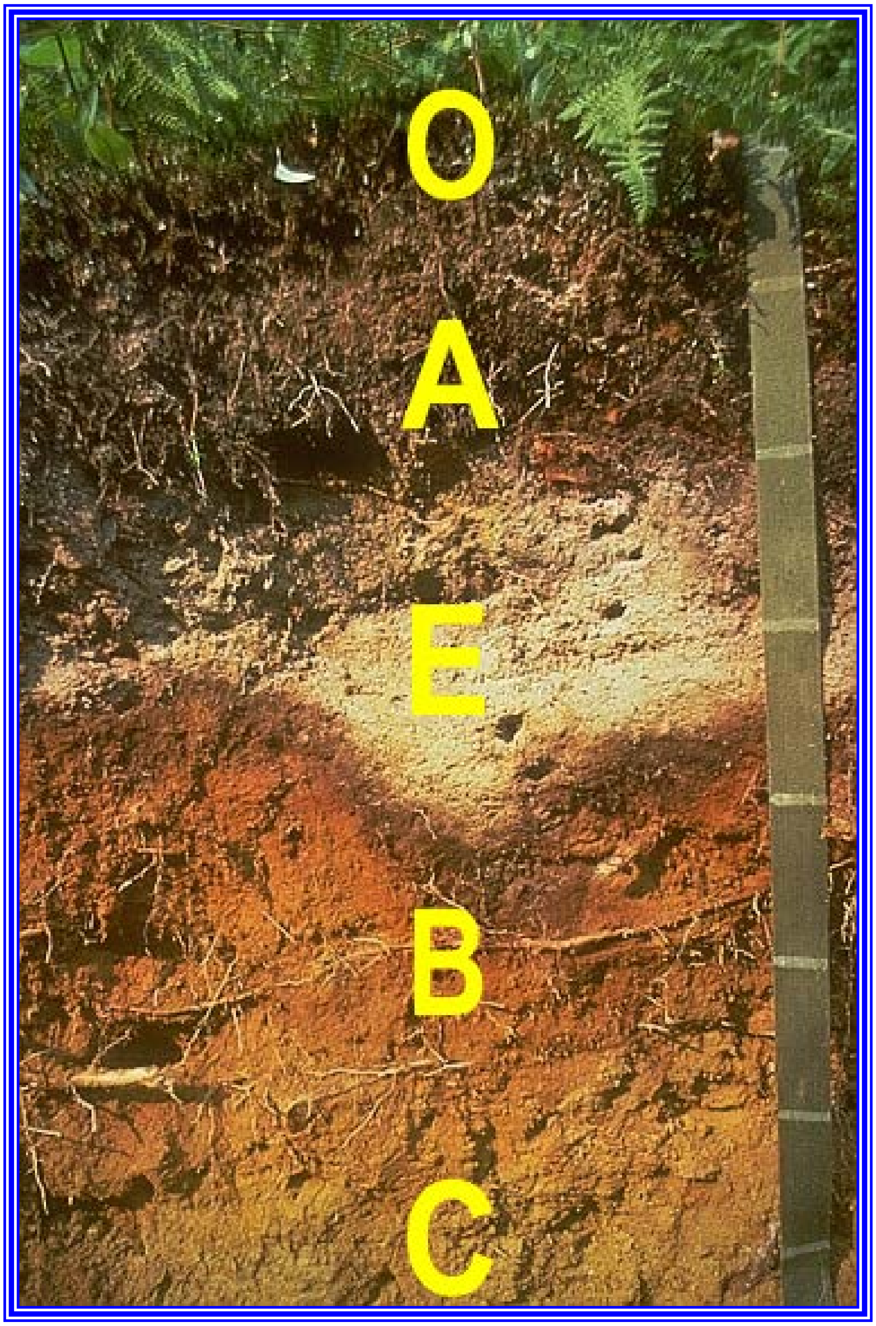
Maryland Envirothon Soil Study Guide



Compiled by the Maryland Envirothon Soils Workgroup September 2002

- Dan Bard – Maryland Department of Agriculture
- Barry Burch – Frederick County Board of Education
- Carl Robinette – USDA, Natural Resources Conservation Service
- Elmer Weibley – Washington County Soil Conservation District
- Chad Wentz – USDA, Natural Resources Conservation Service
- Lenore Vasilas-– USDA, Natural Resources Conservation Service

Revised 2017 by James Brewer - USDA, Natural Resources Conservation Service

Introduction

Sustaining our soil productivity and the management of our other natural resources is an important concern of farmers, rural landowners, homeowners and governmental agencies. This document will provide the scope by which farmers and landowners utilize soil and water conservation plans to maintain these important resources. It will also identify best management practices that will conserve, protect and enhance their land.

As soil scientists analyze and examine soils, they believe texture is the most important aspect of a soil. By determining a soil's texture, an individual is able to characterize the interrelationships among the other soil properties of the soil. Hence, the individual is better informed as to the ability and the uses of the land.

Stated below are objectives that an individual can learn to improve their awareness and knowledge of soils and its capabilities:

1. Recognize the factors affecting soil formation and the composition of the soil.
2. Identify the various landforms and associated soil parent materials.
3. Identify in the field soil properties (such as texture, depth of bedrock, seasonal high water table, flooding, slope, etc.) that directly impact soil interpretations.
4. Utilize the soil survey to develop an assessment of the limitations for regional land us planning.
5. Develop an understanding of the soil properties that affect soil health and soil quality.
6. Determine the health and quality of the soil in the field.
7. Develop an understanding of, and the ability to apply the Land Capability Classification System in an effort to protect farmland from urban pressure.
8. Develop an understanding of the soil's impact on the hydrologic cycle.

We encourage the use of this document to develop a better understanding of soils, the factors associated with soils development, and its uses, as well as soil conservation districts and the various means to control soil erosion and water quality degradation.

