2015-2016 Rural and Urban Soils CDE Resource Manual

I. History of Ohio Geologic Activities

The Ohio landscape was formed by a series of geologic activities. These activities have contributed to the present day lay of the land. By understanding the Geologic History of Ohio we can begin to understand how soils formed.

Igneous Rock Formation

The oldest record of the Ohio geologic history is deep beneath the surface of the ground. The oldest Ohio geologic materials are the igneous rock formed from molten magma or lava. The only reason that geologist know about the basement rock, often used to describe igneous rock, is from deep drilling. Basalt and Granite are common examples of the basement rock.

Sedimentary Rock Formations

The second period of the Ohio geologic history is the deposits of sediments which eventually formed our present day bedrock. The bedrocks in the Ohio landscape are from Sedimentary Rock. To understand Sedimentary rock formation you must understand the activities that occurred to form sediments.

Approximately 600 million years ago, Ohio was part of a coastal plain similar to the present day Gulf Coast. In other words, the landscape was under ocean waters.

All river systems eventually drain to the oceans. The rivers deliver not only water but a vast supply of sediments that were washed off the surfaces of the land. Many of the sediments washed off the surface of the land where particles from igneous or metamorphic rocks. As the sediments hit the oceans, they settled out to the ocean floors. Depending on the properties of the sediment and the activity of the ocean determined where the particles settled and where they concentrated. For example, coarse materials such as sand will settle out more quickly while fine materials such as clay will settle out slowly and at a different location. As more sediments were delivered to the ocean floor, they form rocks in two ways. One way is the overlying layers build up and compress the lower particles forming rocks. The second way involved chemical crystallization of dissolved materials. Dissolve materials that were washed into the ocean waters turn into crystals when the water was evaporated. These crystals settled to the ocean floors and form rock. Overtime, the ocean waters retreated to the present day boundaries and the bedrock exposed in Ohio was limestone, sandstone, coal, shale, and siltstones. There are numerous types of sedimentary rock but these are the most abundant in Ohio.

Sandstone was formed where sand was laid down and covered. Shale was formed from fine particles such as clay compressed together. This rock was formed in the deeper parts of the ocean where the water was still enough for clay particles to settle out. Siltstone was from silt particles. Limestone was formed from deposits of dead sea animals and calcium carbonate crystallization. The carbonates consumed by the sea animals to form shells and other skeletal features where converted to limestone after the animals died off and settled to the ocean floors. Present day coral reefs are currently making limestone bedrocks. Coal, which is a valuable sedimentary rock, was formed from plants and trees that were buried quickly.

At one time the entire landscape surface was a form of sedimentary bedrock and the exposure of the bedrock to natural forces began to weather the material, carve valleys, and eventually form soils. In essence, the entire Ohio landscape looked similar to southeast Ohio or parts of West Virginia with the deep valleys, steep slopes and the high knobs.

Metamorphic Rock Formation

Metamorphic rock is igneous and sedimentary rock that is converted to another more stable form. Examples of Ohio metamorphic rock is slate. Shale was converted to slate under extreme pressure.

Glaciations on the Ohio Landscape

The product of the Ice Age brought on the continental ice sheets or what is also known as the glaciers. The first glacier began about 1 million years ago starting near the Artic. As the snow accumulated the weight of the massive snow fall began to move the ice from under its own weight. A way to picture this activity is imagine jello on a table. If you were to take the flat end of a tray and push down on the jello the jello will squeeze out from under it and move in all direction on the table. This is how glaciers move. The weight squeezes the ice out from under itself.

The once hilly topography began to take on a new form as the glaciers moved across the Ohio landscape. The ice sheets filled in the valleys and bulldozed the hilltops as they slowly moved across Ohio. They ground up limestone bedrock in the eastern part of the state creating a mixture of fertile material conducive for plant development.

The ice sheets blocked and changed the river systems. At one time, a large river system flowed north through the center of Ohio and eventually connected with the Mississippi River. Evidence of this river, called the Teays River System can still be found. However, the south bound glaciation blocked the ancient river forming lakes and changing the direction of the water flow. The results of the glaciers created the present day Ohio River.

The massive weight of the ice carved and compressed the area of what are today the Great Lakes. The glaciers were responsible in creating the once swampy area in northwest Ohio once known as the Great Black Swamp. The ground was carved out and compressed to form a very flat low lying area that prevented water from escaping. As a result, as huge swamp was created.

The melting of the glaciers had a huge impact on many landscape features. After the glaciers melted, the volume and force of the water was so tremendous that new valleys where carved and very coarse material was laid down. The width of the valley along the Scioto River was created by the meltwater from glaciers. Cities such as Newark and Dayton were built on the outwash material formed by the melted glacier. The melt water also, contributed to the abundant and plentiful aquifer systems found all across Ohio.

The ice sheets deposited a mixture of particle sizes leaving behind the till plain known today across two thirds of the State, influenced by glaciation. The edge of the glaciers can be viewed by the geologic map marking the boundary where the ice sheets shaped the landscape.

The final glacier receded about 15,000 years ago and little geologic activity has occurred since then. Shortly after the glaciers receded, the weathering processes and organisms begin to develop on the rich materials left by the glacier activities. In time soil began to develop and organisms flourished across the landscape.

When settlers began to discover the Ohio landscape they realized they had come across a paradise. They saw a paradise with moderate temperatures, plenty of resources, and great soils. These available resources were made possible by the unique geological activities making the Ohio landscape one of the most favorable places for settlement.

II. Five Soil Forming Factors

Soil is an offspring of many earth materials that went through a developmental process. These earth materials were transformed into a new species by water, temperature, and living organisms and are still going through an alteration process. The rate of transformation was and is dependant on the type of material, the intensity of climate, the type of organisms, the shape of the land, and the amount of time that has passed. Some earth materials are unstable at when exposed to the surface and break down rather quickly while others are more resistant to change. The climate, which is precipitation and temperature of a given area, drive the major chemical and physical alterations of the materials. Some areas receive large quantities of rain with high temperatures while other areas experience very little rain and mild temperatures. The shape of the land or the relief of the land influences the distribution of climatic factors by concentrating water in some areas while other areas collect very little water. However, living organisms must work, eat, use, and live in the earth materials before it can be considered soil. All of the activities for soil to develop take time and the amount of time given to the transformation processes influence the soil. In summary the five soil forming factors are Parent Material, Climate, Relief, Organisms, and Time.

Parent Materials

To understand soils you first must understand where they came from. Just like you and I are offspring of our parents soil is an offspring of parent material. One must also understand that the parent material experienced a chemical and physical alteration called weathering. Weathering is the process of breaking down materials in place so that soil can form. Soils are nothing more than earth materials that have been transformed into a medium for sustaining life with different types of parent material yielding different types of soils. The following are a description of the parent materials found in the Ohio landscape.

<u>Residuum</u>

A very abundant earth material is bedrock. After the formation of bedrock the weathering process took over. The natural conditions of the atmosphere broke the large massive rocks into smaller and smaller pieces until the material was small enough for organisms to establish residence and develop soil. We call weathered bedrock Residuum and is the predominant parent material in Southeast Ohio. Some bedrock types are more prone to weathering than others which explain the relatively dynamic hills and valleys associated with the unglaciated Southeast Ohio landscape.

How do we recognize Residuum? One of the biggest predictors of soil developed from Residuum is the lay of the landscape. Areas with very contrasting slopes and large differences in elevation from one location to another are clues of residuum parent material. The second and more definitive sign of residuum parent material is to examine the soil profile.

If you were to look at soils that came from Residuum they often are fairly shallow and evidence of the weathered bedrock will be exposed at the lower portion of the soil pit. The kind of characteristics you would fine in soils from Residuum includes layers of broken bedrock. If you were to take a knife and poke around at the profile it will be clear where the weathered rock begins based on how hard it will be to push the knife into that area. Most of the time pieces of the rock fragments can be pulled out of the profile. If you were to take the rock fragment and scratch it with your finger nail or with the blade of a knife some powdery particles will easily be removed from the outside surface of the rock fragment. This powdery substance is sometimes called rock flour. A small amount of the rock flour can accumulate into the palm of your hand which is evidence that the rock is experiencing some form of weathering. Sometimes the presences of bedrock are not shown in the profile but the topography of the landscape may suggest otherwise. You may be standing on the actual bedrock and don't realize it. If you were to dig at the bottom of the pit with a shovel then it will quickly feel like you were trying to dig through a concrete sidewalk. This is the most definitive clue to soil developing from the parent material Residuum.

Colluvium

Some soils are developed from materials moved by gravity and settled at a lower position on the landscape. Materials moved by the force of gravity are called Colluvium. The stability of materials on a higher landscape positions are usually weakened by geologic activities that include earthquakes, intense rainfall, or water cutting into a hillslope. The once stable materials are weakened to a point where the forces of the particles holding each other together can no longer resist the force of gravity which then carries the various debris down the hill and rest at a lower landscape positions. The activities of material moving down the landscape are referred to as landslides, slumps, avalanches, and/or debris flows. So, we could say that the material was once Residuum and then converted to Colluvium by gravity. Once the material comes to rest Colluvium is established, weathering occurs, organisms become established and soil begins to develop. Colluvium and Residuum are within the same region were the Residuum is found on the higher landscape positions and Colluvium is usually found at the footslopes in which both are associated with areas not effected by glaciers.

How do you recognize Colluvium? Similar to Residuum the examination of the entire landscape is necessary for predicting whether or not the soil came from Colluvium. Gravity influenced parent material are found areas with steep slopes and contrasting elevations. Unlike Residuum the parent material Colluvium, will be located on the low lying footslopes while the Residuum can be located at the backslopes and the peaks of the hills. However, confirmation must be made by looking at the soil profile.

Since the soil was a product of different materials rolling down, the hill the assortment of rocks fragments will have a disorganized appearance. Rock placement will not have any reasonable pattern but rather appear jumbled and randomly place. Also, the rock fragments of numerous sizes can be found throughout the entire profile both top and bottom. Disorderly placements of coarse fragments are good evidence the soil derived from colluvial materials.

<u>Alluvium</u>

Alluvium is all together a different species. The next time you pass a small stream on a mid August day observe the clarity and calmness of the water. If the water is shallow enough you can see the bottom of the stream bed or observe aquatic animals swimming around because the water is so clear. After a big rain event come back to that same stream and observe the color and intensity of the water. The water level will be significantly higher and the clarity appears muddy. The muddy water is a result of soil particles that have been eroded off the surface of the land and washed into the stream channel. If the rain events persist the water level in that stream may rise above the side walls of the channel and spread out across the flat laying floodplain. The water with in the stream channel is moving rapidly and the turbulence keeps the particles in suspension. When the water spreads out onto the floodplain the velocity of the water slows down and the turbulence decreases significantly allowing for some of the particle to settle out. After precipitation has ceased then the water begins to recedes back into the channel only to leave behind the settled particles which may have formed a thin layer of material on the surface of the ground. The material that is formed out of particles settling from floodwaters is called Alluvium and can be a very conducive material for plants. Soils that come from Alluvium can be found anywhere there is flowing water system and the soils are always very young because the new materials are constantly being laid down.

How do you recognize Alluvium? The location of the landscape is one of the best clues to determine if the soil came from Alluvium. Alluvium always occurs adjacent to a stream system. In other words, alluvial soils occur on the floodplain. The floodplains have a very flat topography and exhibit very little relief immediately next to the river. Sometimes the river is too far away but you may be standing on the floodplain but need further evidence to confirm that the soil is from Alluvium. A soil profile will help confirm the parent material. If one were to get into a soil pit, the alluvial material will generally show stratification in the lower half of the profile. Stratifications are layers or bands of sediment deposited by action of water. Sometimes, the stratifications are not noticeable but because the soils developed from Alluvium are so young they have very few horizons as a result of soil development. Lack of horizons from developmental processes is the final clue to identifying soil parent material Alluvium.

