causing soil particles to clump together into structural units (soil structure). A property of a soil rich in organic matter is ample pore space between the structural units, which is very desirable in helping to aerate the soil. Soil organic matter acts like a sponge to hold water, even from the atmosphere, where it is stored for later use by plants. Soil organic matter is a primary source of food for soil micro-organisms.

Soil Organisms - There are two general categories of soil organisms, Macro or large and Micro or small organisms:

1. Macro-organisms - Macro-organisms include such things as ground hogs, moles, and earthworms. The most important macro-organism is the earthworm. Up to 15 tons of soil pass through earthworms bodies per acre each year. They beneficially aerate the soil by burrowing channels and mixing the soil.

2. Micro-organisms - Micro-organisms include both plants and animals, some of which are very small. Examples of micro-animals are Nematodes, small worm like creatures, and protozoa which are the most common soil micro-animal. They generally live on other soil organisms. Some examples of soil microplants are algae, yeasts, molds mushrooms and bacteria, the most numerous of the micro-plants. A single gram of soil can contain up to 3 Billion bacteria! Soil micro-organisms can:
Cause plant diseases / Eat plant roots (micro-animals) / Compete with plants for soil nutrients / Use up oxygen in a soil that has little oxygen (usually a wet soil) so it is not available for plants. / Cause some soil nutrients, such as sulfur or nitrogen to be changed in form so it will be lost as a gas. / Cause some soil nutrients such as iron or manganese to reach toxic levels. / Produce anti-bodies that kill other soil organisms / Some fungi form a relationship with plant roots (called a micorrhizae) which helps both the plant and fungi to survive. In a few instances, the relationship is so important that neither can survive without the other.

THE 5 FACTORS INFLUENCING SOIL FORMATION



***CLIMATE** – (primarily precipitation and temperature)*

Climate is perhaps the most influential of the four factors acting on parent material because it determines the nature and intensity of the weathering that occurs over large geographic areas. Temperature (freezing, thawing and high temperatures) and rainfall (erosion and leaching) are the main climatic factors that influence soil formation.

For every 10 degree C rise in temperature, the rates of biochemical reactions more than double. Temperature and moisture both influence the organic matter content of soil through their effects on the balance between plant growth and microbial decomposition. Climate also influences the natural vegetation. Humid climates favor the growth of trees. In contrast, grasses are the dominant native vegetation ion subhumid and semiarid regions, while shrubs and brush of various kinds dominate in arid areas. Thus, climate exerts its influence partly through a second soil-forming factor, the living organisms.

Surplus water percolating through the soil profile transports soluble and suspended materials from the upper to the lower layers and may also carry away soluble materials in the drainage waters. Likewise, a deficiency of water is a major factor in determining the characteristics of soils of dry regions. Soluble salts are not leached from these soils, and in some cases they build up to levels that curtail plant growth.

TOPOGRAPHY ***(slope, aspect, and landscape position)***

Topography relates to the configuration of the land surface and is described in terms of differences in elevation, slope, and landscape position...in other words, the lay of the land. Steep slopes generally encourage rapid soil loss by erosion and allow less rainfall to enter the soil before running off. In swales and depressions runoff tends to concentrate and in the lowest landscape positions, water may saturate the soil to such a degree that drainage and aeration is restricted. Wetland soils may develop in such low-lying topography. Soils commonly occur together in the landscape in sequence called a **"catena"** with each member of the catena occupying a characteristic topographic position. Soils in a catena generally exhibit properties that reflect the influence of topography on water movement and drainage. Soils on the top of a hill are generally much drier as compared to being at the bottom of a slope in a depression.

Slope aspect, or the direction a slope faces, affects the absorbance of solar energy in a given landscape. Soils with south-facing slopes are more perpendicular to the sun's rays and are generally warmer the thereby commonly lower in moisture then their north-facing counterparts. Consequently, soils on the south slopes tend to be lower in organic matter.

BIOTA: LIVING ORGANISMS

Organic matter accumulation, biochemical weathering, profile mixing, and nutrient cycling are all enhanced by the activities of organisms in the soil. Vegetative cover reduces natural soil erosion rates, thereby slowing the rate of mineral surface soil removal.

Natural vegetation influences organic matter accumulation. In grasslands, much of the organic matter added to the soil is from the deep fibrous grass root systems. By contrast, tree leaves and needles falling on the forest floor are the principal source of soil organic matter in the forest. As a result, the soils under grasslands generally develop a thicker A horizon with a deeper distribution of organic matter than in comparable soils under forests, which characteristically store most of their organic matter in the forest floor (O horizon) and a thin A horizon or E horizon. An E horizon is generally not found in a grass-land soil. Forest vegetation varies in the acidity of its leaf litter as coniferous needles are much more acidic than hardwood leaves. There is even a difference in the nutrients or chemicals found in various plants and the type of micro-organisms associated with them.

The role of animals in soil-formation processes must not be overlooked. Large animals can bring tunnels to the surface encouraging movement of water and air into the subsurface layers. They enhance mixing of the lower and upper horizons by creating, and later filling, underground tunnels. Earthworms and ants mix the soil as they burrow, significantly affecting soil formation. Earthworms ingest soil particles and organic residue, enhancing the availability of plant nutrients in the material that passes through their bodies. They aerate and stir the soil. In general, the mixing activities of animals are sometimes referred to as **"pedoturbation"**. Human activities also influence soil formation. The clearing of land and subsequent tillage of the soil for crop production has abruptly modified soil formation as well as irrigation and adding fertilizer and lime to soils of low fertility. In areas influenced by urbanization bulldozers have an effect not unlike ancient glaciers…they level and mix soil horizons and set the clock of soil formation back to zero.

TIME

When we speak of a “young” or “mature” soil, we are not so much referring to the age of the soils in years, as to the degree of weathering and profile development. Time interacts with the other factors of soil formation.