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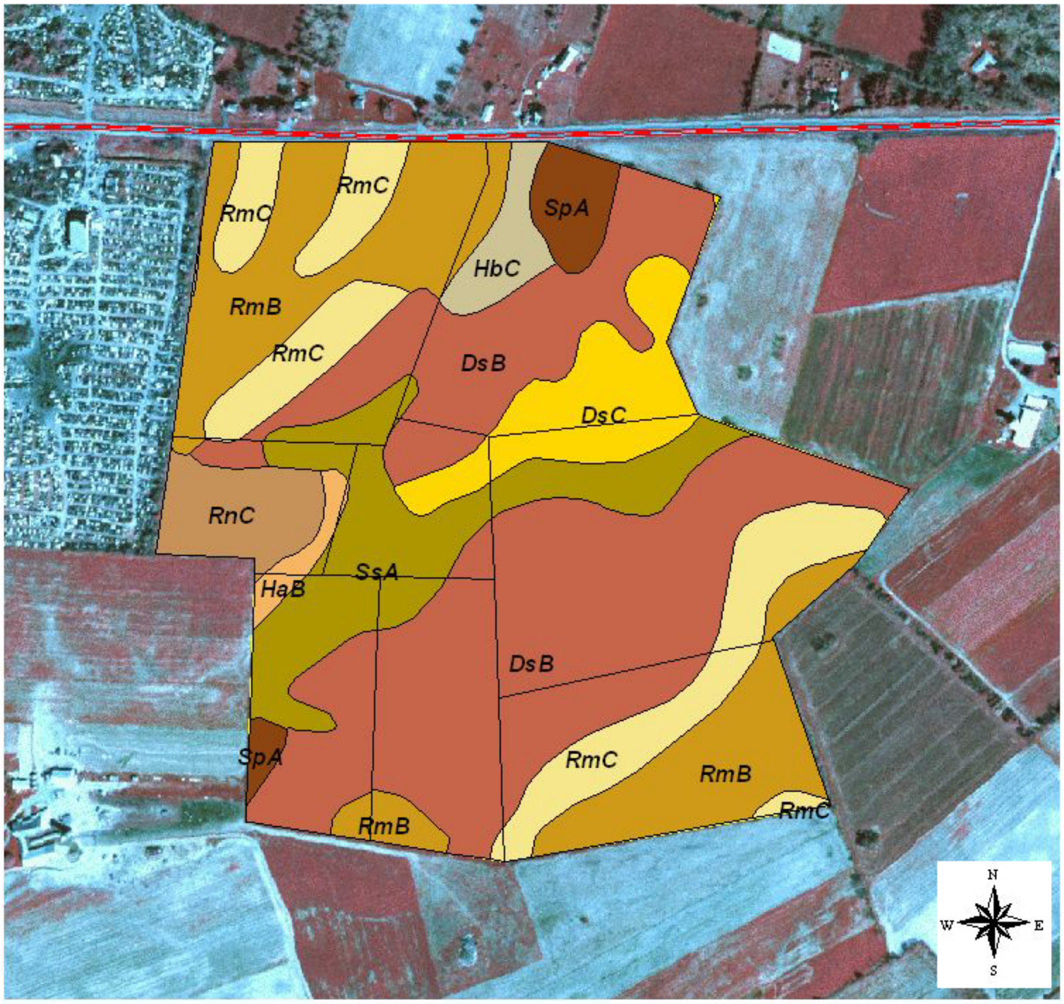
Soils Map



500 0 500 1000 1500 Feet

Maryland Conservation Partnership

Soil Descriptions - Non-Technical

Anywhere County, Maryland

Only those map units that have entries for the selected non-technical description categories are included in this report.

Map DsB - Duffield silt loam, 3 to 8 percent slopes
Description Category: SO5

THE DUFFIELD SERIES CONSISTS OF VERY DEEP AND DEEP, WELL DRAINED SOILS ON UPLANDS. THEY FORMED IN MATERIAL WEATHERED FROM IMPURE LIMESTONE. TYPICALLY THESE SOILS HAVE A DARK GRAYISH BROWN SILT LOAM SURFACE LAYER 10 INCHES THICK. THE SUBSOIL FROM 10 TO 53 INCHES IS YELLOWISH-BROWN AND BROWNISH-YELLOW SILTY CLAY LOAM. THE SUBSTRATUM FROM 53 TO 60 INCHES IS YELLOWISH-BROWN SHALY SILT LOAM. SLOPE RANGE FROM 0 TO 35 PERCENT.

Map DsC - Duffield silt loam, 8 to 15 percent slopes
Description Category: SO5

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Map HaB - Hagerstown silt loam, 3 to 8 percent slopes
Description Category: SO5

THE HAGERSTOWN SERIES CONSISTS OF VERY DEEP, WELL-DRAINED, REDDISH SOILS ON UPLANDS. THEY FORMED IN MATERIALS WEATHERED FROM HARD LIMESTONE. TYPICALLY THESE SOILS HAVE AN 8 INCH PLOW LAYER OF BROWN OR DARK BROWN SILT LOAM. THE MATERIAL BELOW THIS DEPTH AND EXTENDING RATHER UNIFORMLY TO BEDROCK IS GENERALLY YELLOWISH RED CLAY OR SILTY CLAY, WITH LIMESTONE FRAGMENTS COMMON IN THE LOWER SUBSOIL AND SUBSTRATUM. SINK HOLES OCCUR IN SOME PLACES. LIMESTONE ROCK OUTCROPS ARE VERY COMMON BUT SOIL CAN USUALLY BE FARMED BETWEEN OUTCROPS. SLOPES RANGE FROM 0 TO 60 PERCENT.

Map HbC - Hagerstown silty clay loam, 8 to 15 percent slopes, very rocky
Description Category: SO5

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Map RmB - Ryder-Duffield channery silt loams, 3 to 8 percent slopes
Description Category: SO5

THE RYDER SERIES CONSISTS OF MODERATELY DEEP, WELL-DRAINED SOILS ON UPLANDS. THEY FORMED IN MATERIAL WEATHERED FROM SHALY LIMESTONE. TYPICALLY, THESE SOILS HAVE A YELLOWISH BROWN SILT LOAM SURFACE LAYER 8 INCHES THICK. THE SUFSOIL FORM 8 TO 30 INCHES IS YELLOWISH-BROWN FRIABLE SILT LOAM IN THE UPPER PART AND LIGHT YELLOWISH-FROWN FIRM CHANNERY SILTY CLAY LOAM IN THE LOWER PART. THE SUBSTRATUM FROM 30 TO 35 INCHES IS YELLOWISH-BROWN AND BROWN VERY CHANNERY SILT LOAM. SHALY LIMESTONE IS AT 35 INCHES

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Map RmC - Ryder-Duffield channery silt loams, 8 to 15 percent slopes
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Map RnC - Ryder-Nollville channery silt loams, 8 to 15 percent slopes
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THE NOLLVILLE SERIES CONSISTS OF DEEP, WELL DRAINED SOILS ON UPLANDS. THEY FORMED IN RESIDUAL MATERIALS DERIVED FROM ARGILLACEOUS LIMESTONE AND LIMY SHALE NOLLVILLE SOILS ARE ON CONVEX UPLAND RIDGES OF LOW RELIEF. TYPICALLY THESE SOILS HAVE A DARK YELLOWISH BROWN CHANNERY SILT LOAM SURFACE LAYER 10 INCHES THICK. THE SUBSOIL FROM 10 TO 29 INCHES IS YELLOWISH BROWN SILTY CLAY LOAM OR ITS CHANNERY ANALOGUE, AND FROM 29 TO 41 INCHES IS STRONG BROWN SILTY CLAY. THE SUBSTRATUM FROM 41 TO 57 INCHES IS STRONG BROWN VERY CHANNERY SILTY CLAY LOAM. SLOPES RANGE FROM 3 TO 35 PERCENT.

Map SpA - Swanpond silt loam, 0 to 3 percent slopes
Description Category: SO5

THE SWANPOND SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, SLOWLY PERMEABLE SOILS. THEY FORMED IN RESIDUUM WEATHERED FROM CALCAREOUS SHALE AND LIMESTONE ROCK, ON BROAD FLAT SUMMITS, BACKSLOPES, DEPRESSIONS, AND UPLAND DRAINAGE SWALES. TYPICALLY THESE SOILS HAVE A BROWN SURFACE LAYER 12 INCHES THICK. THE SUBSOIL FROM 12 TO 70 INCHES IS A YELLOWISH BROWN CLAY. THE SUBSOILS FROM 70 TO 73 INCHES IS A BROWNISH YELLOW SILTY CLAY. SLOPES RANGE FROM 0 TO 8 PERCENT.