<u>Glacial Till</u>

Glacial Till is jumbled heterogeneous material deposited directly by the ice after the glaciers retreated some 15,000 years ago. This material is the dominant and most abundant parent material in the glaciated landscape of Ohio. The glaciers flowed across the land like a river following the path of least resistance picking up debris ranging in size from clay particles to large boulders the size of small houses. The glaciers did not simply push all the materials but rather a majority of the particles were picked up and incorporated into the ice sheet becoming a part of the glacier itself. Once the glaciers retreated, the debris was left behind. We call this jumbled unorganized material Glacial Till.

How do you recognize if the soil came from Glacial Till? If you are standing in the glaciated part of the landscape then more than likely they will be standing on soil derived from Glacial Till. The best way to determine if the parent material is Glacial Till is by looking at the soil profile. In the soil pit, one would examine the profile from top down. In scanning the profile the evaluator should look for small rock fragments. The small rock fragments may not be seen until two or three feet from the surface. Once you see coarse fragments, then you will know that the soil parent material is till especially if the rock fragment is a piece of granite carry by the glaciers all the way from Canada. Highly eroded soils will expose the coarse fragments on the surface while soils that lie on in depressions will have coarse fragments in the deeper portions of the soil profile. In most cases the actual Glacial Till may be exposed at the bottom of the soil pit. If the Glacial Till is exposed, which is very likely, it will generally have a lighter color than the overlying horizons.

Loess

Silt is a fine particle that has a similar feel to flour. Silt particles are small enough that they can be carried by wind. A large amount of silt carried by the wind and deposited in another location is referred to as Loess (pronounced as lō-əs and rhymes with Gus). This parent material was originally in a form of a solid rock but was ground down into a powder form called rock flour. After the glaciers melted, the fine materials washed down slope into the floodplains of the Missouri and Mississippi River valley creating huge mud flats. The mud flats dried out and were exposed to the conditions of the atmosphere. Wind picked up the fine silt grains creating huge dust storms spreading across the Midwest similar to the Dust Bowl in Oklahoma during the 1930s. The states like Iowa and Illinois received a large portion of Loess while Ohio, being farther away from the Missouri and Mississippi River received the tail end of the wind blown silts. Most of the silts covered the Till material after the glaciers retreated. The region in Ohio with the deepest loess is located in South West Ohio where approximately two feet of Loess covered the glacial till. The parent material in this region is said to be Loess over Glacial till. So there are two types of parent materials. The northwest to north central part of Ohio were exposed to just a thin layer of loess over the glacial till material.

The soils with a loess cap will occur only in the glaciated landscape. If the silt material is observed, it will always be found over Till except for a small region in Southwest Ohio (Hamilton, Clermont, Brown, Highland, southern Warren and southern Clinton County). These soils have very deep silt mantles.

How do you recognize soil developed from Loess? The texture is the best way to determine if the top portion of the profile was derived from Loess. A soil scientist will take a sample from each horizon in the top 12 to 24 inches. With the sample the individual will wet the soil up to a moldable form and simply feel it. To the soil scientist will feel very soft, feel like flour, and will be easy to work. If the soil texture falls in the silt loam or silty clay loam then the soil consist of abundant silt particles and was originated from Loess. Another small clue is the evidence of very small rock fragments in the upper part of the soil profile. Obviously, wind is not strong enough to carry small rocks so the presences of these fragments indicate Till. If these rock fragments are found, that tells the evaluator the depth at which the Loess parent material ends and the Till begins. Depending on the location of the rock fragments and the texture of the surface horizon may indicate only the parent material Till. It takes time and practice to recognize Loess material over Till.

<u>Outwash</u>

After the ice from the glaciers melted, the flow of water was so intense that the force of water could carry large particles a long distance. Major river systems were created during these periods of melting and the channels cut by these rivers were much larger than the present day streams and the floodplains of these rivers where much wider than the current flood plains, which result in the present day stream terraces. Stream terraces are essentially old floodplains from the melting of glaciers. Stream terraces are composed mostly of Outwash material. Like Alluvium, Outwash is a result of running water carrying particles and stratifications are created when the turbulence of the water decreases. The difference between the two is Outwash is composed of stratified sand and gravel while the Alluvium is made of finer sediments. Outwash is present in the river valleys in all parts of Ohio. Anywhere there is a gravel pit in which one could purchase a truck load of sand is where outwash is present. The next time you see a gravel pit think outwash.

How do you recognize the Outwash? Look at the position in the landscape. If the location of the selected soil site is on a bench adjacent to a floodplain and the upland (see section defining upland and floodplain) then the chances of the soil derived from outwash are good. However, the best way to determine the parent material is get into the soil pit. If you were to get into a soil pit, the lower portion of the soil profile will have stratifications of coarse sand and gravel. The sand and gravel will be fairly loose and pulling a sample of the coarse material will be rather easy as it almost fall into your hand. Since the material was carried by strong currents they rolled for many miles rounding off the edges until the shape of the rocks where almost spherical. The abundance of nice round sand and gravel layered in a stratified manner are excellent clues that the soil was made from Outwash.

<u>Lacustrine Sediments</u>

After the glaciers melted not all the water flowed through a river system but rather some of the water was trapped. These trapped bodies of water formed glacial lakes and the still nature of a lake provides time for very fine particles such as clay and silt to settle out. For whatever reason, some of the fine particles wash into the lakes and floated. Over time these fine sediments settled and accumulated at the bottom of the lake bed.

The lakes eventually disappeared and left behind Lacustrine Sediment. The parent material where fine silt and clay particles settled out by still bodies of water are referred to as Lacustrine Sediments. Lacustrine sediment is a parent material that occurs mostly in the glaciated landscape and the exact distinction of these old lake beds are hard to pick out on the landscape but can be accomplished when examining the soil profile.

How do you recognize that the soil came from Lacustrine sediments? Examining the soil profile is the best way to evaluate Lacustrine sediments but can be difficult to distinguish. Soils from the lake sediments drain water very slowly. As a result, the surface horizons will be very dark and the subsoil will be very grey (to learn more see section about Water and Soil Drainage). However, not all soils with a dark surface and grey subsoil are from Lacustrine parent material but the description can sometimes lead the evaluator to think about it. The soils from these sediments are rare but the dark surface and grey subsoil are the first clues. The most definitive characteristics of Lacustrine Sediments are the platy structure of the material in the lower portions of the soil profile (C horizon). A soil scientist will examine the structure of the Lacustrine sediment and look for clues of platy structures. The layers of the structure can be pealed back like a layer of pancakes on plate can be pealed off layer by layer. To recognize soils are from Lacustrine sediments takes practice.

<u>Beach Deposit</u>

During the era of glacial lakes, the edges of these lakes were similar to the edges of the present day Lake Erie. The edges of the lakes are sandy and are call beach ridges. Similar to the present day Lake Erie the glacial lakes 15,000 years ago where depositing sand particles on the shorelines. After the lakes disappeared these sand piles were left behind as well. Soils from these Beach Deposits began to form. These soils are usually located at the edges of the Lacustrine sediments.

How do you recognize a soil derived from Beach Deposits? The best way to notice a soil from the beach deposit is the texture of the soil is very sandy. Also, the soil will have little development and little evidence of structure. The Beach Deposits are not common parent materials but can be recognized fairly easily by the abundance of sand that makes up these soils.

<u>Organic Deposit</u>

The soils that were once swamp land have abundance in organic material. The wetland has a shallow water depth enough to allow for some water loving plants to grow. As these plants and animals died, they settle to the bottom of the wetland. Since there is no oxygen the breakdown of the plant residue was little to none. Overtime a build up of this dark light organic material accumulated. Soils from Organic deposits are very rare but can be found in Northwest Ohio and vegetable crops are commonly grown on these soil types. They developed in the glaciated portions of the Ohio landscape.

How do you know if the soil is from Organic Deposits? A soil scientist will quickly know if the soil is from organic deposit based on the feel and texture of the soil surface. The soil will have a relatively deep layer of dark and lightly decomposed plant material. The organic material will feel very light weight and you can almost see the individual plant matter when examined closely. The soil will have a bouncy feel to it as you walk over top of Organic Deposits. The subsurface below the dark organic matter will have very light grey colors and there will be evidence of little shells from aquatic animals that once resided in the old wetland. The subsoil will also produce a sulfur smell. Organic soils are very distinctive from other soil types and are often referred as Muck soils in which they formed from Organic Deposits.

<u>More Than One Parent Material</u>

Not all soils are derived from just one parent material. In some instances the soils are associated with two or even three parent materials. For example, at the boundaries of the glaciated landscapes there are soils that have been influenced by both Residuum and Glacial Till. Loudonville soils are an example of this with a thin layer of soil derived from Glacial Till over the Residuum. As explained earlier in the South West portions of Ohio, there are two types of parent material in which the Loess covers the Glacial Till. Also, soils along the flood plains are not always composed of alluvial materials alone. Floodplains can have the more recent Alluvium over the Lacustrine sediments. For several reasons the present day floodplain was a still water body where fine particles had time to settle out, but whatever was damming the water broke loose allowing the water to flow as a stream system. The flowing water then deposited sediments over the Lacustrine sediments to form Alluvium over Lacustrine. This last double feature of parent material can be challenging to pick out and require a lot of practice. Overall, it is important to keep in mind that some areas may have two parent materials that make up the soil profile.

<u>Using Maps</u>

The uses of maps are very helpful in predicting soil parent materials. The Ohio Department of Natural Resources has geologic and soil maps which can be very helpful for field studies. In addition the soil surveys provide a good idea of what to expect in a given area. Observe the desired location and study the type of parent material from various resources made available to that region. Make note of what to expect and confirm your results with the actual field observations.

Climate

The second soil forming factor is Climate. Climate is essentially the amount of water being distributed in conjunction with the temperature of that area. The degree of water and temperature contributes to the soil formation.

Without water there would be no soil. The moon is an example of parent material with no influence of water. Since, there is no water or atmosphere the moon doesn’t have any soil just parent material and relief.

Water is the main chemical agent in creating soil. A soil develops in part based on the type of climate that exists in a given region. Areas with high temperatures and high precipitation will have different soils than areas with low temperature and low precipitation. Ohio generally has the temperate climate and is part of the humid continental zones. The average temperature is 50 degrees Fahrenheit and the average precipitation is 40 inches per year. Compare this climate with the State of Georgia. The humid subtropic climate of Georgia has a range of 40 inches of rain in the central state to approximately 75 inches annually in the northeast of the state. The mild winters and the hot moist summers of the Georgia landscape contribute to different soil types than the mild winters and mild summers of the Ohio landscape. The intensity of rain and higher temperatures produce soils with a deeper red color indicative of a highly weathered soil versus the brownish soils of the Midwest. The type of Climate has an influence on the development of the soils.

Relief

Relief is the third factor in soil development. Relief is the shape of land and the shape influences the drainage, movement of water, crop cover, and erosion. Relief is described by the landform, slope gradient, and slope position. Climate is the quantity of precipitation and the relief is the distribution of the precipitation once it makes contact with the earth surface. Slope gradient and slope positions dictate which soils will gain or lose water. Steep slopes on the higher landscape position lose water while depressions on the lower positions gain water after precipitation. As a result, soils on the steeper slopes are usually better drained than soils in the depression.

The effects of relief can be observed with soils of similar parent material. Kokomo soils are found on the footslope and depressions of the landscape. These soils have very dark topsoil (A horizons) and very grey and wet subsoil (B horizons) contrasting the Lewisburg soils that are found on the higher summit locations. Lewisburg soils have brown topsoil and brighter brownish red color subsoil that indicate sufficient drainage. Although, Kokomo and Lewisburg soils come from the same Glacial Till parent material the relief influenced the amount of water each soil received. To help evaluate the different soils types the observations of landform, slope position, and slope gradient should be noted.

<u>Landforms</u>

Geologic activities that formed the parent materials and shaped the surface of the earth are called landforms. Groups of landforms are called landscapes. The common landforms in the Ohio landscape are the floodplains, terraces, and upland. Rare landforms that occur in Ohio are the dunes, eskers, kames, beach ridges, end moraines, and old lake beds. Landforms are recognized by their shape and the position with respect to other landforms.