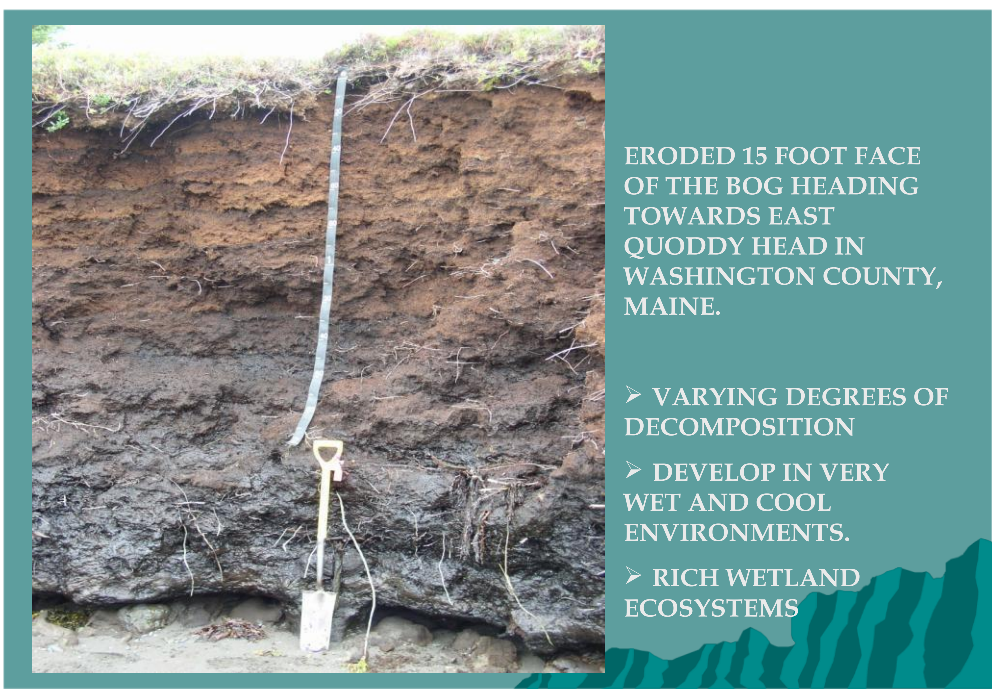
Soil takes a long time to develop. Estimates are that it takes about 100 years to develop one inch of top soil. Also, after soil material initially forms, the combination of topography, slope and living organisms act upon it to create a unique set of characteristics that distinguish the soil from other soils. The longer a soil has to develop, the deeper the soil is and the more well developed it is. In Maine, we have geologically young soils because it has only been 10,000 - 12,000 years since the last glacier receded. In tropical areas soils developed for millions of years.

PARENT MATERIALS

The mineral and organic matter from which a soil is developed over time and under the influence of climate, topography and vegetation is called the ***parent material***. In some places, such as the tropics, parent material is simply decomposed bedrock which has weathered in place. In Maine however, our parent materials are usually not weathered in place bedrock but soil material which has been transported by water or glaciers, from one location to another. Sometimes we can find more than one parent material in one location as a result of the advance and retreat of glaciers, glacial lakes forming and draining and the advance and retreat of the ocean. What follows is a discussion of the six general categories of soil parent material found in Maine.

ORGANIC

Some soils consist of mostly of organic matter, with little or no mineral components. These are soils that usually develop in wet conditions, such as swamps, bogs or marshes, but can also occur in cold areas like mountains or off the coast. Under drier upland conditions, leaves, twigs, or grasses decompose fairly rapidly when they fall on the soil surface. In areas where the soil is wet or cold, micro-organisms responsible for decomposing the organic matter are slowed so that the organic matter builds up. Over time the mineral soil is buried beneath a deep layer of organic matter and you have an organic soil. In soil science, after 16 inches or more of organic matter builds up on the mineral soil surface, the soil is considered to be an organic soil.

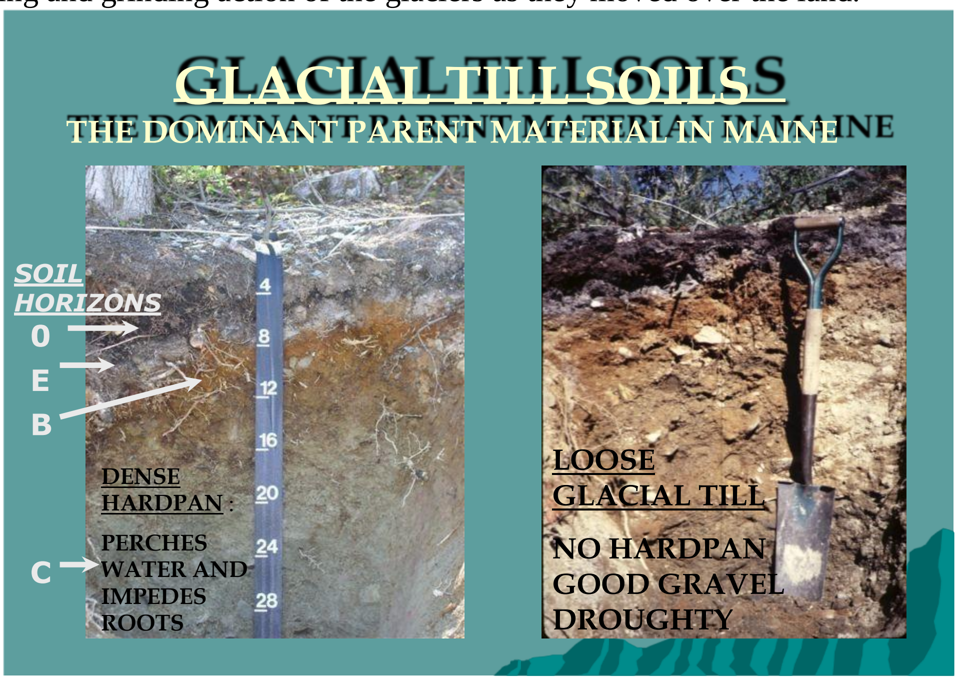


ORGANIC SOIL

MATERIALS

GLACIAL TILL

Our most common type of soil is called glacial till. It is soil material that was moved from one place to another directly by a glacier. It may have been pushed by the glacier like a bulldozer or dropped out underneath the glacier as it melts (all glaciers are made up of very dirty water which has a lot of soil material in it). Glacial till soil material deposited by a glacier is unsorted, meaning that it has a random mixture of sand, silt, clay and rocks. All of the other mineral soil parent materials have been water sorted, to some extent (meaning that they are generally deficient in at least one of the sand, silt, clay or rock components found in glacial till). There are two general categories of glacial till; ***lodgment till***, deposited beneath glaciers and ***ablation till***, pushed by glaciers. Because lodgement till material was deposited beneath glaciers it experienced extreme compaction and is therefore very dense below the top 1 to 2 feet of weathered topsoil. It has what we call a "**hardpan**" and can be very hard to dig a hole in. Ablation till on the other hand is loose and generally easier to dig because it did not have the enormous weight of a glacier on it. The rocks found in glacial till are generally angular and not rounded. This is because of the scraping and grinding action of the glaciers as they moved over the land.