Map SsA - Swanpond-Funkstown silt loams, 0 to 3 percent slopes
Description Category: SO5

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THE FUNKSTOWN SERIES CONSISTS OF VERY DEEP, MODERATELY WELL DRAINED, MODERATELY PERMEABLE SOILS ON UPLAND DRAINAGEWAYS AND HEAD SLOPES. THEY FORMED FROM LOCAL ALLUVIAL AND COLLUVIAL MATERIALS OVERLYING LIMESTONE RESIDIUUM. TYPICALLY THE SURFACE IS YELLOWISH BROWN SILT LOAM FROM 0 TO 12 INCHES, FOLLOWED BY STRONG BROWN GRAVELLY SILT LOAM FROM 12 TO 22 INCHES. THE UPPER SUBSOIL IS STRONG BROWN VERY GRAVELLY SILT LOAM FROM 22 TO 30 INCHES. THE LOWER SUBSOIL AND SUBSTRATUM IS YELLOWISH BROWN OR YELLOWISH RED SILTY CLAY LOAM, CLAY LOAM OR SILT LOAM. SLOPE RANGES FROM 0 TO 3 PERCENT.

This section of the manual includes material from the NRCS publications ***From the Surface Down*** *and* ***Field Book for Describing and Sampling Soils****, the University of Maryland publication* ***A Guide to Landjudging in Maryland*** *and the GLOBE program's publication* ***GLOBE 2002 Teachers Guide - Soils Chapter****. For more information, citations and websites for these publications are listed at the end of this section.*

Overview

Soils are a thin layer on top of most of the earth's land surface. This thin layer is a basic natural resource. Soils deeply affect every other part of the ecosystem. They are used by humans to meet many needs. Soils hold nutrients and water for plants and animals. Water is filtered and cleansed as it flows through soils. Soils affect the chemistry of water and the amount of water that returns to the atmosphere to form rain. The food we eat and most of the material we use for paper, buildings and clothing are dependent on soils. Much of our life's activities and pursuits are related and influenced by the behavior of the soil around our houses, roads, septic and sewage disposal systems, airports, parks, recreation sites, farms, forests, schools, and shopping centers. What is put on the land should be guided by the soil that is beneath it.

Land is a natural resource as are water and mineral deposits. It is essentially fixed; more land cannot be made, except what little might be reclaimed from the sea or filled into water bodies. Much land and its associated soil resources have been misused. Many acres misused to the point where reclamation is nearly impossible or impractical. As our population increases and the pressure for land intensifies, it is important that the wisest use be made of this resource. We can no longer afford to mismanage land and soil.

SOIL COMPOSITION

Soils are composed of three main ingredients: minerals of different sizes; organic materials from the remains of dead plants and animals; and open space that can be filled with water or air. A good soil for growing most plants should have about 45% mineral (with a mixture of sand, silt and clay), 5% organic matter, 25% air, and 25% water (fig. 1).

Soils are dynamic and change over time. Some properties, such as temperature and water content change very quickly. Others, such as mineral transformations, occur very slowly over hundreds or thousands of years.

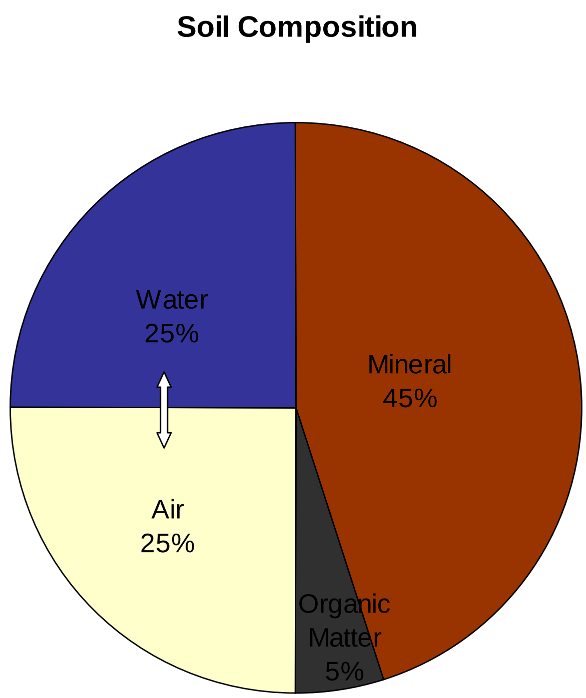

Figure 1. The relative proportion of mineral, organic matter, air and water in a soil that is optimum for growing plants.

FACTORS OF SOIL FORMATION

Soils are natural expressions of the environment in which they were formed. They are derived from an infinite variety of materials that have been subjected to a wide spectrum of climatic conditions. Soil development is influenced by the topography on which soils occur, the plant and animal life which they support and the amount of time which they have been exposed to these conditions.

Soi1 scientists recognize five major factors that influence soil formation: 1) parent material, 2) climate, 3) living organisms (especially native vegetation), 4) topography and 5) time. The combined influence of these soil-forming factors determines the properties of a soil and their degree of expression (fig. 2).

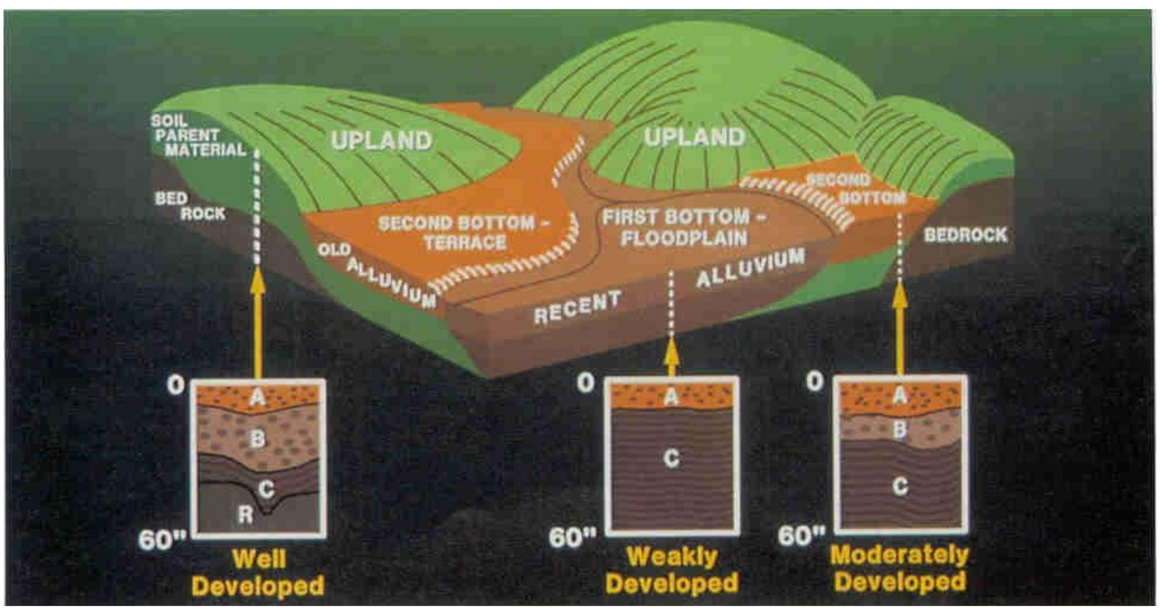

Figure 2. The five factors of soil formation affect the processes that influence soil development.