<u>Flood Plain</u>

Flood plains are landforms that occur next to river systems on the lowest lying position on the landscape. These flat lying landforms are a result of flooding events from the rivers or streams overflowing the channels and spreading out. It is the landscape position where eroded sediments from uplands are transported, sorted, and deposited according to the sediment load being carried by the energy of floodwaters creating the parent material Alluvium.

Flood plains may occur on several levels above the primary channel. The immediate adjacent level is a natural levee. The natural levee is an area that is higher than the rest of the flood plain because this is the area where the stream first deposits its load during a flood. The rest of the flood plain may have subtle rises which are covered by water based at different flooding levels. Old channels may be abandoned and segmented by a new channel cutting and subsequently isolated as a depression or slough which can retain water long after the water has retreated. Flood plains size range from a few feet in width to several miles wide along the Mississippi River.

How do you know you are in a floodplain? Floodplains are very flat and nearly level slope gradient. This is the first clue that tips an evaluator standing in a floodplain. If the slope position is none then locate a stream that should be nearby. The soil profile will give evidence of alluvium with stratifications. All these components are a part of the floodplain.

Terraces

Terraces lay in between a floodplain and the upland. These landforms are intermittence of an old flood plain thousands of years ago. Terraces are mostly a result of the outwash from the melt water of glaciers. The intensity of the water dropped off sand and gravel creating the present day benches that rise above the floodplain. The once floodplains are now stream terraces with a parent material of Outwash or Lacustrine.

How to recognize a stream terrace? If a stream terrace is present it will lay in between a floodplain and upland. However, the stream terrace does not always occur. In some cases neither a floodplain nor a terrace borders a river but rather the river is immediately adjacent to upland. Stream terraces will have risers and then a bench. The riser begins at the edge of a flood plain when the slope begins to rise to a higher elevation. The bench is the level position at the top of the riser. Most of the terrace parent material is coarse sand and gravel, however, sand and gravel is not always associated with terraces. Other unique landforms such as eskers, kames, beach ridges, dunes, and some spots on the end moraines are characterized by sand and gravel. Make special note of the position on the landscape and also observe the soil profile to correctly determine the location of a terrace.

Upland

Upland landform is a result of weathered sedimentary rock, glacial till, and lacustrine sediments. These landforms make up the majority of the Ohio landscape, and are the highest positions on the land above the terraces and flood plain. Upland landforms have a range in slope positions and variations in gradient.

To recognize an upland landform one must have concluded that there is no evidence of a floodplain or a terrace. Another big clue to an upland position is the parent material. Is the parent material glacial till, bedrock, and colluvium? If so the soil is more than likely on the upland positions.

Other landforms that occur in the Ohio landscape but are rare include the sand dunes, eskers, kames, and old lake beds. More information about these landforms can be found on the various sources. (Provide different sources for the readers).

To distinguish the type of landform involves analyzing the surrounding area in conjunction with the soil and parent material. The process involves putting the puzzle together.

Slope positions

Slope positions refer to the type and location of slope. They include summit, shoulder, backslope, footslope, and depression. One of the slope positions can be classified as no slope position. One way to understand slope position is to imagine a crowded room of people and the room of people represents a landscape. Refer back to this image as the different positions are discussed. Detecting the position of the slope can help the evaluators predict and rule out certain soil types.

Summit

A landscape position on the top of a hill is called the summit. Summits are the highest position on the landscape. In the crowded room the summits are the top of each persons head. Each person has a different height and the summit of each persons head can be at different elevations. Just like the crowded room there are several summits on the landscape and they can occur at different elevations. The summits end when there is a change in the slope gradient.

Shoulder

A shoulder slope generally but not always is located between the summit and backslope positions. A shoulder position is similar in shape to each shoulder of the people in the crowded room. The slope is a convex shape changing from very gentle slope to a steeper gradient. The point where the gradient is constant is the end of the shoulder slope.

Back Slope

A back slope is a straight linear slope with no change in angle. In the crowded room the people may be in a different position. Some people may be leaning forward while others are standing straight up with each back have a different angle. Just like the crowded room the landscape has slopes that are at a continuous angle similar to the human back. The back slope ends when a change in the grade occurs. The back slope is always between a shoulder and foot slope position.

Foot Slope

The foot slope has a similar shape to the human foot. Starting with the ankle and ending with the toes the shape is concave with a constant change in angle. The footslope is the inverse of the shoulder slope. The slope begins at the bottom of the backslope and ends when the gradient is level. In the crowded room each person has a different shoe size. Some people have large shoe sizes while others have short little feet. The landscape is very similar with varying sizes in the foot slope. Some are very short while others extend for several yards.

No Slope

No slope is usually identified on the flood plain. In the crowded room the floor represents the area with no slope. When no slope is confirmed then the slope positions is labeled as none.

Depressions

The depressions are low lying positions with no outlet for water. They can occur in all areas in landscape where water can collect and no outlet is available. In the crowded room everyone is eating fruit from a small bowl. The bowls are like depressions on the landscape with all slopes pointing to the center which allows for water to collect.

To determine the landscape position one should take a step away from the original site location. Sometimes the relief is not as obvious unless they walk to other location. If the slope position is not obvious then walk around and examine the site from all directions. A different location can sometimes bring into light the right shape and angle of the slope.

Slope

Slope is the angle of inclination of the soil surface. The slope of the soil surface is the quantitative measure of relief. The slope measurement is derived from the mathematical formula for determining slope on a graph which is rise over run. It is expressed as a percent, which is the number of feet rise or fall per 100 feet run. Any given units of rise or fall divided by the run multiplied by 100 will give the percent slope of a given location rise/run x 100 = percent slope.

Knowing the slope of a specific area is important for management and design purposes. In agricultural fields the slope should be known to ensure safe equipment operations. Farm equipment is susceptible to roll over if the slope is too steep. Slope is taken into consideration for reduction of erosion and water runoff in which certain planting and cultivation practices are made. Slope is important in the installation of subsurface drainage.

Slope is very important for engineering purposes. Civil Engineers constantly look at the slope of the landscape for designing and construction of bridges, buildings, roads, wetlands, ponds, and septic systems. An engineer or installers needs to examine the topography of the field to determine the high and low points and how much rise or fall for a given length they have to work with. In many cases the skill of surveying the landscape to develop a topographic map is necessary for many structures. Every aspect of slope is necessary for development or construction on the landscape. In the field of home sites slope is needed to make necessary designs for both the home and the septic systems. How much slope the engineers has to work with will determine the type and location of the system and the location of the house itself.

Topographic maps are an excellent tool for analyzing slope of an area. Topographic maps were made by surveying equipment. Technology such as GPS now assist measuring slope in addition to other surveying features. Tools such as an abney level and clinometer are used by soil scientist to quickly measure slope for a specific position. In designing a system or field management plans requires understanding of slope of the entire area which uses surveying equipment such as the Total Station, Transits, and GPS.

To quickly determine slope in the field setting is used by taking a clinometer or abney level. Two stakes or objects of equal high are set a distance a part. The evaluator will look through the abney level or clinometer at the top of one stake and aim the pointer at the other stake. The number on the level will tell the evaluator the percent slope. For accurate evaluations of the slope an engineer will survey the area.

Organisms

Soil is defined by the presents of structural development. In later chapters we will discuss soil structure in further detail. Other earth materials do have structure and other professions analyze the structural units to define and classify the different components of the geological materials. Geologists analyze structure in rock formations for classification and identification purposes. Soil structure is a much different process than the structural units made by geologic processes. Keep in mind the key word is SOIL structure. Soil structural development, which is the definitive characteristic of soil, is a construction process driven by none other than living organisms. The fourth soil forming factor is Organisms.

The buildings we live and work in are architectural structures constructed using wood, concrete, steel, nails, and mortar. Inside these buildings are spaces and passage ways. Doors and windows are outlets to the outside world. Hallways are routes from one location of the building to the other. Rooms are made for sleeping, working, eating, and storage. In addition we use these buildings to keep ourselves cool or warm depending on the outside temperature. These structures are made by humans from the surrounding resources. Organisms do the same thing to soils. They take the material around them and begin the construction of soil aggregates which develop into soil structure. Aggregates are clumps of particles that are can be distinguished from other particles or aggregates. Whether the construction process is intentionally or by accident the aggregates are composed of spaces and passage ways that serve as place for sleeping, working, eating, storage, and protection for the many organisms. Materials are not considered soil until the living organisms have constructed soil aggregates. Living organisms that contribute to soils development are bacteria, fungi, animals, plants, and even humans.

Microorganisms such as bacteria and fungi are very important in soil development. The abundance of microorganisms in the soil is phenomenal with a handful of soil having more microorganisms than there are people on the earth and their influence on the soil is the largest factor in creating soil. Bacteria decompose plant residue to the most resistant plant compound called organic matter. Fungi also contribute to the breakdown of plant residue and have root like structure called mycelium that contribute to the enmeshment of soil particles. Fungi produce “glue” called glomalin which cause particles to stick together. When the microorganisms break down the plant residue to form what is call organic matter. The microorganisms, organic matter and clay molecules all work together to form aggregations.

Plants are also very important with the development of soil aggregates by contributing to the enmeshment of particles but also providing food to the bacteria and fungi once they reach their life span and die off. Now the microorganisms and plants coexist in the sense that one is dependant on the other and vice versus. Plants must provide a continued source for organisms and organisms provide for the plant in converting different forms of nutrients so they are made available for plants to uptake by the roots. As a result, the chemical compounds associated with this relationship ensure structure development and more importantly stability.

Many types of animals from small insects to larger animals contribute to soil developments. Animals burrow and mix up the soil with various activities instinctive to each species. Ants burrow numerous tunnels while squirrels bury their nuts into the soil. Animal feces and death of animals all play a role in soil fertility and developments. The biggest contribution of animals is the mixing of the material.

Humans can even play a role in soil developments. Different management practices influence the process of soil development. Native Americans would practice burning vegetation to keep the plants down. This management practice keeps grass plants as the major species which influenced the formation of the topsoil. Humans use excavating equipment to move soil around changing the lay of the land for specific purposes. This in a sense restarts the soil forming processes and creating young new soils.

Time

Time is the fifth and final factor in soil formations. The amount of time that passes plays a role in the type of soil development. Usually, it takes hundreds to thousands of years for soil to develop. Soils in the unglaciated portion of the state are much older and have been exposed to organisms and climate for a longer time period than the younger soils of the glaciated till plains which started forming some 15,000 years ago. Soils on the flood plains are very young compared to the soils on the terraces.

There are even parts of the till plain that vary in part to the time they have had to develop. The two major till plains in Ohio are the Illinoian till plain and the Wisconsin till plain. The Wisconsin glacier was the last glacier to move across the Ohio landscape while the Illinoian glacier which extended farther south than the Wisconsin glacier is much older. The soil types from the two regions are very different from each other in part to the age and time they had to develop.

III. Processes of Soil Formation

Soil Horizons

We have discussed that soil formation is a result of five factors. Essentially, earth materials where transformed into soil by water and organisms. In the transformation process the soils form what we call horizons. Horizons are layers of soil or parent material that run relatively parallel to the surface of the ground. In most situations there are several horizons in the soil profile but the horizons can be broken up in two parts. One type of horizon is associated with the development of soils which we call Soil Horizons. The other type is the parent material. All horizons are described so that we know where the soil begins and where the soil ends. Each horizon will have a feature that causes a person to determine a break from one horizon to the next. The break between each horizon will sometimes be easy while in other cases the breaks between horizons are broad and difficult to distinguish. Regardless, a soil scientist will make a break between horizons based on the different features and characteristics associated with each horizon. These features and characteristics are structure, color, and texture.

Soil Structure

Soil structure is the most important indicator of soil development. We discussed earlier in the section about organisms that soil is not considered soil until aggregates are formed and that aggregates are really formed by the influences of organisms. Soil structure is the arrangement of aggregates and the arrangement leads to different shapes of structure. In examining the soil it is important to make note of the type and strength of a particular structure. The most common soil structure shapes which describe the presence of natural soil development are granular, angular blocky, subangular blocky, and prismatic. Structural units that are not associated with soil development but are used to describe the activity caused by heavy equipment or signs of parent material are platy, massive, and single grains.