OUTWASH or STRATIFIED DRIFT

This is the soil material that is found where sand and gravel pits are dug. It is the coarsest (large soil particles = sand) of our soil parent materials and generally lacks all but maybe a trace of silt or clay in most subsoil horizons. They often have a topsoil horizon which formed from fine soil particles that were probably wind blown over the gravel after the glacial stream dried up but before vegetation covered surrounding areas. These soils were deposited by **glacial melt water** streams and rivers and they are therefore water sorted. Rivers within the glacial ice formed **eskers** which are narrow sinuous landforms that are stratified sands and gravel. As the earth warmed, at the end of the last ice age, glaciers started to melt rapidly. The streams and rivers that formed by the melting glaciers carried the dirty melt water away from the glaciers. Heavy particles, such as sand and gravel, were able to drop out of the flowing water while lighter particles, such as silt and clay, were carried downstream. After many years, the sand and gravel would build up to form the soils that are now our gravel pits. If you look at the excavated side of a gravel pit you will usually see layers of sand and gravel (**stratification**). These layers formed due to variations in the speed of the melting water. In cooler times, the glacier melted more slowly so the stream or river flow was slower and therefore only smaller sand particles could be carried. At warmer times (middle of the summer), glaciers melted faster so the stream or river flowed faster and could therefore carry larger soil and gravel particles. Because of the constant water flow, the rocks collided with each other causing them to be rounded. After the glaciers completely melted, the streams and rivers dried up and soil was able to form which today supports tree and other plant growth.

LACUSTRINE SEDIMENTS

These soils are also known as **lake bottom sediments** because they formed at the bottom of a lake. During the time that glaciers were melting and forming all of those streams and rivers, glacial lakes were also forming. Lots of times the streams and rivers were blocked by other glaciers as they flowed away from their glacier of origin. When that happened, a glacial lake would form which would last until the glacier dam melted. These glacial lakes were fed by muddy streams and rivers which had already dropped most of their sand and gravel onto the stream bottom. Soil particles left in the water as it entered the lake was very fine sand, silt and clay, with no rocks. Water moves through a lake slowly, depending upon the lake size and amount of water entering the lake. As a result, soil particles which could not drop out of the fast moving stream or river could now drop out to the lake bottom. Generally, very fine sand and silt soil particles dropped out first with some clay also settling out, if the lake water was moving very slowly or was stagnant. You will often find layering of soil in these lake sediments for the same reason you do with the stratified drift; fluctuating speeds of water, flowing through the lake. When the glacier was melting rapidly and large volumes of water were entering the lake, water moved through the lake more quickly, only allowing the very fine sand to drop out. When the glacier was melting slowly, water entered and left the lake slowly, allowing the silt and some clay to drop out of suspension. After the ice dam melted, the soil would dry up and become vegetated.

MARINE SEDIMENTS

Our finest textured soils are called marine sediments because they formed beneath the ocean. You can see modern day marine sediments being formed by visiting the ocean where mud flats occur. They are made up of mostly clay with some silt and very little sand and very few rock fragments. Going back to the melting glaciers, remember how the sand and gravel dropped onto the stream or river bottom and the very fine sand and some of the silt dropped onto the lake bottom? All that was left in suspension, as the melt water left the lake, was clay and the finer silt particles. Clay and small silt particles are microscopic in size and can take up to six months to settle out of calm water. Since the ocean is the last place water can drain to, it must stay there until it is recycled by evaporating and being redeposited to the land as precipitation. Eventually, even the clay particles will drop out, forming mud flats. Marine sediments can be found a long way from the present location of the coast because the ocean was once much higher that it is today. In fact, it was once found up to 300 feet above its present location. That was primarily due to the tremendous weight of the glaciers pressing down the land, allowing the ocean to move inland. As the glaciers melted, the land rebounded, moving the ocean back to where it is today.

ALLUVIAL SOILS

Alluvial soils are formed from soil materials which were recently deposited by **moving water**. They are found in such areas as flood plains or beaches and vary in texture from sand to silt, depending on the speed of water from which they were deposited. Alluvial soils can be distinguished from other soils by the lack of traditional profile development (atypical sequence of soil horizons). This is because soil material is deposited so frequently that it does not have enough time for a traditional sequence of soil horizons to develop. Often layers with different soil textures or colors are found in the soil profile. Layering is due to varying speeds of water depositing the soil particles. Slow moving water will result in finer soil particles being deposited while faster water will only allow the larger soil particles to drop out of suspension. Varying colors are due to the source soil material or level of horizon development. If top soil eroded upstream, it will have a dark brown color when deposited. If it is subsoil which eroded, the deposit will have a much lighter color.

FOUR BASIC PROCESSES OF SOIL FORMATION

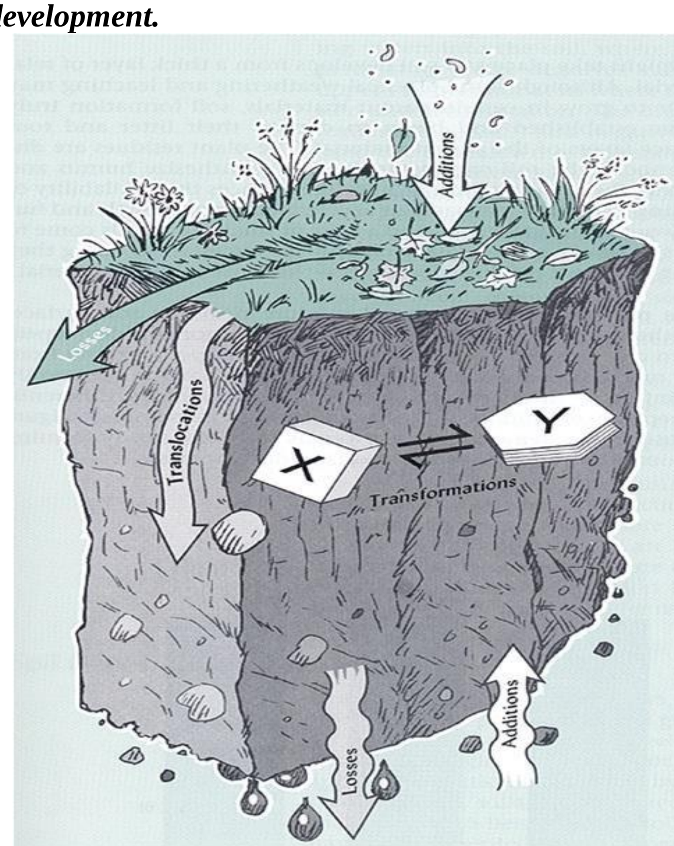
TRANSFORMATIONS: When soil parts are chemically or physically changed or destroyed and combining parts to make new products. Many transformations involve weathering.