Parent Material

Parent material refers to organic (such as fresh peat) and mineral material in which soil formation begins. Mineral material includes partially weathered rock, ash from volcanos, sediments moved and deposited by wind and water, or ground up rock deposited by glaciers. The material has a strong effect on the type of soil developed as well as the rate at which development takes place. Soil development may take place quicker in materials that are more permeable to water. Dense, massive, clayey materials can be resistant to soil formation processes.

Bedrock such as limestone, sandstone, shale, granite, gneiss and schist, slate, marble and many others break down into **residuum** (residue) through the weathering process. It is this residuum that becomes the parent material of soil and imparts some of the parent characteristics into the resulting soil profile.

Soil material and rock fragments may fall, roll or slide downslope under the influence of gravity and water. This incoherent mass of material that generally accumulates on the lower portion of slopes and in depressions is called **colluvium**. Rock fragments in colluvium generally are angular in contrast to the rounded waterworn cobbles and stones found in alluvium and glacial outwash.

Streams and rivers commonly overflow their banks and deposit fresh materials on the floodplains. These fresh or recent deposits, commonly topsoil, comprise the parent materials for the soils developed on these floodplains. Since there is new material added almost annually, the soils never have time to form well-developed horizons. Therefore, these young soils have poorly developed profiles, and most of their character is inherited from the parent material. This type of parent material exceeds 0.5 m (20 in.) in depth, and it is referred to on the scorecard as **recent alluvium**.

Soils located on stream terrace positions that contain water worn coarse fragments have parent materials referred to as **old alluvium**. These soils were originally deposited by water and commonly have had time to form well-developed horizons. They never or rarely flood, and thus are not influenced by deposition of fresh materials.

In the Mid-Atlantic region, large areas are underlain by the complex series of water-deposited sediments left by previous geologic events. These older sediments comprise the Coastal Plain along the Atlantic seaboard. In Maryland, these materials occupy half of the land area, and they comprise nearly all the parent material for Delaware soils and large segments of New Jersey. These **Coastal Plain sediments**, although much older than the recent alluvium along streams, have not been cemented and consolidated into bedrock--thus, the name unconsolidated sediments. Often these sediments have been capped or coated with a thin (several cm to several m) veneer or sheet of material consisting mainly of silt (loess). The wind may have carried this material from the glacial outwash areas before the rise in sea level that formed the Chesapeake Bay. The Coastal Plain soils are formed in these sediments and silt-cap parent materials. Therefore, soils occurring on the upland portions of the Coastal Plain are considered to have Coastal Plain sediments as their parent materials on the scorecard. Recent alluvium can and does occur on the Coastal Plain in the same landscape positions (along streams and rivers) as in other sections of the state.

Climate

Climate is a major factor in determining the kind of plant and animal life on and in the soil. It determines the amount of water available for weathering minerals, transporting the minerals and releasing elements. Climate, through its influence on soil temperature, determines the rate of chemical weathering.

Warm, moist climates encourage rapid plant growth and thus high organic matter production. The opposite is true for cold, dry climates. Organic matter decomposition is also accelerated in warm, moist climates. Under the control of climate freezing, thawing, wetting, and drying break parent material apart.

Rainfall causes leaching. Rain dissolves some minerals, such as carbonates, and transports them deeper into the soil. Some acid soils have developed from parent materials that originally contained limestone. Rainfall can also be acid, especially downwind from industrial processes.

Living organisms

Plants affect soil development by supplying upper layers with organic matter, recycling nutrients from lower to upper layers, and helping to prevent erosion. In general, deep rooted plants contribute more to soil development than shallow rooted plants because the passages they create allow greater water movement, which in turn aids in leaching. Leaves, twigs, and bark from large plants fall onto the soil and are broken down by fungi, bacteria, insects, earthworms, and burrowing animals. These organisms eat and break down organic matter releasing plant nutrients. Some change certain elements, such as sulfur and nitrogen, into usable forms for plants.

Microscopic organisms and the humus they produce act as a kind of glue to hold soil particles together in aggregates. Well-aggregated soil is ideal for providing the right combination of air and water to plant roots.

Animals living in the soil affect decomposition of waste materials and how soil materials will be moved around in the soil profile.

Landscape position

Landscape position causes localized changes in moisture and temperature. When rain falls on a landscape, water begins to move downward by the force of gravity, either through the soil or across the surface to a lower elevation. Even though the landscape has the same soil-forming factors of climate, organisms, parent material, and time, drier soils at higher elevations may be quite different from the wetter soils where water accumulates. Wetter areas may have reducing conditions that will inhibit proper root growth for plants that require a balance of soil oxygen, water, and nutrients.

Steepness, shape, and length of slope are important because they influence the rate at which water flows into or off the soil. If unprotected, soils on slopes may erode leaving a thinner surface layer. Eroded soils tend to be less fertile and have less available water than uneroded soils of the same series.

Aspect affects soil temperature. Generally, for most of the continental United States, soils on north-facing slopes tend to be cooler and wetter than soils on south-facing slopes. Soils on north-facing slopes tend to have thicker A and B horizons and tend to be less droughty.

Position

Position generally refers to the point on the landscape where the soil is located. Most soil series have a rather limited range of position and land form. In figure 3, the landscape is divided into (1) upland, (2) upland depression, (3) terrace, and (4) floodplain. Most soils can be classified into one of these landscape positions by observing the general surroundings in respect to streams or natural drainage systems.

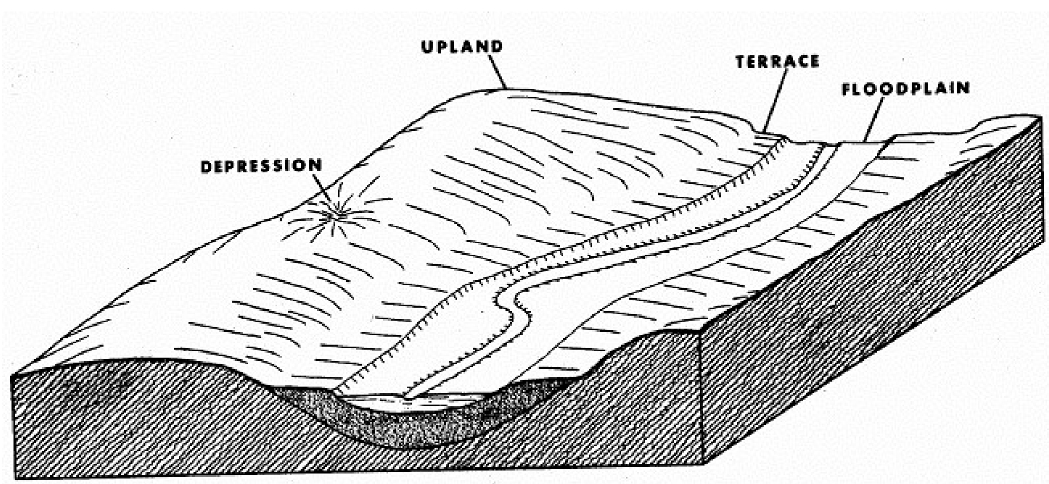

Figure 3. Landscape position can be upland, upland depression, terrace, or floodplain.

The **floodplains** refer to areas near streams that flood periodically. These soils may be quite productive, but they have a flooding hazard that seriously limits their use for urban development or agriculture. **Terrace** refers to soils developed in older alluvial materials above the zone of current flooding. **Upland depressions** or waterways refer to soils developed on concave land forms or at the heads of drainage ways and along waterways where surface drainage is retarded. Water tends to pond in these depressions, and the soils commonly have a darker and thicker surface horizon because of organic matter accumulations. Areas unaffected by stream activity in recent geologic time, and ordinarily lying at higher elevations (than alluvial plains) on rolling and convex positions, are designated **upland**.