Structure can be observed in two ways. One way of observing soil structure is take a knife and sample a horizon. The other way to observe soil structure as is in place on the soil profile. Taking the time to observing soil structure in both ways is highly suggested. In both methods one could make a distinction between the individual blocks and shapes made by natural breaks if soil structure is present. On the profile one will notice several faces of the soil structure. We refer to the peds still in place of the soil profile as faces because they resemble faces sticking out of the profile very much like the faces of the Presidents on Mount Rushmore.

<u>Granular</u>

Granular structures are the smallest of all structural units but are the most stable aggregates. Granular structure always occurs in the top horizon called the A horizon but the A horizon may not always have granular structure. The presence of granular structure is a good indication that soil has little disturbance or the soil has been managed well.

Granular structure is the desirable surface structure for most uses, especially crop production. Granular is very porous and allows for quick infiltration of rain water rather than letting the water run along the surface. This structure allows for good infiltration of water, good drainage of water, and excellent water holding capacity for plants. Granular structure provides little resistance for root penetration to reach necessary nutrient for up take. It is very desirable for the top soil to develop granular structure.

Blocky Structure

Blocky Structure in a way resembles the shape of a cube or block. This structure is divided into two subcategories Angular Blocky and Subangular Blocky. Angular Blocky is block shape soil aggregation with very distinct sharp edges. If a soil horizon had angular structure then you would be able to remove a piece from the soil profile and tell exactly where you took it out. The sides of the Angular Blocky structure fit together very well almost like a puzzle piece. This structure can be found in all horizons that are associated with soil development.

Subangular Blocky is bock shape soil aggregation that does not have distinct edges but rather they are more rounded. Subangular Blocky resemble the shape of granular structure except the size is much larger. This structure is the most common shape for many horizons in Ohio soils. This structure can be found in all horizons associated with soil development including the top soil horizons (A horizon).

Prismatic

Prismatic structure is interesting to look at. Strong prismatic structural development will have a definite appearance of a prism, hence the name. There are relatively flat edges on all six sides of the soil structural unit. This structure is larger than blocky and granular. If prismatic structure is present it will only be in the B horizon (subsoil horizons below the top soil and above the parent material), however, the B horizon will not always have prismatic structure.

Platy

Platy structure is not an indication of good soil development but rather parent material or compaction. In most settings Platy structure is not desirable because the nature of the structure restricts the flow of water. However, excavators create platy structure intentionally when building dams or dikes by compacting the soil firmly. In this case the platy structure is important in holding back water. Platy structure is not always linked to compaction but also created due to layering of materials such as lacustrine sediments from old glacial lakes or in rare instances alluvial deposits on floodplains. Platy structure has the tendency to look like layers of soil material that can be peeled off in thin sections. Imagine being served a stack of pancakes. The individual pancakes can be pulled off one at a time. Soils horizons with platy structure can be observed the same way. If the platy structure occurs near the top of the soil profile (A horizon or upper B horizon) then the structure was formed due to heavy equipment running over the soil. If the platy structure occurs near the bottom of the soil profile (the parent material also called the C horizons) then the structure is due to parent material formations.

Massive

The term massive really means the absent of soil structure. Massive is associated with a structureless horizon or a mass of soil particles with no distinct edges. Massive structure is only associated with the C horizons or also called the layer of parent material (non soil material). In analyzing granular, blocky, prismatic, or platy structure the individual breaks between structural units can be observed either on the soil profile or after a sample has been taken. In analyzing a massive horizon no natural boundaries can be observed on the soil profile and any breaks that are made when sampling are a result of the tool used to pull out the sample. The correct way to describe this structure is structureless massive.

Single Grain

Single Grains is a result of loose sand. This is also a part of the C horizon or parent material that never developed into soil. The correct way to describe this situation is structureless single grains. Basically, a pile of sand is when you describe that particular C horizon is single grains. Single Grains will always appear in the sandy textured C horizons and in no other horizon.

Structure Strength

Granular, blocky, prismatic, and platy structures can be described by their strength. If these soil structure units are very easy to see then they are said to be strong. If the structure units are not very well defined then the units are said to be weak. If they appear to be in the middle then the structure is said to be medium. An example is the soil structure in the A horizon has strong granular structure. The granular structure is very stable and distinct. Another example is the soil structure in the B horizon has weak subangular blocky. This means the soil has little development and the blocky structure is present but is hard to see.

Why is soil structure important?

One may ask why we even care about soil structure. Why would anyone take the time to analyze the different types of structure within the soil? The answer is quite simple. Structural development is the sign of soil aggregates and is what makes soil distinct from other earth materials. The formation of aggregates and structure leads to a very important characteristic of soils that truly allows all activities within the soil to occur. That characteristic is pore spaces. The fact that earth materials can make microscopic clumps with microscopic pore spaces as well as large clumps with macro pore spaces is essentially what contributes to the life on this planet.
Soil aggregation and pore spaces allow for proper drainage of water but at the same time allow for proper storage of water for plants. Soil structure allows for free flow of gases,

in particular oxygen, for necessary chemical reactions but at the same time stores gases for the very same reason. The numerous channels in the soil allow for animals and microorganisms to live in addition to providing passages for root penetration and stability. Soil structure is essential for cleaning the water as it passes through allowing the water molecules to draw into the fine pore spaces and sticking to the surface of soil particles preventing unwanted biological waste to enter our drinking water source. Pore spaces and soil aggregates is truly what makes soil fascinating.

Color

Color is the most obvious feature in the distinguishing horizons within in a soil profile. Different colors are result of different soil processes. The darker colored soil horizons are a result of organic matter accumulation. Red and brown colored horizons are associated with the chemical processes of aluminum and iron oxides. The grey color horizons are soil horizons with prolonged wetness with pore spaces saturated with water. Soil horizons with grey and red mottles are horizons with prolonged water saturations that fluctuate during certain times of the year. In a soil evaluation these colors are noted to provide others the activity that occurs in the soil. More information about water and soil colors is explained in the Water and Soil Drainage section.

Texture

Soil texture refers to the combination of the three soil separates sand, silt, and clay. The size range of each separate is as follows:

Clay – particles with diameter less than 0.002 mm
Silt – particles with diameter between 0.002 to 0.05 mm
Sand – particles with diameter between 0.05 to 2.0 mm

The largest sand particles are 1000 times the size of the largest clay particles. Let's say that a quarter represents a clay molecule. A medium sand separate on the same scale will be equivalent to something 40 feet in diameter (I need to make sure this is correct and I need to compare to an actual structure).

The percentages of each separate in a given sample are combined to determine the texture. The soil texture can be determined using the textural triangle. Texture is an important characteristic that allows you to draw many conclusions about the probable behavior in the field. Soil structure, water holding capacity, drainage, consistence, and chemical properties are all affected by soil texture. In general, coarse-textured soils with lots of sand particles hold relatively little water, drain rapidly, and are low in fertility. Fine-textured soils with lots of clay particles hold large amounts of water, drain slowly, and are very chemically reactive. (Provide the texture triangle with the lines for each texture side a different color. For example the clay lines will be red, silt will be blue, and the sand will be green so that the reader can easily use the triangle with little instructions)

Most soils have particles that are larger than 2.0 mm. These particles are called coarse fragments and are not considered a part of the texture class. In some cases the presence of coarse fragments are important in the behavior of the soil in which one should make not of their presence. However, they are a separate characteristic from soil texture.

The three soil separates behave differently in bodies of water. If one were to take the three soils separates and drop those in a jar of water the rate at which each particle falls will be different. The sand which is the largest will settle to the bottom of the glass jar in a few seconds, silt particles will all settle out within two hours while the clay particles will take several days to settle to the bottom. In the landscape where water influences the soil the behavior of the particles are the same. In the case of an outwash terrace, one could easily observe different layers of sand and gravel. A pattern would be observed in which the coarser particles will be at the bottom of each horizon and the particles will get finer as you travel up the profile to a point where a thin ban of fine textured silt particles lay. Right above the thin ban of silt the coarse sand and gravel start over again. This pattern was a result of the same action occurred in the lab with three soil particles settling out at different rates. The concept of stratification is a result of water bodies influencing sand, silt, and clay. This is important because these observations are helpful in soil evaluation to figure out where the soil came from (the type of parent material) and the limitations incurred on the soil.

Soil texture will sometimes vary from horizon to horizon. The A horizon of the Alexander soil will have texture of loam with approximately 20 percent clay and the B horizon of the same soil will have a texture of clay loam with approximately 35 percent clay. This is a result of the clay molecules of the surface horizons that traveled to the lower horizons. The process is called illuviation (soil particles going **I**nto a horizon or **I**lluviation). Soil such as the Eldean will have high clay textured B horizons but will have very sandy textured C horizons. Soil texture for each horizon is very important to describe to allow for interpretation and land use management plans.

Master Horizons

After the features are recognized the horizons are labeled. The naming of horizons are simply for communication and organization purposes. The soil horizon labels for Ohio soils are composed of O, A, E, B, C, and R horizons. In some cases the soil horizons are given subcategories with a lower case letter to indicate features within the horizon.

O Horizon

This horizon consists of organic material on the surface of mineral soil. The organic material will be lightly decomposed and individual fragments of the plant can still be seen. This horizon is directly related to the organic deposits in the original formation of the soil from once bogs and marshes. These horizons are rare.

A Horizon

This is the mineral horizon at the surface and the horizon with the most activity of organisms thus making this horizon darker than the lower horizons. The A horizon is the usually composed of granular structure and darker colors. The soils that were formed under forest vegetation such as Miamian have an A horizon only a few inches thick. The soils that are formed under prairie grasses or drain swales can have A horizons that are 10 to 25 inches or deeper. Almost all A horizons have been plowed by conventional tillage.

E Horizon

The E horizon is found in forest soils directly below the A horizon. The E horizon is light in color, lower in organic matter, and less fertile than the A horizon. The Clay, aluminum, iron, and some nutrients have been washed and leached out to lower horizons. The E horizon is expected to be found in soils still occupied by old growth forest. Although these areas are rare because nearly all soils in the Ohio landscape has been plowed in which the original E horizons have been mixed in with the present day A horizons. If the E horizon is present it will lay between the A horizon and B horizon.

B Horizon

The B horizon is the mineral soil below the A and E horizon and is considered the subsoil. Although most soils go from A to B horizons some undisturbed soils go from E to B horizons. It is usually the horizon of accumulation. Many clay particles, iron, aluminum, nutrients, or a combination of these have traveled from the A and especially the E horizon and accumulated in the B horizons. The B horizon is usually the horizons with prismatic structure, weak cementation result in brittleness (fragipan), reddish brown color (Well drained/ Moderately well drained), Grey colors (Somewhat poorly drained/Poorly drained), and the combination of these. Keep in mind that there can be more than one B horizon depending on the color, structure, and texture in the profile.

All soils must have an A horizon. Most soils have an A and a B horizon and some cases soils will have all three. The A is always above the E and B horizons and the E is always in between the A and B horizon if the E horizon is present. In young soils found on the floodplain may only have an A horizon and then the parent material.

C Horizon

The parent material is designated with the C horizon. Although the parent material is considered one unit they can have several layers made by stratification in which there can be more than one C horizon. The C horizon may be composed of any of the parent materials mention in previous sections from weathered bedrock to outwash materials. The C horizon is the zone where the soil ends and potential for the material to transform to material has not yet occurred. The C horizon is always below the A and B horizon. In young soils the A horizon leads right into the C horizons. In older soils the C horizon is below the B horizons.

R horizon

The R horizon is consolidated (hard) bedrock, such as limestone, shale, and sandstone. The depth of bedrock varies from a few inches to a several hundred feet in the Ohio landscape.

Diagnostic Subsurface Horizons

Water and Soil Colors

We said earlier that soils are exposed to different amounts of water based on the type of climate. We also mentioned that relief plays an important role in the distribution of water after contact with surfaces has been made. We also said earlier that soils have numerous pore spaces which can fill up with water. The zone at which all pore spaces are filled with water are said to be saturated. The zone at which the saturated layer meets the unsaturated layer is called the water table. The water table rises and falls within the soil profile based on the amount of precipitation, evapotranspiration, and soil drainage. Evapotranspiration is the loss of water due to evaporation by the sun and transpiration by plants.