TRANSLOCATIONS: The movement of inorganic and organic materials laterally or up and down within a soil horizon. Water is the most common translocation agent and can move down with gravity or rise up by capillary action.

ADDITIONS: Inputs of materials to the developing soil profile from outside sources. A common example is the input of organic matter from fallen plant leaves. Another addition is dust particles from a nearby source or across the ocean.

LOSSES: Materials are lost from the soil profile by **leaching** to groundwater, erosion of surface materials, or other forms of removal. **Evaporation** and plant use cause losses of water. Leaching and drainage cause the loss of water and other dissolved substances. **Erosion** is another major loss agent. Organic matter is also lost by **microbial decomposition**. Animals and people can also contribute additions, such as manure and fertilizers.

Here is a schematic illustration of additions, losses, translocations and transformations as the fundamental processes driving soil profile development.



THE SOIL PROFILE and the 6 PRIMARY SOIL HORIZONS

A soil profile is a vertical cross-section of the soil through all of its horizons and extending to the unweathered parent material. Simply put, it is all of the soil layers down to the soil material from which the soil developed. Soil horizons are layers of soil, approximately parallel to the soil surface that has distinct characteristics as a result of the soil forming process. **There are six primary soil horizons**:

O HORIZON

The "O" horizon is an organic matter accumulation from dead plants and animals. It is sometimes referred to as "litter", "duff" or "humus". Organic soil horizons are found above the mineral soil, unless some form of soil disturbance has occurred. They are commonly found in forested areas, thin “O” horizons may occur in grasslands, however they are absent in plowed fields. “O” horizons tend to range from dark brown to black in color.

A HORIZON

The "A" horizon is a mineral soil horizon which may appear similar to the “O” horizon as it is dark brown to black in color. It is usually found at the soil surface or just beneath of the "O" horizon. In traditionally forested (Northern) areas of Maine, the "A" horizon may be absent, except for those soils which are wet much of the year. In cultivated fields or grasslands in Maine, there is generally an "A" horizon which is called an "Ap" horizon. An "Ap" horizon indicates that there is an "A" horizon which has been plowed. These horizons are typically 8 - 12 inches deep, the depth of the average plow. "Ap" horizons do not only include what used to be the "O" and "A" horizons but can also include other horizons which are mixed in by the plowing process (portions of the E and B horizons). In extreme cases where a lot of erosion has taken place, the "Ap" horizon may extend down into the parent material, eliminating all of the other horizons.

E HORIZON

The "E" horizon is a soil horizon which has undergone **intense leaching**. It is generally only found in traditionally forested areas, particularly softwood forested areas. This is because of the leaching process. In forests, there is an organic layer (“O" horizon) which rests upon the mineral soil below. When it rains or the snow melts, water infiltrates through the organic matter to the mineral soil. As the water passes through the organic matter, it becomes acidified and acts as a bleaching agent to the soil horizon directly below it. This is the "E" horizon. It typically appears white or gray due to the bleaching action and varies in thickness but is usually only an inch or two thick. In wet sandy soils however, where there is a thick "O" horizon, the "E" horizon can be as much as 1 1/2 feet thick. It is not generally found in field or plowed areas because of the mixing action of the plowing. It is also not often found in wet soils, except for sands which can still leach even when wet.

B HORIZON

The "B" horizon is found below the "O", "A" or "E" horizons but above the unweathered parent material. In Maine, it is often seen as the horizon where the leached material from above was deposited. It will often appear as a yellowish, reddish or even black color (depending on whether the leached material was mostly iron or organic matter). In wetter soils, where the iron has been leached out of the soil, colors of the "B" horizon are not as bright. An exception is the wet sandy soils where much organic matter may leach into the "B" horizon from above, beside and even beneath it, giving it a black or very dark red color. In most wet non-sandy soils the "B" horizon won't show signs of accumulating iron or organic matter but do show signs of weathering such as having soil structure, root penetration, worm channels etc. The same is true for our drier, finer textured soils (clays and silts). They are too fine for much leaching but do show signs of weathering.

C HORIZON

This is the horizon which is used to indicate the **unweathered parent material**, though it may be a different parent material from the one which the soil above developed. This is because it is possible to have more than one parent material deposited in one location. The important thing to remember about the "C" horizon is that it has not undergone the soil forming and weathering process, as the soil above has. Basically, it still resembles the soil material as it was originally deposited.

R HORIZON

The "R" horizon is used to indicate **bedrock**. It may or may not be the bedrock from which the soil above developed. In Maine, it is often not the bedrock from which the soil immediately above developed. This is because most of our soil material was moved around by glaciers or water from melting glaciers.

SOIL PROPERTIES

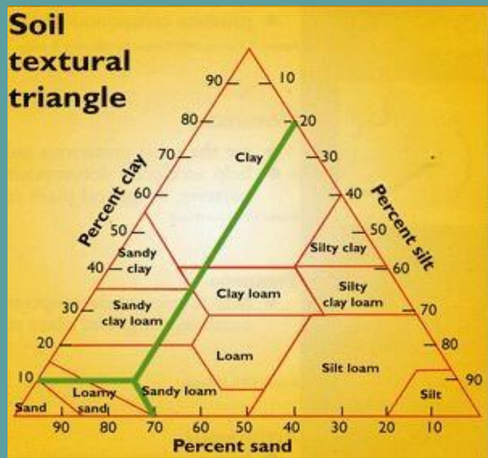
There are **five primary soil properties** which are important to understand and which greatly influence how a soil may be used for many purposes:

SOIL TEXTURE

The mineral component of soil is made up of various combinations of three soil separates:
SAND - the largest of the particles and is from 0.05mm - 2.0mm in diameter.
SILT - is intermediate in size and is from 0.002mm - 0.05mm in diameter.
CLAY - is the smallest of the soil separates or particles and is less than 0.002mm in diameter.