Slope Characteristics

Slope generally is expressed as a percentage that is calculated by dividing the difference in elevation between two points by the horizontal distance and multiplying by 100. For example, a 10 percent slope would have a 10-foot drop per 100 horizontal feet. The percent slope can be estimated visually, but the Abney level, or a similar type of instrument, is used for more precise measurements.

Slope classes are used for interpretive purposes. The classes are nearly level, gently sloping, strongly sloping, moderately steep, steep and very steep. The range in percentages for these classes will vary depending on the topography of the area. Because of contrasting landscapes, two divisions are used in establishing limits for the slope classes in Maryland: (1) the Coastal Plain and (2) a combination formed by the Appalachian and Piedmont provinces. The slope classes and appropriate ranges of percent for the two divisions are shown in table 1.

Table 1. Slope classes for Maryland's Coastal Plain and Piedmont-Appalachian provinces and their corresponding letter designations in the soil survey.

Slope Class	Coastal Plain	Piedmont-Appalachian	Soil Survey
	Percentage	Percentage	Letter Designation
Nearly level	0-2	0-3	A
Gently sloping	2-5	3-8	B
Strongly sloping	5-10	8-15	C
Moderately steep	10-15	15 25	D
Steep	15-25	25-50	E
Very steep	25+	50+	F

Time

Time is required for horizon formation. The longer a soil surface has been exposed to soil forming agents like rain and growing plants, the greater the development of the soil profile. Soils in recent alluvial or windblown materials or soils on steep slopes where erosion has been active may show very little horizon development.

Soils on older, stable surfaces generally have well defined horizons because the rate of soil formation has exceeded the rate of geologic erosion or deposition. As soils age, many original minerals are destroyed and many new ones are formed. Soils become more leached, more acid, and more clayey. In many well drained soils, the B horizons tend to become redder with time.

SOIL FORMING PROCESSES

The four major processes that change parent material into soil are additions, losses, translocations, and transformations.

Additions

The most obvious addition is organic matter. As soon as plant life begins to grow in fresh parent material, organic matter begins to accumulate. Organic matter gives a black or dark brown color to surface layer. Most organic matter additions to the surface increase the cation exchange capacity and nutrients, which also increase plant nutrient availability.

Other additions may come with rainfall or deposition by wind, such as the wind blown or eolian material. On the average, rainfall adds about 5 pounds of nitrogen per acre per year. By causing rivers to flood, rainfall is indirectly responsible for the addition of new sediment to the soil on a flood plain.

Losses

Most losses occur by leaching. Water moving through the soil dissolves certain minerals and transports them into deeper layers. Some materials, especially sodium salts, gypsum, and calcium carbonate, are relatively soluble. They are removed early in the soil's formation. As a result, soil in humid regions generally does not have carbonates in the upper horizons. Quartz, aluminum, iron oxide, and kaolinitic clay weather slowly. They remain in the soil and become the main components of highly weathered soil.

Fertilizers are relatively soluble, and many, such as nitrogen and potassium, are readily lost by leaching, either by natural rainfall or by irrigation water. Long- term use of fertilizers based on ammonium may cause acidity in the soil and contribute to the loss of carbonates in some areas.

Oxygen, a gas, is released into the atmosphere by growing plants. Carbon dioxide is consumed by growing plants, but lost to the soil as fresh organic matter decays. When soil is wet, nitrogen can be changed to a gas and lost to the atmosphere.

Solid mineral and organic particles are lost by erosion. Such losses can be serious because the material lost is usually the most productive part of the soil profile. On the other hand, the sediment relocated to lower slope positions or deposited on bottom lands has the potential to increase or decrease productive use of soils in those areas.

Translocations

Translocation means movement from one place to another. In low rainfall areas, leaching often is incomplete. Water starts moving down through the soil, dissolving soluble minerals as it goes. There isn't enough water, however, to move all the way through the soil. When the water stops moving, then evaporates, salts are left behind. Soil layers with calcium carbonate or other salt accumulations form this way. If this cycle occurs enough times, a calcareous hardpan can form.

Translocation upward and lateral movement is also possible. Even in dry areas, low-lying soils can have a high water table. Evaporation at the surface causes water to move upward. Salts that are dissolved in solution will move upward with the water and deposit on the surface as the water evaporates.

Transformations

Transformations are changes that take place in the soil. Microorganisms that live in the soil feed on fresh organic matter and change it into humus. Chemical weathering changes parent material. Some minerals are destroyed completely. Others are changed into new minerals. Many of the clay-sized particles in soil are actually new minerals that form during soil development.

Other transformations can change the form of certain materials. Iron oxides (ferric form) usually give soils a yellowish or reddish color. In waterlogged soils, however, iron oxides lose some of their oxygen and are referred to as being reduced. The reduced form of iron (ferrous) is quite easily removed from the soil by leaching. After the iron is gone, generally the leached area has a grayish or whitish color.

Repeated cycles of saturation and drying create a mottled soil (splotches of colored soil in a matrix of different color). Part of the soil is gray because of the loss of iron, and part is a browner color where the iron oxide is not removed. During long periods of saturation, gray lined root channels develop. This may indicate a possible loss of iron or an addition of humus from decayed roots.

SOIL FEATURES

There are many properties or features that describe and characterize soils (fig. 4). Some of these features (such as color, texture and depth) are relatively easy to record while others require very sophisticated equipment and highly technical procedures (such as chemical data and mineralogical analysis).

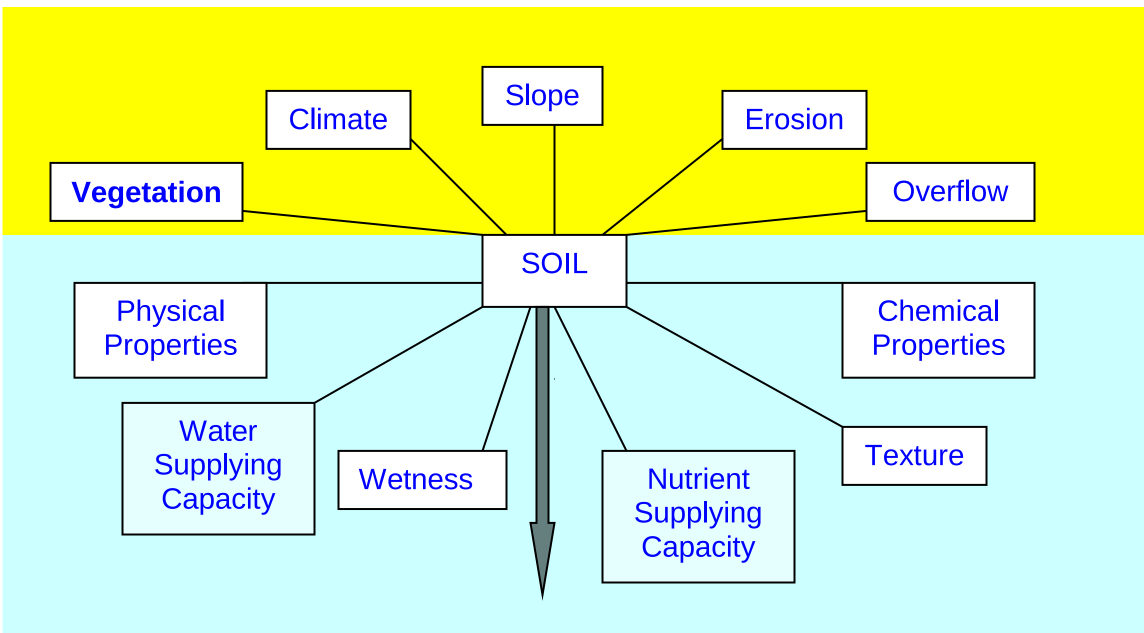

Figure 4. Soil properties that can influence use and management of land.