All soils at some point in a given year are saturated to the surface due to precipitation and other hydrologic factors. However, the duration of saturated conditions may vary depending on the relief, the permeability of the parent material, the evapotransporation, and overall drainage capabilities of the soil. The duration of saturated conditions will contribute to certain chemical reactions which influence the soil color. These variations in soil color are key components in identifying the soil drainage. The color differences are tools to identify the length of time at which a soil is saturated and the soil drainage class.

Soils with steep slope usually drain faster than soils on the low lying footslopes or depressions but not always. Soils with high clay or densic material in the subsoil, usually, are slower at percolating water than soils with a sandy parent material. All conditions are subject to full saturation but how long the soil is saturated will be dependant on the factors influencing soil drainage.

Colors are good clues to the drainage capabilities if the soil. Bright brownish colors indicate well drained soil where as dull grey colors indicate long term waterlogged soils. Clues in the soil profile that indicate some duration of saturated soil conditions are call redoximorphic features (mottles). The redox features do not tell the point at what the water table reaches but rather tells the duration of the water table for a given soil horizon. The overall color in addition to the abundance of redoximorphic features provide information to the evaluator as to what length of time the soil will experience total water filled pore spaces.

Take a moment to think about a steel rod. A new steel rod is grey or silver in color when not exposed to the natural forces of weather. If the rod is exposed to water or humidity then the steel begins to form rust spots. These rust spots are brown to red colors that are created because the water and oxygen react with the iron in the steel rod to form iron oxides. If a brush was applied to the steel rod then the rust would be removed and the grey texture of the steel will be exposed. The soil behaves in a very similar fashion. Soil particles are really made of Iron, Aluminum, Silicon, and Oxygen atoms. The original soil colors are really grey similar to the steel rod we talked about earlier. After exposure to the water then “rust” spots begin to form covering the original color. Iron reacts with water and oxygen to form the brownish colors that we are familiar with in the subsoil. The more exposure to high temperature and precipitation provides more iron and aluminum oxides.

Now if the soil remains saturated too long other chemical reactions occur that cause the soil to react in a different way. If we go back to chemistry classes we will remember that iron can be in two forms. The Ferric (Fe^{3+}) or Ferrous (Fe^{2+}) state. Fe^{3+} is not capable of being dissolved in water where as Fe^{2+} is soluble in water. The rust color of the soil is when iron Fe^{3+} is with oxygen atoms.

The iron elements that transform for one state to the other needs to experience a transfer of electrons. The chemical reaction responsible for electron transfer is called oxidation and reduction reactions. When an element gains an electron the soil is reduced (GER = gain electrons reduced). When an element loses electrons the atom is said to be oxidized (LEO = lose electron oxidized). The iron must lose an electron to become insoluble in water and gain electron to become soluble. How does the iron oxide lose and gain electrons in the soil? The assistance of microorganisms play a big role in this process. The microorganisms are constantly working on organic matter and decomposing the plant residue. One of the major source of energy is organic carbon. As the microorganisms decompose the organic carbon they oxidize the organic matter thus liberating electrons. The electrons must be consumed by some type of element otherwise the soil would be violating the First laws of Thermodynamics (Energy can be changed from one form or the other but it cannot be created or destroyed). Oxygen is a very good electron accepter. In aerobic conditions the soil has plenty of oxygen available to consume the electrons released by the oxidation of decomposed carbon. The carbon is oxidized while the oxygen is reduced which reacts with hydrogen to form water.

In saturated soil conditions the oxygen is unavailable creating anaerobic conditions. The anaerobic microorganism still work on the organic matter for energy source and the carbon continues to be oxidized. However, the electrons released from the oxidation reaction can no longer be consumed by the oxygen atoms. So other elements in the soil began to gain the electrons and are reduced. The first element to take on the electrons in anaerobic conditions is nitrogen. After the nitrogen is reduced then the manganese is reduced. The third element to be reduced is iron. Once the iron gains the electrons the element becomes soluble in water and washes off the soil particles exposing the original colors. The soluble iron may travel just a short distance and oxidize once the water drains out of the soil. The soil with grey color loss the iron and aluminum oxides and soils with brown or reddish color experienced iron and aluminum oxides. This reduction of the iron atoms is a very slow process.

Soil Colors and Drainage Classes

Well Drained Soils are soils with no grey colors in any part of the soil profile. Moderately Well Drained soils have some grey mottles somewhere in the soil profile. The soils that are Somewhat poorly drained have a least one horizon that is gleyed (greater than 50% of the horizon has a color of grey) and grey mottles immediately below the A horizons. Poorly Drained soils have all horizons are gleyed in which more than 50% of the entire profile is grey. Poorly Drained soils usually have deep black topsoil with a dominant grey color immediately below.

IV. Describing and Evaluating Soils

Tools needed to evaluate soils

<u>Knife</u>

One of the most important tools to take to the field is a three inch or four inch lock knife. Pick out a knife of your choice and designate it strictly for soil evaluations. The blade of the knife should be strong enough to withstand pressure from digging into the soil. The knife does not need to be sharp.

Usually, a soil knife is used in examining a pit. When a soil pit is dug, the bucket of the backhoe smears the soil profile. The knife is used to chip away the smooth surface to expose the natural features of the profile. The knife assists in picking out horizons. After the soil horizons are picked out, the knife is used to pull samples from each horizon.

A knife can act as an extension of your finger. In other words, you can feel soil by probing around with a knife. Sticking the knife in a silt horizon will feel smooth but putting the knife into glacial till will be rough and difficult. Practice with a soil knife will help you evaluate the soil.

<u>Measuring tape</u>

A measuring tape is crucial to soil evaluations. Knowing the depths of the soil horizons is important in describing the soil.

<u>Munsell Color book</u>

The Munsell color book is used to identify the color of individual soil horizons.

<u>Water bottle</u>

The water bottle is used to moist soil samples to identify color and to determine a texture.

<u>Hydrochloric Acid bottle</u>

The hydrochloric acid is needed to check for dense glacial till.

<u>Sample cups</u>

Sample cups can be any shape or size. They are used to collect samples from each horizon. The evaluator puts a sample from each horizon into the respected cups. This helps organize the horizons so that color, texture, and structure can be determined.

<u>Towel</u>

The towel is used to clean your hands after determining soil texture.

Examine the landscape

One of the best things you can do in evaluating soils is examining the landscape. Even as you drive to the site, make note of the changes in the topography, vegetation, and land uses. Many times, the landscape will give you clues to what type of soil to expect. Ask yourself a few basic questions when examining the landscape. Where do I stand on the landscape? Am I on the glaciated landscape? What does the vegetation suggest? What is the landform? Is there a stream nearby? Is there any evidence of exposed bedrock?

What is the topography? Answers to these questions can provide clues to the type of soil one could expect.

Ask the landowner questions

Don't forget to ask the land owner if they know the land use management of the area. An example of talking with a landowner is discussed in the next sentence. A soil scientist was asked to do a site evaluation before the homeowner could sell off the area as two lots. When the soil scientist approached the lot he made note of the topography and lay or the land. The lots where in the glaciated landscape but the area seemed to be disconnected from the rest of the landscape. In other words the area did not seem to flow with the surrounding topography. There appeared to be a small depression where the lots where to be examined. The soil scientist started to auger a hole into the soil and quickly ran into material that is generally associated with glacial till. The material did not appear to be soil but rather parent material. He was confused and couldn't put his finger on what had happen to the area. He finally asked the landowner if he knew the history of the lots. He said the previous land owner had built a pond, however, the pond was filled back in a few year ago due to complications. It all made sense to the soil scientist after the discussion. The area was disturbed and it explained the till material near the surface and the shallow depression that was disconnected with the rest of the landscape.

Examine and determine slope and slope position

If you recall the slope positions include the back slope, foot slope, shoulder slope, summit, depression, or none of the above. By determining the slope position you can predict the type of soil you can expect. Look at the pit location from all angles. This will bring to light the slope position. Sometimes the landscape acts as an optical illusion if you stand in one location.

Once you have determined the slope position this will provide clues as to what soil to expect. Soils on shoulder slopes and summits tend to have better drained soils than those on the foot slopes or depressions. Soils on foot slopes or depressions tend to have deeper A horizons than soils on the back slope.

Sometime during the soil evaluation you should use an abney level or a clinometer to determine slope. Refer to the section about slope to evaluate slope.

Examine the vegetation

The vegetation is just another factor in the soil type. Most plants have developed a niche for the type of soil they grow in. Some plants prefer wet conditions while other plants have adapted to very dry conditions. Knowledge of plant life cycles and identification can be additional help in soil evaluations.

For example: yellow nutsedge is a plant that typically grows in very wet soils. Trees like the sycamore prefer wet soil types.

Examine the soil Profile

After you have examined the landscape and picked up clues the next step is to examine the soil profile. In most cases, a soil pit has already bit dug out for evaluations. In soils contest a section of the profile is marked off. This area is called the control section in which the judge examined the profile. Remember not to dig into the control section.

The first step in the soil pit is to pick out horizons. Usually, the A horizon is the easiest horizon to distinguish because the soil color is darker than the rest of the horizons. Establish the depth at which the A horizon ends and write it down on your card. To pick out the next horizons look for changes in color, structure, rock fragments, and redoximorphic features.

After you have established the depths take your knife and dig out a sample from the middle of each horizon. Place the samples into your sample cup and take exit the pit to examine the soil for color and texture.

Munsell Color Book and Determining soil color

The next step is to check for soil color. You want to look at color before you look at texture because determining texture requires smashing up the sample. Destroyed soil is not an accurate way of reading soil color. In the first cup (A horizon sample), take out a ped (individual soil structure) and break it in half. Sometimes the soil will have numerous colors but you must keep in mind that you are trying to find the most abundant soil color. If you are having trouble, go to the soil pit but don't get into the pit. Stand outside the pit and ask yourself, "what color do I see?" We can confuse ourselves by looking to closely at the soil. By taking a step back it allows the dominant color for a given horizon to appear.

Once you have established the dominant soil color open up your Munsell Color Book to the 10 YR page. The Munsell Color book is set up into three parts. Hue, Value, and Chroma.

Hue is the color. The Hue is designated with a number and one or two letters. 10 YR is the Hue for most soils in the Ohio landscape. The letters YR stand for yellow red and the number is the strength of the yellow red. If you were to turn to the 7.5 YR page will notice the color chips on the page are redder than the color chips on the 10 YR page. The color becomes redder as the number becomes smaller. If you turn to the 2.5 Y page you will notice the colors chips are more yellow than the 10 YR page. However, always start off on the 10 YR page for soils in the Ohio landscape.

On each page you will notice columns and row of color chips. The rows are called the value. The value is the amount of light reflected or adsorbed for each color (hue). The higher the value (going up the page), the more light is reflected. The lower the value (going down the page), the more light is adsorbed. There for a value of 2 is dark where as the value of 7 is light.

The columns is referring to the chroma. The chroma is the purity of the color. The lower the number (the left side of the page) the duller the color. The higher the chroma (right side of the page) the color becomes more pure or brighter.

The proper sequence of reading soil color is written first as Hue then value and finally chroma. For example 10 YR 3/3 is the correct way of writing soil color. 10 YR is the color, 3 is the value and 4 is the chroma.

Under each color chip is a hole in the page. Put the soil ped behind the page so that the soil can be seen through the holes. Run along the page until you are satisfied with the color chip. If you are not comfortable with any of the color chips on the 10 YR page then flip to the either the 7.5 YR page or the 2.5 Y page. Once you have matched the soil color with the chip in the Munsell Color book then write down the Hue, value, and chroma. Repeat this procedure with each horizon.

Make sure that the soil is moist when doing soil color. If the soil is dry apply a couple of drops of water or spray a little bit of water on the soil ped. Soil color is based on a moist level.

Keep in mind you may not find the perfect match. Also, some people see color slightly different than others. What you are trying to find is the closest soil color or the general color of each horizons. Don't get too carried away with the exact soil color.