Any particle over 2 millimeters in diameter is considered a **rock fragment**. Soil texture is determined by the amount of any one or all of the soil separates present in a soil. Soil scientists use what is called a **textural triangle** to make such determinations. Though a lab is needed to do precise textural determinations, most practicing professionals rub a small soil sample between the thumb and fore finger to make determinations in the field. **Coarse soils** tend to be sandier and **fine soils** tend to be more clayey and silty.

SOIL TEXTURE



The Fine Earth Fraction is <2mm in size.

Texture Matters

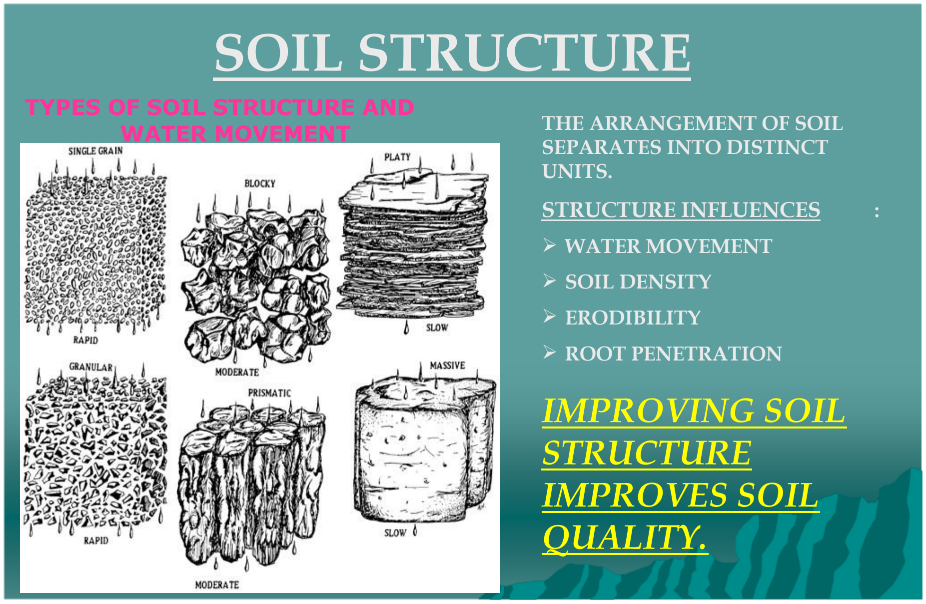
A soil's texture reflects the proportion of three kinds of mineral particles. In decreasing size, the particles are SAND, SILT, and CLAY.

Texture influences a soil's capacity to hold water and nutrients.

SOIL STRUCTURE

Soil structure refers to the combining of soil separates (particles) into **units or groups**. This process is quite important in a soil as it has a direct impact on the amount and type of pores in a soil. It is better to have many small units than to have a few large ones because it results in many more pores between the units.

Soil structural units are referred to by the shape they take. The four main soil structural units are: ***PLATY***, where soil particles form into thin horizontal plate like structures; ***PRISMATIC*** where the soil structural units form into prism like shapes; ***BLOCKY*** where soil structural units form into angular or sub angular block-like shapes and ***GRANULAR***, where soil structural units form that are rounded. Generally, granular structure is the most desirable for plant growth and drainage as it represents many small units commonly found in rich topsoil (organic matter encourages granular structure formation). Blocky structural units are larger than granular units and are typically found in soils with insufficient organic matter. Both prismatic and platy structural units are usually found in the substratum, which has not weathered greatly and are indicative of a hardpan or restrictive layer. They can also be very large in size, resulting in few pores for air or water movement. Soil profiles usually have a combination of structural units, sometimes in the same soil horizon. It is also possible to have a soil with no structure, such as sand which is single grain and some wet clays which are called massive (one large mass of soil with no smaller structural units).



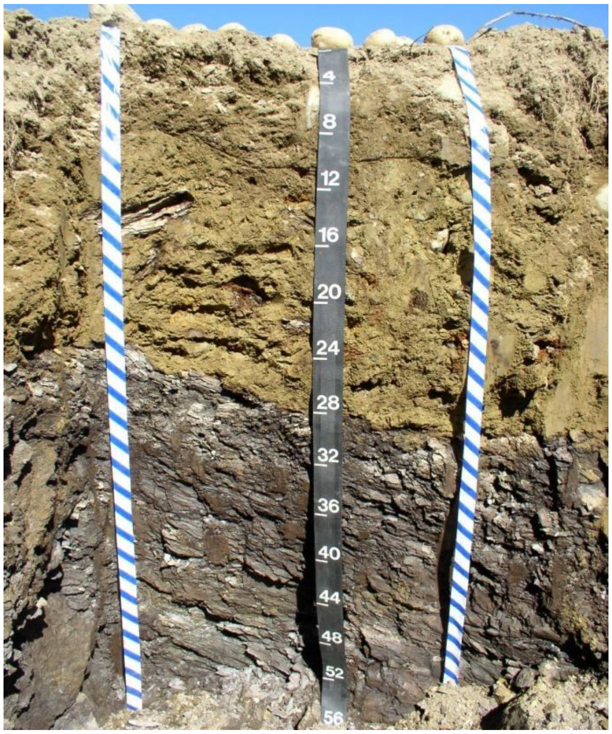
SOIL CONSISTENCE

This term refers to the **firmness of a soil**. If you dig a hole in the ground and use a soil probe to remove a sample of soil from the profile, resistance is generally referred to by how much pressure must be exerted to crush the soil sample. It can also refer to resistance "in place" which means how much pressure must be exerted to penetrate the side wall of a soil pit with a soil probe (usually a knife or screwdriver). The most commonly used soil consistence terms are; **loose**, **friable** (very little resistance to penetration or crushing), **firm** and **very firm**. Sands and gravels are usually loose; topsoil is usually friable and hardpans or clay pans are usually firm or very firm. Soils tend to increase in firmness deeper in the profile

SOIL DEPTH

The depth of soil above **bedrock** is very important, especially if you want to dig a deep hole for any reason (excavate a building foundation for example). A shallow soil is one that is less than 20 inches deep, a moderately deep soil is 20 to 40 inches deep, a deep soil is 40 to 60 inches deep and a very deep soil is one that is over 60 inches deep.

This picture shows a soil profile with the bedrock depth at about 28 inches. This soil is moderately deep.