The Soil Profile

Due to the interactions of the five soil-forming factors, soils differ greatly. Each section of soil on a landscape has its own unique characteristics. The way a soil looks if you cut a section of it out of the ground is called a **soil profile**. When you learn to interpret it, the profile can tell you about the geology and climate history of the landscape over thousands of years, the archeological history of how humans used the soil, what the soil properties are used today, and the best way to use the soil. In a sense, each soil profile tells a story about the location where it was found.

Soil horizons

Soils are deposited in or developed into layers. These layers, called horizons, can be seen where roads have been cut through hills, where streams have scoured through valleys, or in other areas where the soil is exposed.

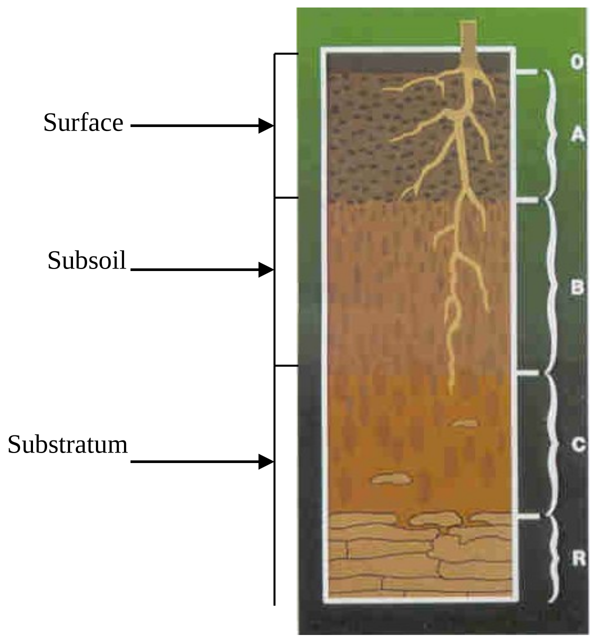

Figure 5. Soil profile separated into horizons.

Where soil forming factors are favorable, five or six master horizons may be in a mineral soil profile (fig. 5). Each master horizon is subdivided into specific layers that have a unique identity. The thickness of each layer varies with location. Under disturbed conditions, such as intensive agriculture, or where erosion is severe, not all horizons will be present.

The uppermost layer generally is an organic horizon, or **O horizon**. It consists of fresh and decaying plant residue from such sources as leaves, needles, twigs, moss, lichens, and other organic material accumulations. Some organic materials were deposited under water (fig. 6). Subdivisions of Oa, Oe, and Oi are used to identify levels of decomposition. The O horizon is dark because decomposition is producing humus.

Figure 6. Profile on the left shows an Oi horizon at the surface; an organic horizon with little decomposition. Profile to the right shows an Oa horizon; an organic horizon that is highly decomposed.

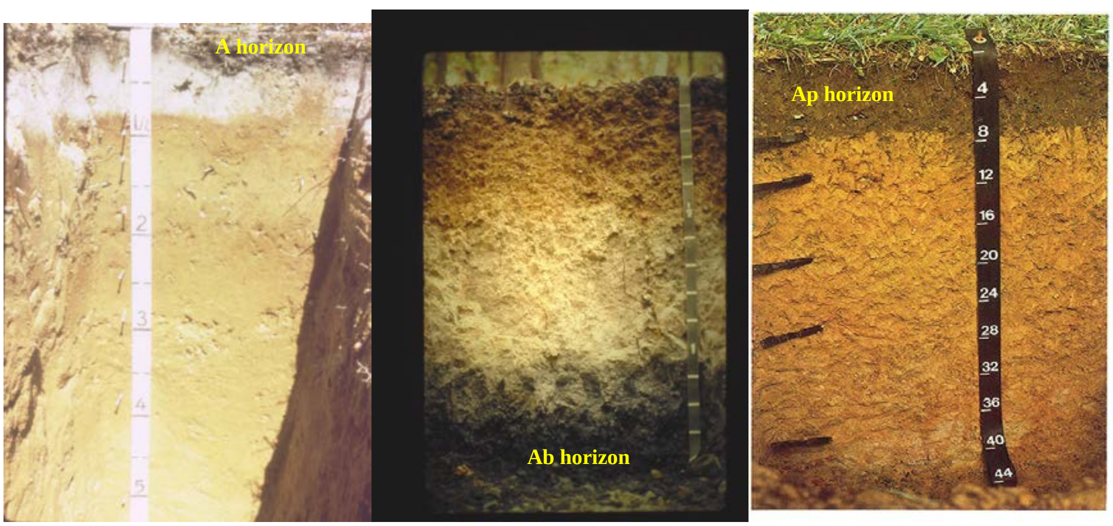

Figure 7. The soil profile to the right shows a well drained soil with an A horizon from the surface to a depth of 5 cm (2 in.). The measuring tape is in feet. The middle soil profile is a somewhat poorly drained soil with the top of the gray due to wetness occurring at 40 cm (16 in.). Tape measure is in meters. The middle soil profile has a buried A horizon starting at 1 m (40 in.). The soil profile to the left is moderately well drained with an Ap horizon from the surface to 20 cm (8 in.).

Below the O horizon is the **A horizon**. The A horizon is mainly mineral material. It is generally darker than the lower horizons because of the varying amounts of humified organic matter (fig. 7). It is the horizon of maximum biological activity. This horizon is where most root activity occurs and is usually the most productive layer of soil. It may be referred to as a surface layer in a soil survey. An A horizon that has been buried beneath more recent deposits is designated as an "Ab" horizon (fig. 7). An A horizon that has been plowed or otherwise manipulated is an Ap horizon (fig. 7).

The **E horizon** generally is bleached or whitish in appearance (fig. 8). As water moves down through this horizon, soluble minerals and nutrients dissolve and some dissolved materials are washed (leached) out. The main feature of this horizon is the loss of silicate clay, iron, aluminum, humus, or some combination of these, leaving a concentration of sand and silt particles.

Figure 8. This profile is a soil found in the Appalachian Plateau showing an E horizon from 20 to 35 cm (8 to 14 in.) and a B horizon from 35 to 55 cm (14 to 22 in.) Measuring tape is in 10 cm increments. Below 55 cm (22 in.) is a C horizon.

Below the A or E horizon is the **B horizon**, or subsoil (fig. 8). The B horizon is usually lighter colored, denser, and lower in organic matter than the A horizon. It commonly is the zone where leached materials accumulate. The B horizon is further defined by the materials that make up the accumulation, such as "t" in the form of "Bt", which identifies that clay has accumulated. Other illuvial concentrations or accumulations include iron, aluminum, humus, carbonates, gypsum, or silica. Soil not having recognizable concentrations within B horizons but show color or structural differences from adjacent horizons is designated "Bw".