Determining Soil Texture

After you have determined the soil color the next step is determining soil texture. Texture is the process of molding the soil up into a texture ball, feeling the sample, looking at the sample, and establish the textural class based on the .

When doing texture it is important to start with the first horizons. Take a small handful of soil from the cup and put it into the palm of your hand. Take the spray bottle and apply a small amount of water to the sample in your palm. With the other hand, start mixing the soil up to incorporate the water in to the soil sample. You may need to add more water after you start mixing the sample. If the sample is too wet then add some dry soil to bring the moisture content down. Work the sample until the soil is a constant consistency. You don't want the texture ball to be too wet or too dry but rather a plastic consistency. This takes practices to know if you have reached the right moisture content for the sample. The right moisture content is important to determine the correct texture.

Once the texture ball is at the proper moisture content then you are ready to establish the texture class. Take the sample and move it around with your thumb and fingers. What are your initial thoughts about the texture? What do you feel? These are simple questions but they can go along way in determining the texture class. If the soil is a sandy loam or loamy sand then your initial thoughts would probably be that the sample had a lot of grit or felt very gritty. If the sample was a silt loam then your initial thoughts would have been the soil felt very smooth and easy to work. If the soil was a clay then the texture would have felt very sticky and hard to push around with your thumb.

The next step involves estimating clay content. Clay content is an observation made by your eyes. There are a couple of methods to help you get started in determining clay percentage. The ribbon test is a very common method. Take the texture ball in your hands and begin to push the sample with your thumb against your index finger to form a ribbon. Keep pushing the soil until the ribbon breaks off. The length of the ribbon will tell you approximately the clay content of the soil. A short ribbon means the soil falls into the silt loam, sandy loam, and loam categories (clay content 10-27%). A medium size ribbon means the soil texture falls into the silty clay loam, clay loam, or sandy clay loam categories (clay content 27% to 40%). A long ribbon means the soil is silty clay, or clay textural class (clay content >40%). A sample with no ribbon at all means the soil is a loamy sand or sand (clay content <10%). Sands and loamy sand textures will not hold together as a texture ball if compresses with your hands.

Another method to determine clay content is the slick method. Hold the sample in your hands. Take your thumb and swipe the sample making a slick in to the soil. The way the mark appears will give you an idea of the estimated clay content of the soil. If the sample falls into the sandy loam, loam, or silt loam category, the groove will have breaks or cracks. If the sample falls into the sandy clay loam, clay loam, or silty clay loam then the groove will have a smooth surface but will have a dull appearance. Clay or silty clay textures will provide a very smooth and shiny groove or slick.

Once you have estimated the clay percentage and sand percentage then you may wish to refer to the textural triangle for a resource.

Developing the skills for texturing soils is a trade that requires practice. A good way to practice texture is collect several samples with known texture classes and clay percentages. Lay the sample out and compare the different samples to each other. Observe how the different sample feel and look. In the process develop your own technique. There is no one way of determining texture except a lot of practice.

Determining Soil Structure

After you have established the color and texture for each horizon then it is a good time to determine structure. Usually, the samples collected in the cups are destroyed from doing color and texture. Therefore, it may be a good time to return to the pit and examine the structure for each horizon.

Start with the A horizon and observe the soil structure in place. Look at where the natural breaks occur. Can you pick out the type of structure within the soil profile? What do the ped faces look like? What type of shape can be observed? If the soil structure is difficult to determine within the soil profile, then you may want to take your knife, and pull out another handful of soil. If there are any, make note of the natural breaks as the material falls into your hands. This is important because than can give you an idea of where the native soil (A and B horizons) ends and the parent material begins (C horizons). If the only breaks in the soil profile is where the knife was inserted then you are in the C horizons. If there are separate aggregates that come out of the soil profile then you are still in native soil. Take the soil and observe the size and shape of the soil and decide the structure for each horizon.

In many situations, you will notice several structure types with in the soil horizons. However, you are trying to determine the most abundant or most obvious soil aggregates. Sometimes, getting too close to the profile can distort your view and cause you to focus on a small area. This area may not represent the entire horizon. Take a small step back inside the soil pit and look at the full horizon. Ask yourself what are my initial observations? Usually, your first thoughts are the correct answers. Finally, detecting structure takes practice just like the other skills of describing soils.

Detecting Redoximorphic Features

Redoximorphic features are the dull grey and bright red colors in the soil. If you recall, these colors indicate the drainage class for the soil. The grey colors are the redox depletions and the bright red colors are the redox concentrations. The collective blotching of these colors can also be called mottling. However, we often pick out the two types of features individually. The drainage class is determined by the presence and depth of the redox depletions (grey colors). Keep in mind, for a mottle to be considered a depletion it must be of a certain color. This means the grey must be of a chroma of 2 or less. For example you are trying to determine if the grey mottle that you are observing is grey enough. Take the Munsell color book and start with the 10YR page. Match the color up with one of the chips. If the color is of a chroma of 2 or less then you know it is a depletion associated with prolong wetness. Therefore, the color maybe a 10YR 4/2 or a

10YR 5/1. The last number must be a 2 or less. After much practice, one would not always need a color book to determine if the depletion is grey enough.

The presence of redoximorphic concentrations (bright red colors) are not used to determine drainage class. However, they usually are found in the same area as the depletions. Redox concentrations can be easier to see. Once you notice a concentration, then you know to start looking for depletions in the same area. After you spot a depletion then make note of the depth and proceed up the profile until you no longer see any presence of depletions. The boundary is the depth at which the depletions occur in the soil profile.

Based on the depth to redoximorphic depletions and the abundance of the grey colors will dictate the drainage class for a given soil. Refer to the section about soil color and drainage class for drainage classification.

Determine Parent Material

Throughout describing soil horizons you should be looking clues for the type of parent material. To recall what types of Parent materials to expect and know what to look for you must refer to the section of Parent material. Parent material can help you understand where the soil came from and establish correct interpretations for land use management. Also, Parent material is important because some of them are restrictive layers.

Determining Restrictive Layers

Restrictive layers are usually horizons in the soil profile that limit root penetration and restrict the flow of water. These horizons include fragipans, dense glacial till, high clay textures (>45% clay content), and bedrock.

<u>Fragipans</u>

Fragipans are horizons that occur in certain soil types that have a unique characteristic. If a fragipan were to occur in the soil profile then they will appear around 30 inches below the surface. The most distinctive characteristic of a fragipan are the fracture seams that run vertically through the fragipan horizon. The seams are grey in color and occur approximately every four inches across. Right above the fragipan is a thin layer of grey depletions. You can follow this grey band to the seams that are spaced every four inches.

Fragipan have a silt loam texture. If suspected horizon has more than 27% clay content then more than likely the horizon you are looking at is not a fragipan. Also, you will not find any rocks or course particles in the fragipan horizon. Fragipans actually are light in clay content. They have angular to platy structure and they are resistant to pressure. If you took an individual moist structure from the fragipan and placed it between your thumb and forefinger, you would have a difficult time crushing the sample. If enough pressure was applied the ped would eventually explode rather than break apart like other peds from different horizons.

If you were to take your knife and dig into the fragipan you will notice the resistance much more than if you were to dig into the overlying horizons. Use your knife as an extension of your fingers to feel the soil.

Dense glacial till

Dense glacial till is a restrictive layer that occurs in the glaciated landscape. This restrictive horizon is actually a parent material and not classified as soil. However, dense till has an influence the overlying soil horizons.

Dense glacial till can be detected using your soil knife. Using the soil knife you will notice an increase in resistance as you probe enter the densic material. Dense glacial till will sometimes have fracture seams that run vertically in the parent material. These seams are grey in color similar to the seams of a fragipan. Unlike the fragipan, dense till will have an assortment of particles and rock fragments. Dense glacial till can also have a texture of loam or clay loam. Also, dense glacial till will react to HCl acid and fragipans do not react to HCl acid. Other characteristics of the till are discussed in the section about parent material.

High Clay horizon

A horizon with high clay content restricts the flow of water. Therefore a horizon that has greater than 45% clay content is considered a restrictive layer.

Bedrock

Bedrock is another densic material that limit root growth and restricts the flow of water. Both weathered bedrock and solid bedrock are considered restrictive layers.

Compacted Fill Material

Summarizing a soil description

After you have examined and evaluated the soil you will have determined slope, slope position, picked out horizons, established the depth of each horizon, determined color, established texture for each horizon, determined structure, picked out redox depletions and concentrations, classify drainage class, determined parent materials, and determined restrictive layers. As a result, you have described the soil. Therefore, interpretations for on-site septic systems, home sites, erosion potential, cropping intensity, and land use management practices.

V. Recommended Best Management Practices to Consider Agricultural Use

Recommended Best Management Practices to Consider. (back of card)

a. Soil Erosion

Problem of condition	BMP Reasoning
Cover Crops Any of the following present: > 2 - 18% slopes; flood plain; medium surface texture; single grained, platy, or massive soil structure; topsoil depth less than 8"; poorly and very poorly drained soils; very shallow to restrictive features; slow or very slow infiltration; or few living organisms.	Cover Crops Cover crops with fine root system should be utilized to reduce soil erosion.
No Till/ Strip Till/ Maintain Residue Any of the following present: >2 - 18% slopes; single grained, platy, or massive soil structure; topsoil depth less than 8"; somewhat poorly drained soils; shallow or very shallow to restrictive features; or slow or very slow infiltration.	No Till/ Strip Till/ Maintain Residue Residue should be maintained at the surface to protect soil surface from erosion.
Grassed Waterway Should be used where water runoff from two adjacent slopes concentrates and flows at erosive rates which could create gullies – slopes should be evaluated within the flagged area.	Grassed Waterway Grassed waterways should be constructed and/or maintained to control erosion.
Contour farming/Strip Cropping Should be used on land with broad uniform slopes from >2-18% with moderately well and well drained soils. – slopes should be evaluated within the flagged area.	Contour farming/Strip Cropping Contour farming / strip cropping should be used to slow erosion. Contour farming should be utilized on 2 to 18% slopes, and strip cropping should be added to slopes from 6 to 18%.
Permanent Pasture Should be used when slopes are >18 to 25%.	Permanent Pasture Seeding of recommended grasses and or legumes should be done. Best management practices include mowing and controlled grazing.

Permanent Woodland Should be used when slopes are greater than 25%	Permanent Woodland Land should be planted with adapted trees
Riparian Buffers/Buffer Strip Should be used in floodplain landscapes.	Riparian Buffers/Buffer Strip Land should be vegetated with recommended grasses and or legumes to protect stream/water from runoff from adjacent land.
Surface Drainage Should be used when all of the following are present: nearly level land; infiltration is slow or very slow; and poorly/very poorly drained.	Surface Drainage Spinner and open ditches should be utilized to move sitting and or ponded water from landscape.
Heavy Use Pads Should be used on medium, moderately fine, and fine surface textured soils that are somewhat poorly or poorly/very poorly drained.	Heavy Use Pads If this site were to be used as a livestock feeding or watering area, heavy use pads should be constructed to protect the pasture and ensure herd health. The damaged areas are highly susceptible to erosion. (For the contest, do not evaluate present land use. If the soil conditions to the left are present, then this BMP should be selected.)
Slight Risk All of the following present: 0 to 2% slopes; coarse, moderately coarse, moderately fine or fine surface textures; granular or blocky structure; > 8" of topsoil; well or moderately well drained; deep and moderately deep to restrictive features; moderate or rapid infiltration; and common or many living organisms.	Slight Risk There is a slight risk for erosion at this site under the current management system. No other BMPs necessary.

b. Soil Compaction

Problem of condition	BMP Reasoning
Crop Rotation Crop rotations should be utilized in all agricultural practices. Crop rotations would not be used in permanent pasture or woodland sites.	Crop Rotation Crop rotation is an important management style that offers numerous benefits to the soil. Benefits include: improved soil structure, nutrient management, pest and pathogen control, and biodiversity.
Cover Crops Should be used if any of the following are present: platy or massive structure; <8" of topsoil; compaction in upper 10"; few living organisms.	Cover Crops Cover crops with tap root system, or a mixed rooting system should be utilized to break up soil compaction, and promote soil structure enhancement.
Controlled Traffic Any of the following present: Fine or moderately fine surface texture; fine subsurface texture; platy or massive structure; or poorly/very poorly drained.	Controlled Traffic Utilize controlled traffic management to limit the equipment load/compaction to permanent traffic lanes throughout the field.
Subsurface Drainage Should be used on soils with slopes <6% that are somewhat poorly or poorly/very poorly drained.	Subsurface Drainage Subsurface drainage improves air and water movement in the soil by removing excess water.
Inline Ripper Should be used with massive structure, or where compaction is present in the upper 10".	Inline Ripper Inline ripper with minimal surface disruption should be used to fracture compaction layer.
Permanent Pasture or Woodland Should be used when slopes are >18% *when this is selected , no other selection should be marked in this section	Permanent Pasture or Woodland Seeding of recommended grasses and or legumes should be done. Best management practices include mowing and controlled grazing.