SOIL DRAINAGE CLASS

This term refers to how far below the soil surface it is to the seasonal high water table and how fast the soil drains when it rains or snow melts. Sandy soils, with a deep water table are considered well drained (they may be droughty to plant growth). Clay soils occurring in a low lying area are often considered poorly drained because they are wet much of the time.

The term water table is use to describe either the "**apparent**" or "**perched water table**". An apparent water table is one that is permanent though it might fluctuate up or down some in the soil. A perched water table however, is the more common type found in Maine soils. It is present only during the wetter times of year (spring or fall) and usually is gone during the summer months. It forms by water infiltrating the soil, after a rainfall or snow melt, and then "perching" above a hardpan which it cannot penetrate. Soil scientists can tell if a perched water table is present in a soil at some time, even if it is dry at the time of examination by observing the soil color.

Soils which are almost always dry usually have bright colors, such as yellows or reds or browns. Soils which are almost always wet are usually dull in color, such as gray, green or blue. Soils which have a perched water table usually have a combination of colors, sometimes referred to as mottling but most commonly referred to by soil scientists as **"redoximorphic features"**. They can be grayish with reddish spots or brown with gray spots. Generally, the grayer the soil is the longer it is wet.

We can only tell if a soil has a water table during certain times of year, however. This is because of complex biological and chemical processes that occur in the soil. If the soil has a water table, when the soil temperature is above 41 degrees F, micro-organisms are active and will be breaking down organic matter in the soil. These organisms need oxygen to breath, just like we do, which they can get from soil air and even from soil water. After about 3 weeks of soil saturation and if the soil water is stagnant (not flowing out of the soil profile), the micro-organisms use up all of the air in the soil water. When this happens, other soil micro-organisms start breaking down the organic matter, ones that don't need free air. They are called **anaerobic micro-organisms** and they get their oxygen by oxidizing minerals in the soil (such as iron or manganese). The unreduced iron or manganese in soil is usually strongly attached to soil particles and does not move when water moves through the soil. When the oxygen is removed or reduction occurs, they can move very easily in the soil solution/soil water. In a soil where there is a temporary (seasonally high) water table, for a short duration, there will be a few gray spots in the general reddish, yellowish or brownish soil colors where small amounts of iron or manganese lost their oxygen and nearby, a few brighter red or yellow spots where the iron or manganese moved to before the water table dropped enough for air to once again oxidize the iron or manganese. In soils which have a water table present for a longer time, there will be more gray colors with some red or yellow spots. In those soils, the iron or manganese may have leached completely out of the soil profile. It is important to understand however, that this process won't occur if the soil temperature falls to below 41 degrees F, considered **biologic zero**. Therefore, a water table which is present from November to April will not alter soil colors and will therefore not leave any indicator of its presence behind.

*These pictures show **redoximorphic concentrations**, the orange rusty area around the root channels and **redoximorphic depletions** the light gray areas immediately adjacent to the root channel and the general gray soil matrix color surrounding the features. (In the past these features were referred to as mottles)*

SOIL pH

Soil pH is the degree of acidity or alkalinity of a soil, measured on a scale of 1 - 14 where 7 is neutral, **less than 7 is acidic** and **greater than 7 is basic or alkaline**. In general, soils which receive more rainfall than evaporates or transpires (soils which experience leaching) are acidic. Soils where evapo-transpiration exceeds precipitation are generally alkaline. Because we have about 40 inches of precipitation each year in Maine and only about 20 inches of evapo-transpiration, our soils are usually acidic, unless they have been limed or developed from calcareous parent material. This is particularly true of our soils which form under softwood trees because rain water moving through the layer of needles on the forest floor becomes acidic and is more effective at leaching. Soils which are strongly acid or alkaline can be toxic to plants and soil micro-organisms. Therefore, soils should be managed so that they are nearly neutral in pH for optimum plant growth.

CATION EXCHANGE CAPACITY

Very small soil particles, organic matter and clay particles, generally have **negative charges** on their edges and flat surfaces. They act like magnets to attract positively charged ions in the soil solution such as calcium, sodium, ammonium and potassium. This is one of the most important soil properties in that it affects soil fertility for plant growth and a soils ability to treat contaminated water moving through it. It also relates to soil pH. Soils which do not have a lot of positively charged ions attached to them are acidic and soils with high amounts of those positively charged ion are alkaline. Acidic soils very strongly hold onto positively charged ions so that they are not available to plants as nutrients. Soils which are neutral in pH have enough positively charged ions to supply plants for growth but not so many that they can be toxic to the plants. Ideally, soils will have a good mixture of positively charged ions and not be overloaded with one particular type.

A soils ability to hold onto positively charged ions is referred to as **Cation Exchange Capacity**. It is directly related to soil texture and organic matter content. This is because very small particles such as silt, clay and decomposed organic matter (humus) have a much greater surface area with negative charges than larger particles such as sand. For example, the surface area of one gram of clay is at least 1000 times that of coarse sand. Soil organic matter has the greatest cation exchange capacity of any soil particle, often being many times that of clay or silt.

SOIL EROSION AND SEDIMENT CONTROL

Soil erosion is the detachment of soil particles and loss from an area by the action of water, ice, gravity or wind. In New England, water-generated erosion is the most significant cause. Erosion is a natural process that has been occurring since the earth was formed. Most of the time, natural erosion is a slow and steady process, with the exception of unusual weather events such as floods, hurricanes and similar storms or other natural disaster events such as volcano eruptions, earth quakes and tidal waves. When the erosion process is sped up, it is called **accelerated erosion**. By far, the most common cause for accelerated erosion is activity by man. When people strip the land of its vegetation, the bare soil is exposed to rainfall and runoff with nothing to protect the soil particles from being washed away. When people change a forest to paved roads, driveways, lawns, parking lots and other impervious surfaces, rainfall can no longer infiltrate into the ground so it runs off to other areas. When this increased runoff water flows across areas that are not impervious, particularly bare soil areas, erosion is greatly increased.

One of the by-products of erosion is **sedimentation**. Sedimentation is the settling out of soil particles carried by runoff water. That happens when the speed of the runoff water slows down enough for the soil particles to drop out of suspension. If the sediment drops in a place designated for that to happen such as behind a sediment barrier of silt fence or staked hay bales, there isn't much of a problem. If however, the sediment carries over to another person's land or into a water body, sedimentation becomes a big problem. Another problem with erosion, particularly for farmers, is the **loss of topsoil** from crop fields. **Topsoil** is the most productive soil layer in a farmers' fields so if it is lost, the field becomes less productive.