Still deeper is the **C horizon** or substratum (fig. 8). The C horizon may consist of less clay, or other less weathered sediments. Partially disintegrated parent material and mineral particles are in this horizon. Some soils have a soft bedrock horizon that is given the designation Cr. C horizons described as "2C" consist of different material, usually of an older age than horizons which overlie it.

The lowest horizon, the **R horizon**, is bedrock (fig. 9). Bedrock can be within a few centimeters of the surface or many meters below the surface. Where bedrock is very deep and below normal depths of observation, an R horizon is not described.

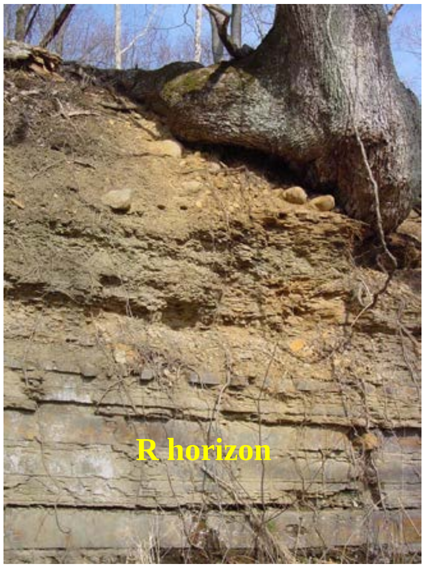

Figure 9. This soil profile has 110 cm (44 in.) of unconsolidated soil material over hard bedrock.

Generally, soil horizons are found in the order presented (fig. 10). However, a soil profile may lack certain horizons or have horizons out of order due to factors that influenced that soil's development. For example, a soil profile may lack E and B horizons if it is a young soil that has not had the time for an E and B horizon to develop. Or, a soil may have a buried A horizon if that soil has had material deposited on top of what was once the soil surface (fig. 7). This may occur on flood plains after a flooding event deposits sediments, because of erosion deposition, or because man has deposited material on top of the soil.

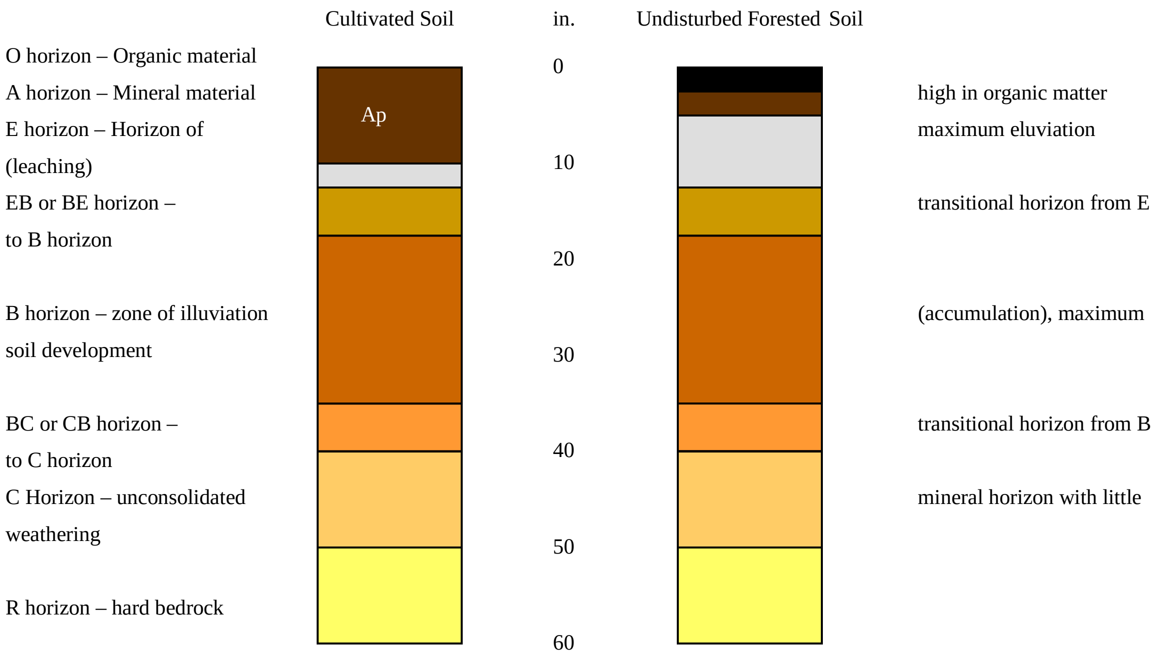

Figure 10. Common horizons designations and the order in which they are most commonly found.

Color

To the casual observer, color is the most noticeable soil property. Maryland soils vary in color from red, yellow and brown to gray in the subsoil (B horizon) and from black to very light gray in the topsoil (A horizon). Color is a significant indicator of several soil properties, including the organic matter content and drainage condition. The three components that have the most affect on soil color are organic compounds (usually black or dark brown), iron oxides (usually red, orange or yellow) and the color of the mineral grains (usually gray).

Black or very dark colors in the A horizon suggest relatively high organic matter contents. Most cultivated Maryland soils have organic matter in their plow layer ranging between 1 and 4 percent by weight. In some poorly drained soils, the organic matter content will reach 10 percent and higher. Generally, the darker the A horizon the higher the organic matter content. In Maryland, this generalization can be taken a step further; a deep, dark colored A horizon indicates the soil was formed under very poorly drained conditions. Organic matter enhances soil tilth (physical condition) or structure and is a natural nitrogen supplier under favorable conditions. As the organic matter content decreases, the color is determined more by the mineral components of the horizon. Pale colors indicate that the horizon has low organic matter content (fig. 11).