Slight Risk All of the following present: coarse, moderately coarse, or medium texture in surface and subsoil; single grained or granular structure; > 8 inches of topsoil; well or moderately well drained; deep or moderately deep to restrictive features; no compaction layer in the upper 10”; common or many living organisms.	Slight Risk There is a slight risk for compaction at this site under the current management system.

c. **Water Quality**

Problem of condition	BMP Reasoning
<u>Cover Crops</u> Should be used if any of the following are present: >2 to 18% slopes; <4" of topsoil; compaction present in the upper 10"; slow or very slow infiltration; common or few living organisms.	<u>Cover Crops</u> Diverse cover crops with multiple rooting systems should be utilized to break up soil compaction, enhance infiltration, reduce erosion, scavenge nutrients, and promote soil structure enhancement.
<u>Grassed Waterways</u> Should be used where water runoff from two adjacent slopes concentrates and flows at erosive rates which could create gullies – slopes should be evaluated within the flagged area.	<u>Grassed Waterways</u> Grassed waterways should be constructed and/or maintained to protect sediments from entering water systems.
<u>Drainage Water Management</u> Should be used when all of the following are present: 0 to 2% slopes; and somewhat poorly, or poorly/very poorly drained soils.	<u>Drainage Water Management</u> Drainage water management structures hold back soil water in drainage systems for plant uptake in the growing seasons, and water control in the fallow seasons. Drainage water management structures are known to reduce nutrient loads in the water system.
<u>Increased Setbacks/Filter Strips</u> Should be used when site borders a stream or water course and any of the following are present: >2 to 18 percent slopes, very slow infiltration. – Pit information card will indicate if a bordering stream should be included in the observation.	<u>Increased Setbacks/Filter Strips</u> There is a high potential for surface runoff in these soils, with loss of nutrients and sediments. Setbacks should be increased, or filter strips installed to protect water systems.
<u>Blind Inlet</u> Should be used when somewhat poorly, or poorly/very poorly drained soils are in a closed depression landscape position.	<u>Blind Inlet</u> Blind inlets can be used to remove excess water from sites without an outlet. Blind inlets also will filter the water prior to discharge.

<u>Fertilizer placement preventing groundwater pollution.</u> Should be used if any of the following are present: coarse textured subsoil; slow or very slow infiltration. <u>Permanent Pasture or Woodland</u> Should be used when slopes are >18 *when this is selected , no other selection should be marked in this section <u>Slight Risk</u> All of the following present: < 2 percent slopes; moderately coarse, medium, moderately fine or fine subsoil textures; >4 inches of topsoil; well or moderately well drained; no compaction in the upper 10"; rapid or moderate infiltration; many living organisms.	<u>Fertilizer placement preventing groundwater pollution.</u> Fertilizers should be placed in the root zone of the soil profile to ensure soil interaction/contact. <u>Permanent Pasture or Woodland</u> Seeding of recommended grasses and or legumes should be done. Best management practices include mowing and controlled grazing. <u>Slight Risk</u> There is a slight risk for water quality degradation at this site under the current management system. No other BMPs necessary.

Soil Fertility

A growing crop uses its roots to extract nutrients from the soil. The continuous growth and harvest of crops removes nutrients from the soil. Often, the soil in unable to provide enough nutrients for the crop to reach its yield potential. Therefore, the farmer will need to add nutrients to the soil through fertilization.

The primary plant nutrients that are provided absorbed by plant roots are nitrogen, phosphorus, and potassium.

The soil fertility recommendations used in this contest are based on the *Tri-State Fertilizer Recommendation for Corn, Wheat, Alfalfa, and Soybeans – Ohio State University Extension Bulletin E-2567.* These recommendations are based on field studies and represent the best, generally accepted recommendations for fertilizer application rates.

Nitrogen

Nitrogen is a relatively mobile nutrient. Unlike the other macronutrients, nitrogen cannot be built up to in the soil. Nitrogen can move with water, and therefore can be lost through leaching. Also, prolonged period of wetness can cause nitrogen to be lost through denitrification. There is also no completely reliable test for soil nitrogen. Since nitrogen is both mobile and difficult to quantify, fertilizer recommendations for nitrogen are based on the crop and the expected crop yield.

Due to its mobility, nitrogen lost from farm fields is an environmental concern. Nitrogen that is lost through leaching can end up in surface water. Nitrogen can contaminate drinking water sources and present serious risks to public health. Excess nitrogen in surface water also promotes the growth of undesirable algae, leading to problems such as hypoxia and harmful algal blooms.

Corn and wheat are grass crops that require nitrogen fertilization. Soybeans and alfalfa are legumes and able to fix nitrogen from the air to fulfill their nitrogen needs. Plants that are able to fix nitrogen do not typically require nitrogen fertilization.

For the contest, *the students will be given a target crop from the following list: corn, soybeans, wheat, or alfalfa. This target crop will be provided with the Site Information at each soil pit.*

For corn and wheat:

Apply nitrogen

For soybeans and alfalfa:

Do Not Apply

Phosphorus

There are reliable soil tests for phosphorus which indicate that amount of plant available nutrient present in the soil. These soil tests are the basis for fertilizer application rate recommendations. Logically, soils with a low test level require higher rates of fertilization than soils with higher test levels.

Compared to nitrogen, phosphorus is a relatively immobile soil nutrient. The amount of phosphorus in the soil can be increased. Fertilization in excess of crop need will raise soil test values. However, not all phosphorus applied to soil will remain. Some can be lost though runoff and leaching, which can pollute surface water. Excess phosphorus in surface water can stimulate algae growth and lead to harmful algal blooms.

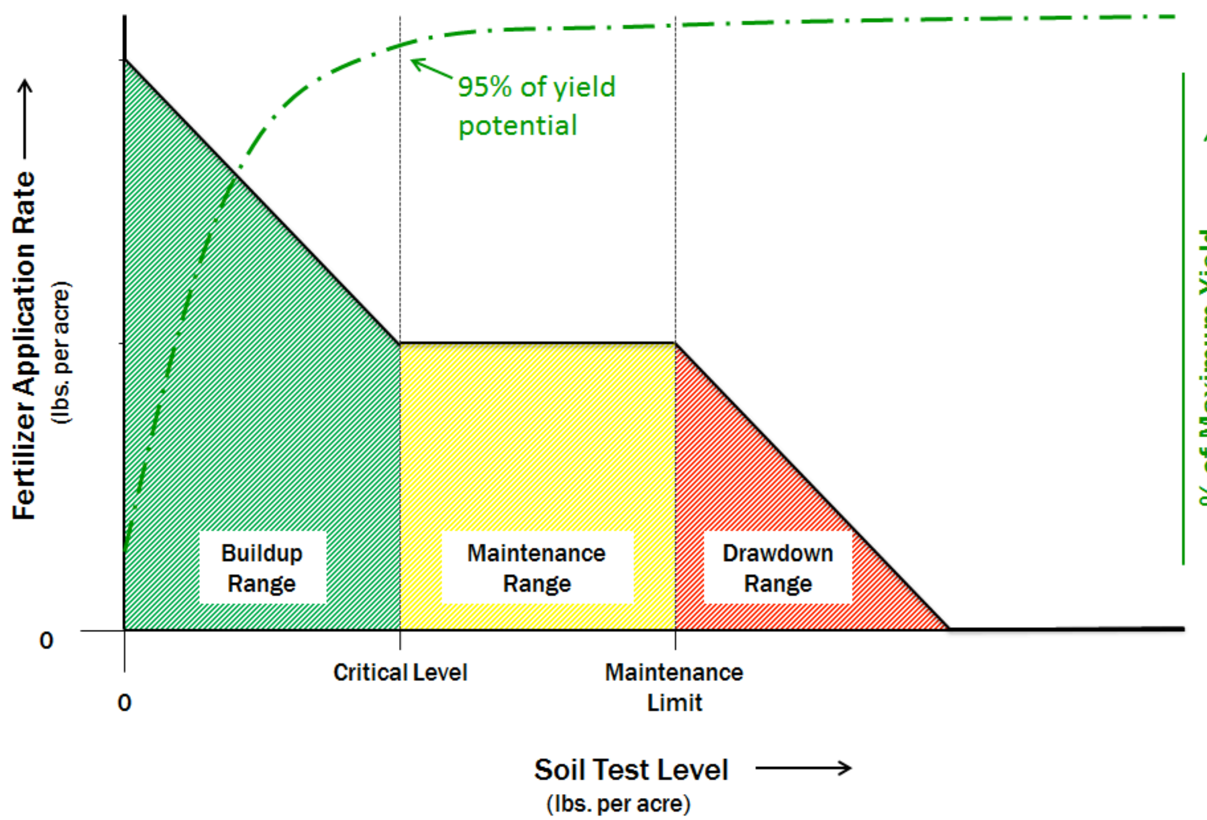
The risk of phosphorus loss and negative environmental impact is greater when soil test levels are high.

The fertilizer recommendations in the Tri-State Bulletin are based on a conceptual model illustrated in the figure below. In the soil there is a **critical level.** If the soil tests are below this critical level, then the soil may not be able to supply enough nutrient to optimize plant growth. When soil tests are below the critical value, excess fertilizer should be added to the soil to build up the fertility until soil test levels are above the critical level.

If the soil test values are between the critical value and the **maintenance limit**, then fertilizer should be applied to replace the nutrients lost each year through harvest – known as the maintenance rate. In this range, the soil fertility is adequate, and the strategy is to apply only enough fertilizer to maintain this fertility and soil test level.

If the soil test values exceed the maintenance limit, then there is no agronomic reason to apply additional fertilizer. Crops would not be expected to respond to the additional fertilizer. This is the drawdown range, and the strategy should be to utilize residual soil nutrients and reduce soil test levels.

Tri-State Fertilizer Recommendations and Yield Response Curve



For the contest, *the students will be given a phosphorus soil test level (in pounds per acre) and a target crop from the following list: corn, soybeans, wheat, or alfalfa. This information will be provided with the Site Information at each soil pit.*

For corn and soybeans:

Build up *if the soil test level is < 30 pounds per acre*

Maintain *if the soil test level is 30 to 60 pounds per acre*
Draw Down *is the soil test level is > 60 pounds per acre*

For wheat and alfalfa:

Build up *if the soil test level is < 50 pounds per acre*
Maintain *if the soil test level is 50 to 80 pounds per acre*
Draw Down *is the soil test level is > 80 pounds per acre*

Potassium

There is also a reliable soil tests for potassium which can be used to make fertilizer application rate recommendations.

Potassium is also relatively immobile in the soil, so it can be built up in a manner similar to phosphorus. Unlike nitrogen and phosphorus, potassium is not associated with pollution and environmental concerns.

(In the Tri-State guide, potassium recommendations are based on the soil test level and the soil's capacity to hold nutrients, also known as the Cation Exchange Capacity. This complexity of the Cation Exchange Capacity is beyond the scope of this guide and contest. For this contest, the critical level and maintenance limits are based on an "average" Cation Exchange Capacity of 10.)

The critical level for soil test phosphorus is 200 pounds per acre. If the soil test is below this level, then the fertilizer should be applied at a rate that will built soil fertility.