HARMFUL EFFECTS OF ACCELERATED EROSION

LOSS OF TOPSOIL – Not only can this affect a farmers productivity in his/her fields, it can also make it harder to grow a lawn or any other vegetation you may want to help stabilize the soil from further erosion.

STREAM BANKS – If soil erodes from stream banks, the stream channel can change causing a loss of property for landowners and even threatening homes, driveways and other buildings.

ROADWAYS – If soil erodes from the edge of roads, the roads can become unstable and may collapse or washout. Culverts and bridge abutments may washout and guard rails may become unstable. These can cause serious harm or even death to people driving on roads as they become unstable.

STREAM CHANNELS – Sediment in stream channels can cover the stream bottom. Over time, if enough sediment deposits in the stream channel, it can cause the stream to overflow its banks or cut a new channel. Sediment on stream bottoms can also smother organisms and destroy fish spawning beds. The sediment particles in the stream water can block sunlight from reaching the stream bottom and it can act as an abrasive on fish gills and scales.

PONDS – Sediment can smother plants and organisms on the lake or pond bottom. Sediment also carries contaminants such as phosphorous into lakes. Phosphorous readily attaches to soil particles as water infiltrates into soil. When the soil particles erode and wash into lakes, the phosphorous becomes available to algae. In most Maine lakes and ponds, phosphorous is the limiting nutrient for an algae bloom. That means that all of the other nutrients necessary for an algae bloom in a lake or pond are normally available with the exception of phosphorous. If enough soil, with attached phosphorous, washes into a pond or lake for uncontrolled algae growth, a bloom will occur, seriously degrading water quality. Not only will the lake or pond become green and smelly, but the deeper parts will become devoid of oxygen in the summer months. Cold water fish normally have to spend the summer months in the deep holes of a pond or lake to survive warm temperatures. If there is no oxygen in those deep holes, the cold water fish cannot survive so there will no longer be a cold water fishery.

COST – Erosion can also be costly to deal with when soil particles wash into road ditches clogging capacity, plugging culverts and causing road washout and/or flooding. Maintenance costs go up with erosion and the resulting sedimentation into ditches and storm sewers but failing to do proper maintenance can be even more costly.

THE EROSION PROCESS

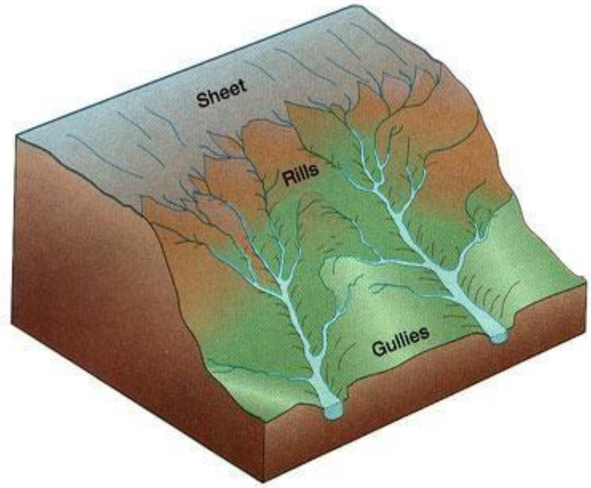
Most soil is protected from erosion naturally by being covered with **vegetation**. The vegetation intercepts rain drops so the drops hit the ground slowly and without much force. Then the plant roots hold the soil particles in place so any water that runs over the surface can't erode the soil. The plants themselves also provide resistance to overland flow of water, slowing it down. If however, the vegetation is removed so bare soil is exposed to the elements, the process of erosion will soon occur unless erosion control measures are taken.

Following are the sequential steps that normally occur during the erosion process:

RAIN DROP EROSION – This occurs when rain drops fall from the sky and hit the bare soil surface with great force. The force of the rain drops dislodges soil particles and splashes them up into the air. The loosened up soil particles can then easily be picked up by runoff water and carried off site.

SHEET EROSION – Sheet erosion occurs when soil particles are moved by a thin sheet of runoff water over a broad area. It is more or less uniform.

RILL AND GULLEY EROSION – In most instances, an area of bare soil is not perfectly smooth across the entire area. Run off which may start as sheet flow soon concentrates in small grooves which are called rills. Rills are small, shallow channels that are typically widespread over the bare soil area. If the runoff is not stopped or if the rills are not repaired, some of them will become gullies which are deep channels. Once gullies form, run off tends to concentrate in them causing even more serious erosion problems.



STREAM EROSION – If run off concentrates into gullies which are not repaired, frequently it eventually reaches a stream channel. If that happens, the large volume of concentrated flow may overwhelm the stream causing erosion of the stream banks and channel. This is particularly a problem for small streams. It is a major cause for loss of property and can even impact public safety.

Other factors affecting the erosion potential of a soil are:

SOIL INFILTRATION CAPACITY AND SOIL PERMEABILITY – These factors are related to the soil texture and structure.

- **Texture** - More rainfall infiltrates into a sandy or gravelly soil than a silty or clayey soil. Therefore, there is less runoff from a site with sandy or gravelly soil than one high in silt and clay content.
- **Structure** – If a soil is not sandy or gravelly, the ability for rainfall to infiltrate into it is very closely related to its structure. If soil particles have a granular structure, there are many void spaces into which rainfall can infiltrate. This is because granules are usually small and there are a lot of them. If the structure is blocky, the structural units are larger and therefore there are fewer void spaces so infiltration is reduced. If the structure is platy or prismatic, the units are very large and therefore there are only a few void spaces for rainfall to infiltrate. These soils are usually called restrictive and are relatively impermeable. Therefore, they have the more runoff than soils with granular of blocky structure.

SOIL TEXTURE – The most easily eroded and soil particles and those most easily carried away in runoff water are very fine sand and silt. Larger sand particles are heavy and therefore can't be as easily carried by runoff water. Clay particles stick together so they do not become easily dislodged by rain drops.
TOPOGRAPHY – erosion is more prevalent on sloping sites than flat sites. The steeper the site, the faster the water moves and the more erosive it becomes.
WATERSHED SIZE – Sites with large contributing watersheds have more erosion potential than sites with small watersheds. The volume and velocity of the runoff water are major factors in determining how much erosion occurs on a site.

CONTROLLING EROSION ON DEVELOPMENT SITES

1. **Step one** - in controlling erosion on a site that construction will occur on is **proper planning**. You begin with trying to fit the development to the site. That means you make every effort to clear land for construction in areas that have the least potential for erosion problems. Pick the site with the best soils, with the smallest watershed, the gentlest slopes.

2. **Step two** is **to minimize the up slope watershed runoff area**. You do not want to have clean runoff water from a field or forested area upslope of your construction site washing across the area you will be disturbing. This can be done by installing runoff diversions such as slight ditches or angled barriers such as silt fence.

3. **Step 3** - you **install the proper temporary erosion and sediment control measures** down slope of the area you intend to disturb so that any eroded soil particles are captured before moving off site. The device used must be able to handle the expected amount of runoff and sediment load. These can include silt fence, staked hay bales, erosion control mulch or a host of manufactured devises such as silt sock for small watershed areas where sheet flow is expected. For larger watershed areas and those where concentrated flow is expected, detention basins or similar measures may be needed.

Step 4 4. is to **only disturb as small an area at one time as necessary** to construct the project.

Step 5 5. – **maintain the temporary erosion control devices** after each storm event. Repair them if necessary and clean any accumulated sediment form in back of them so they have full capacity for the next storm.

6. **Step 6** – after construction is completed in the area where soil has been disturbed, **permanent erosion control measures** need to be installed. These can include loam and seed, erosion control mulch, pavement, gravel for a driveway or parking lot or any similar material that will not easily erode.

7. **Step 7** – **maintenance** is required for many permanent erosion control measures. Make sure the grass is growing uniformly over the site or that the erosion control mulch or gravel does not have any channels washed into it.

SOIL SURVEY INFORMATION

The Natural Resources Conservation Service's (NRCS) Soil Survey Program has developed soil survey information for most of the United States of America. Traditionally soil surveys were developed on a countywide basis with a published soil survey manuscript and soil maps available at the NRCS county field office. Today soil survey information is available to the public in many forms. The most common and most popular is the Web Soil Survey internet website. **Web Soil Survey** can be found at http://websoilsurvey.nrcs.usda.gov/app/. Using Web Soil Survey a person can create a soil survey report for an area that they have an interest in. An area of interest can be highlighted on a map from the website or using a street address. To learn more about the soils surrounding your school try typing the schools address into Web Soil Survey.

NRCS soil survey information can affect land use planning in a survey area. It contains **predictions of soil behavior** for selected land uses. Soil survey information also highlights **soil limitations**, improvements needed to overcome the limitations, and the impact of selected land uses on the environment. Soil survey information is designed for many different users. Farmers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Soil survey information also addresses operability considerations. Planners, community officials, engineers, developers, builders, and home buyers can use soil survey information to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use soil survey information to help them understand, protect, and enhance the environment. Statements made in soil survey reports are intended to help the land users identify and reduce the effects of soil limitations that affect various land uses. Great differences in soil properties can occur within short distances. There are over 100 different kinds of soils, called **soil series**, recognized in Maine. Soil series differ by the influences of the five soil forming factors. Some soil series are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations. These and many other soil properties that affect land use are described within soil survey information. The location of each soil series is shown on the **detailed soil maps**. The properties for each soil series in a survey area of interest are described. Information on several specific uses is available for each soil series.

Soil maps are delineated into polygons called **map units**. Map units may contain one or more soil series depending upon the scale (level of intensity) of the soil mapping. Information about each map unit can be found in written descriptions and interpretation specific tables. For developed areas, soil map units are delineated into polygons at least 3 to 6 acres in size. For undeveloped areas, such as large tracts of woodland, soil map are often a minimum of 16 acres in size. Occasionally a higher degree of detail is required for decision making purposes. In these cases a professional soil scientist would be hired to conduct a **high intensity soil survey** which would show finer differences within the landscape. An example of this would be in a subdivision development. A high intensity soil survey is time consuming and costly to develop. High intensity soil survey maps can show differences in soil types for areas as small as 1/8 acre.

SOIL JUDGING

Soil judging is an important part of the Envirothon soils exam. Soil judging involves identifying some of the soil properties listed above in a soil pit at the soils station. On the soils judging scorecard you will need to identify the presence or absence of the soils horizons, determine color, texture, structure, depth to bedrock, slope of the land, surface stoniness, drainage class, and parent material.

Updated February 2011

SOIL PROFILE CHARACTERISTICS

	O Horizon	A Horizon	E Horizon	B Horizon	C Horizon	R Horizon
PRESENT	____	____	____	____	____	____
ABSENT	____	____	____	____	____	____

SOIL COLOR

BLACK	____	____	____	____
GRAYISH	____	____	____	____
OLIVE / OLIVE BROWN	____	____	____	____
DARK BROWN	____	____	____	____
YELLOWISH / REDDISH BROWN	____	____	____	____

SOIL TEXTURE

SANDY	____	____	____	____
LOAMY	____	____	____	____
CLAYEY	____	____	____	____

SOIL STRUCTURE

GRANULAR	____	____	____	____
BLOCKY	____	____	____	____
PLATY	____	____	____	____
NO STRUCTURE	____	____	____	____

JUDGING SCORECARD

SOIL DEPTH TO BEDROCK

SHALLOW _______________ (less than 20 in.)

MODERATELY DEEP _______________ (20 to 40 in.)

DEEP _______________ (> 40 in.)

SLOPE OF THE LAND

LEVEL ________ (0-3 %)

GENTLY SOPING ________ (3-8 %)

STRONGLY SLOPING ________ (8-15 %)

STEEPLY SLOPING _______ (> 15 %)

SURFACE STONINESS

SLIGHT / NONE ___________________ (Doesn’t interfere with farming)

MODERATE _______________________ (Interferes with farming, clearing feasible)

SEVERE ______________________ (Too stony to farm or clear economically)

SOIL DRAINAGE CLASS

WELL DRAINED ____________ (Generally bright colors, may be olive in the lower part)

MODERATELY WELL DRAINED___________ (Bright surface colors with some grays and / or mottles in the lower part)

POORLY DRAINED _____________ (Generally dull gray or black throughout the profile)

SOIL PARENT MATERIAL

GLACIAL TILL	__________	(unsorted glacial deposits)
SEDIMENTS	__________	(lake or ocean deposits)
OUTWASH	__________	(melting glacial stream deposits)
ORGANIC	__________	(peat)
ALLUVIAL	__________	(floodplains, dunes, beaches)