The maintenance level for potassium is 300 pounds per acre. If soil tests levels are above this level, then soil test levels can be drawn down by applying little or no fertilizer.

For the contest*, the students will be given a phosphorus soil test level (in pounds per acre) and a target crop from the following list: corn, soybeans, wheat, or alfalfa. This information will be provided with the Site Information at each soil pit.*

For all crops:

Build up *if the soil test level is < 200 pounds per acre*
Maintain *if the soil test level is 200 to 300 pounds per acre*
Draw Down *is the soil test level is > 300 pounds per acre*

Soil Acidity (pH)

The availability of nutrients in the soil is rules by the complexities of soil chemistry. Ruling this system is the soil acidity, measured by the soil pH. Most crops do well in soil that is near neutral (pH 7). If the soil is too acidic or too basic, the plant will no longer be able to extract some nutrients from the soil.

Farmers can manage the soil pH through soil amendments. If the soil pH is below 6.4, the application of lime is recommended. Lime will lower the acidity (raise the pH). Lime is any amendment that will raise the pH, generally crushed limestone.

It is uncommon for the soil in Ohio to have a pH above 8.0. If the soil pH is above 7.9, then the pH should be lowered through the addition of sulfur or a similar amendment.

For the contest*, the students will be given a soil pH with the Site Information at each soil pit.*

Raise *if the pH is below 6.4*
Maintain *if the pH 6.4 - 7.9*
Lower *if the pH is above 7.9.*

Fertility Section Summary

Nitrogen	**Do Not Apply** Soybeans and alfalfa	**Apply** Corn and wheat	
Phosphorus	**Build Up** Corn and soybeans < 30 lbs. per ac. Wheat and alfalfa <50 lbs. per ac.	**Maintain** Corn and soybeans 30 - 60 lbs. per ac. Wheat and alfalfa 50 - 80 lbs. per ac.	**Draw Down** Corn and soybeans > 60 lbs. per ac. Wheat and alfalfa > 80 lbs. per ac.
Potassium	**Build Up** < 200 lbs. per ac.	**Maintain** 200 - 300 lbs. per ac.	**Draw Down** > 300 lbs. per ac.
pH	**Raise** < 6.4	**Maintain** 6.4 - 7.9	**Lower** >7.9

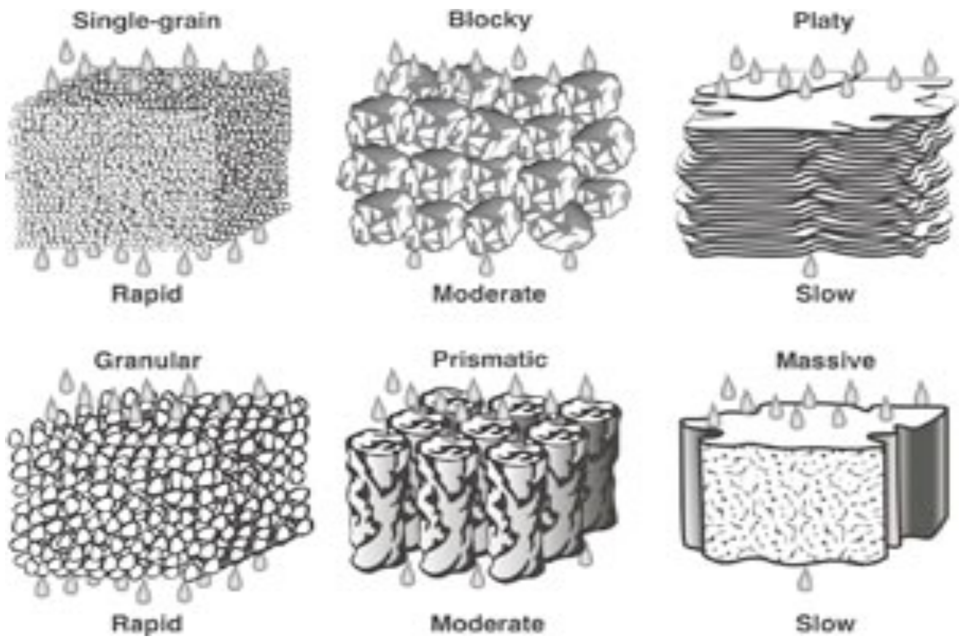
Infiltration

Infiltration is a measure of how fast water enters soil from the surface. Good infiltration is important to soil quality because water that enters the soil too slowly may lead to ponding or erosion from surface runoff. Additionally, poor infiltration will not allow for proper soil filtration of nutrients.

For the purpose of this contest, infiltration will be evaluated based on the texture and structure of the topsoil.

- *Rapid*: Rapid infiltration has slight limitations for erosion, water quality, and soil health. Water moves into the soil fast enough that the risk for erosion, water quality issues, and soil health is eliminated. Soils with rapid infiltration are coarse textured with any structure in the surface.
- *Moderate*: Moderate infiltration has slight limitations for erosion, water quality, and soil health. Water moves into the soil fast enough that the risk for erosion, water quality issues, and soil health is eliminated. These soils are moderately coarse textured soils with any structure, medium textured soils with granular and blocky structures, and moderately fine textures with granular structure.
- *Slow*: Slow infiltration has a severe rating for erosion, and is moderate for water quality and soil health. These soils are highly prone to erosion, and have the potential for water quality degradation, and poor soil health. These soils are moderately fine textured with blocky structure, and fine textured with granular or blocky structure.
- *Very Slow*: Very slow infiltration has a severe rating for soil erosion, water quality, and soil health. These soils are highly prone to issues with erosion, water quality degradation, and poor soil health. These soils are medium, moderately fine, and fine textured soils with platy or massive structure in the surface.

		Structure				
		Single Grained	**Granular**	**Blocky**	**Platy**	**Massive**
Texture	**Coarse**	Rapid	Rapid	Rapid	Rapid	Rapid
	Mod. Coarse	-	Moderate	Moderate	Moderate	Moderate
	Medium	-	Moderate	Moderate	Very Slow	Very Slow
	Mod. Fine	-	Moderate	Slow	Very Slow	Very Slow
	Fine	-	Slow	Slow	Very Slow	Very Slow



Living Organisms

Soil is not an inert growing medium, but rather an ecosystem with billions of bacteria, fungi, and other microbes. In contrast to the underlying parent material, soil has been altered by the interactions of climate, relief, and living organisms.

The basic needs of life can be found in the soil. The soil itself provides shelter. Water and air can readily infiltrate from the surface. This environment is so hospitable to life that millions of species and billions of organisms live in the soil. In fact, there are more soil microorganisms in a teaspoonful of soil than there are people on the earth.

The creatures living in the soil are critical to soil health. They give the soil structure, and therefore reduce soil erosion and increase water infiltration and availability. They decompose organic matter and cycle nutrients, and therefore affect plant growth. Finally, a large proportion of the world's genetic diversity is found in the soil.

The healthiest soils are those with a diversity and abundance of life. Farmers with the healthiest soils nurture that life by creating a diversity of plant life above the soil surface, with year-round ground cover, no tillage, and judicious pesticide use.

Roots and pore spaces are an indicator of healthy soils and will be used for the soil CDE to determine living organisms. Soil roots and pores are described based on quantity, size and location in a 10cm x 10cm ($100cm^2$) assessment area. Roots and pores in the assessment area are counted to determine the amount and size of the roots. The following table is used to determine the amount of roots, and pores in a soil horizon.

For consistency, judges will provide students with the number of roots and pores per $100cm^2$ in the topsoil. This information will be provided on the pit information card at each site. Student will need to use that information to determine the quantity class of living organisms. The quantity class table below will be used.*note – very few and moderately few will not be used for the CDE contest.

Quantity Class [1]	Code		Average Count [2] (per assessed area)
	Conv.	NASIS	
Few	1	#	<1 per area
Very Few [1]	—	#	<0.2 per area
Moderately Few [1]	—	#	0.2 to <1 per area
Common	2	#	1 to <5 per area
Many	3	#	≥5 per area

Diagram from Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Urban Use

Recommended Best Management Practices to Consider. (back of card)

a. Soil Erosion

Problem of condition	BMP Reasoning
Slopes between 6 and 35 percent	- Moderate to extensive landshaping is required; a protective soil cover should be used to reduce erosion during construction.
Areas subject to flooding, slippage, subsidence, seasonal high water table less than 8 inches on nearly level concave slope, or slopes greater than 35 percent	- Choose an alternate site. *when this is selected , no other selection should be marked
Fine texture present in the subsoil or substratum	- Basement walls should be reinforced and porous material used for backfill to reduce damage from shrinking and swelling.
Seasonal high water table present within 40 inches	- Footer drains, elevated site, exterior waterproofing coatings on the basement walls, and granular porous material for backfill should be used to prevent wet basements.
Single grained soil structure in the subsoil	- Basement excavation should include 3/1 side slopes to decrease the likelihood of soil sloughing and undercutting.
Bedrock within 60 inches	- Moderate to extensive excavation of bedrock is required, or redesign the building to accommodate the site.
No moderate or severe limitations	- Good site; limitations are easy to overcome.

d. Sewage Treatment Systems ***Choose 1, most appropriate**

Problem or soil condition	BMP Reasoning
Slopes greater than 18 percent	- Manufacturer's prohibitions and instructions should be followed when installing components on steep slopes. An alternative method of distribution should be used.
Areas subject to flooding, slippage or subsidence	- Choose an alternate site.
Any of the following present: Slopes 6 to 12 %; coarse or fine texture in any layer; single grained, platy or massive soil structure; or moderately deep to restrictive soil features or bedrock.	- Use an alternative system or design component such as drip distribution, spray irrigation, or an approved pretreatment device to ensure uniform dispersal and water quality standards.
Seasonal high water table within a depth of 16 inches, with no other moderate or severe limitations.	- Design and implement an engineered drainage system to effectively lower the seasonal water table.
Less than 20 inches to restrictive soil features or bedrock.	- Elevate the infiltrative surface of soil absorption components above the ground surface to increase the vertical separation distance through the use of approved sand fill material.
No moderate or severe limitations	- Conventional leaching trenches will work well on this site.

e. Driveways and Local Roads

Problem or soil condition	BMP Reasoning
Slopes greater than 6 percent	- Contruct driveways and local roads across the slope to reduce the angle of incline. Place drainage ditch on the upslope side.
Flood plains	- Elevate driveways and local roads above the anticipated high water level
Soils subject to slippage or subsidence	- Costly measures are needed to reduce the hazard of slippage or subsidence.
Any of the following present: medium textured soil in any layer; moderately fine textured soil in the surface; or single grained and granular structure in the subsoil.	- Replace the surface soil and/or subsoil with suitable base material to prevent damage due to low soil strength.
Seasonal high water table within a depth of 16 inches	- Surface and/or subsurface drainage is needed to reduce wetness and increase soil strength.
Bedrock within a depth of 40 inches	- Costly measures are needed for excavating, filling, and grading roadbeds and driveways.
No moderate or severe limitations	- Good site; limitations are easy to overcome.

f. Lawns Gardens and Landscapes

Problem or soil condition	BMP Reasoning
Slopes greater than 6 percent	- Avoid unnecessary cutting of the soil during construction. Provide mulch on new lawns and around trees and shrubs to prevent erosion.
Areas subject to slippage or subsidence	- Choose an alternate site. . *when this is selected , no other selection should be marked
Soils subject to flooding	- Use and manage this site within its limitations
Fine, moderately fine, or coarse surface texture	- Mix an adequate layer of medium topsoil in the existing soil surface layer.
Any of the following present: fine, moderately fine, or coarse subsoil or substratum texture; or platy or massive subsoil structure.	- Use plants adapted to adverse subsoil conditions or use an 8 inch cover of medium topsoil to increase the favorable soil depth.
Seasonal high water table within a depth of 16 inches	- Provide surface and/or subsurface drainage. Use plants tolerant of wetness.
Bedrock or restrictive soil feature within a depth of 30 inches	- Select shallow rooted trees and shrubs. Use a medium cover of soil material to increase soil depth to at least 30 inches
No moderate or severe limitations	- Good site; limitations are easy to overcome.