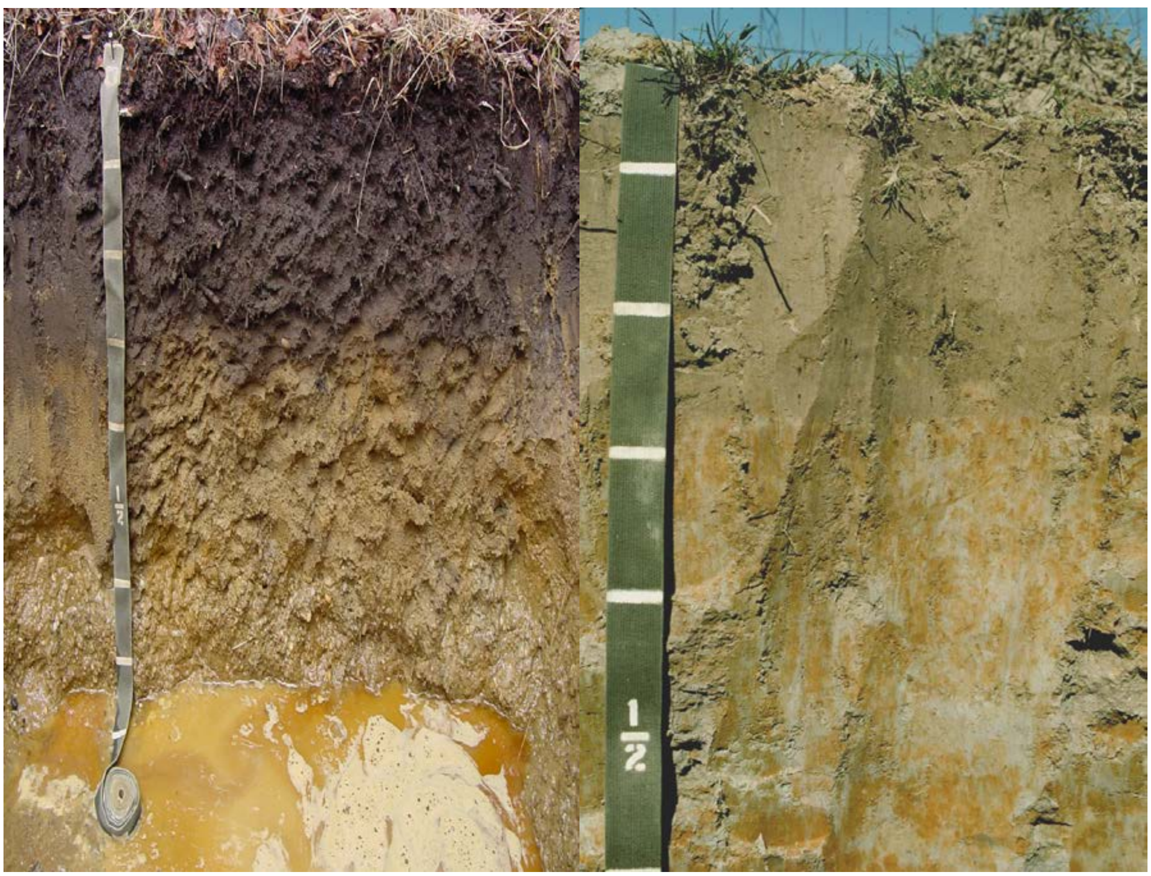

Figure 11. The soil profile on the left has a dark surface high in organic matter, while the soil profile on the right has a pale surface low in organic matter. The measuring tapes are in meters.

Subsoil colors are not greatly influenced by organic matter. Usually, the iron compounds coating the mineral particles are largely responsible for the color of this horizon. Soils formed under well-drained conditions, where oxygen is readily available, have subsoils with bright colors, usually brown, red or yellow (iron oxide colors). Some grayish tones may occur in these soils, but they are associated with the weathering of rocks and not drainage. Usually, soils formed under well-drained conditions are uniform in color, however, **mottles** (splotches of color), may occur due to weathering of rock fragments or parent material colors, etc (fig. 12). Brown, red or yellow colors can be interpreted as indicating good natural drainage making artificial drainage unnecessary. Septic systems should work in these soils unless they contain too much clay. Also, these soils should provide good dry locations for houses with basements.

Figure 12. The red and gray colors in this soil profile are inherited from its parent material.

When these bright colors are mixed with areas of gray (color of the mineral grains) the soil developed under conditions of imperfect drainage. The mixed pattern, called **redoximorphic features**, indicates that the soil is saturated with water for significant periods during the year (fig. 13). This pattern is caused when iron is reduced due to wetness and moved leaving splotches where of gray colors where the mineral grains have been stripped of iron. Artificial drainage usually is necessary for good crop production and septic systems are subject to periodic failure when installed in these soils.

Figure 13. The red and gray colors in these soil profiles are due to wetness. These splotches of colors due to wetness are called redoximorphic features. The soil profiled and the left has a predominance of gray due to the loss of iron starting close to the bottom of the spade. The soil on the right has a predominance of red with gray splotches starting at 1 m (40 in.). The measuring tape for the profile on the right is in meters.

When gray (color of the mineral grains) predominates with only streaks and spots of brighter colors (redoximorphic features) the soil was formed under poorly drained conditions. The spots of brighter colors are where the iron has re-oxidized forming spots similar to rust. These soils are called **hydric soils**, soil that have a water table near the surface for significant periods of time. Artificial drainage is necessary for crop production, and these soils are poor building sites, especially where septic systems are needed.

Figure 14. This soil profile is a hydric soil. The predominance of gray colors with splotches of red near the soil surface demonstrates the typical pattern of redoximorphic features found in a hydric soil.

When determining colors, make sure that the soil is moist. Moistened soil better illustrates color variations, making it easier to distinguish one horizon from another. Soil scientists use standard color (Munsell) charts to determine color (fig. 15); this permits uniformity and eliminates some of the human variable. According to the chart, a soil horizon described as yellowish-brown in Maryland has exactly the same color as a yellowish-brown horizon in California.

Figure 15. The Munsell soil color book is used to standardize soil color designations.

Organic vs. mineral soil material

Organic soil contains high amounts of organic matter. Organic soil material will be very dark in color, contain fibers, and will feel greasy when rubbed. Organic soil material is usually found at the soil surface, where leaves, twigs, and other sources of organics accumulate. When observing organic soil material, you may be able to readily identify leaves and twigs and other sources of organics. This is relatively undecomposed and is considered to be peat. If the source of organics is not easily identified the organic matter is more highly decomposed and would be considered mucky-peat (intermediate decomposition) or muck (high decomposition).

Mineral soil texture (USDA)

Texture is determined by the relative proportion of sand, silt, and clay (mineral material <2mm in diameter). Sands range in size from 2 millimeters (very coarse) to 0.05 millimeter (very fine); silts range from 0.05 to 0.002 millimeter and clays are less than 0.002 millimeter. Figure 16 illustrates the relative sizes between the three major particles. Particles larger than 2 millimeters, such as gravel, stones and coarse fragments are considered as modifiers of soil texture, but are not included in the textural class. Coarse-textured (light) soils are composed predominantly of sand particles. Fine-textured (heavy) soils are dominated by clay particles. Medium-textured soils, such as loams, are characterized by having sand, silt and clay in such proportions as to exert nearly equal influence on the character of the soil.

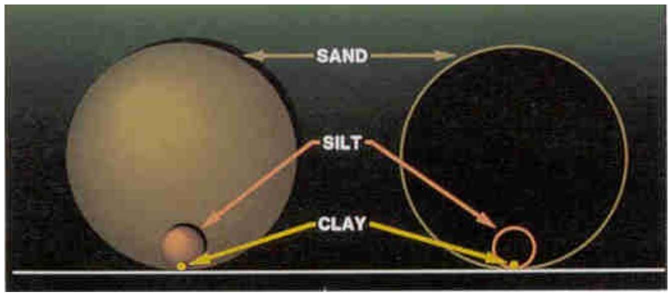

Figure 16. The relative sizes of sand silt and clay.

Soil texture is very important; it influences a soil's available water capacity; tilth; ease of tillage; resistance or susceptibility to erosion; drainage and permeability; and capacity to absorb and release nutrients. Therefore, texture exerts a profound influence on soil productivity and management requirements.

Sand particles can be distinguished by the naked eye. The coarse silt fraction can be seen under a low-power magnifying glass, but individual clay particles are so fine that only electron microscopes can reveal them.

Soil texture can be determined in the lab by measuring the proportion of sand, silt and clay. A textural triangle (fig. 17) is used to determine the texture once the proportion of sand, silt and clay are known. However, soil scientists need a quick method for determining soil texture in the field. This is done by feel. Moistening the soil and rubbing it between the thumb and forefinger permit a close textural class estimate (fig. 18). By employing this method, even the beginning student can acquire the skill of determining several textural classes. (Remember to use only less than the 2-millimeter material.) Usually, the subsoil in most Maryland soils will contain more clay than the surface

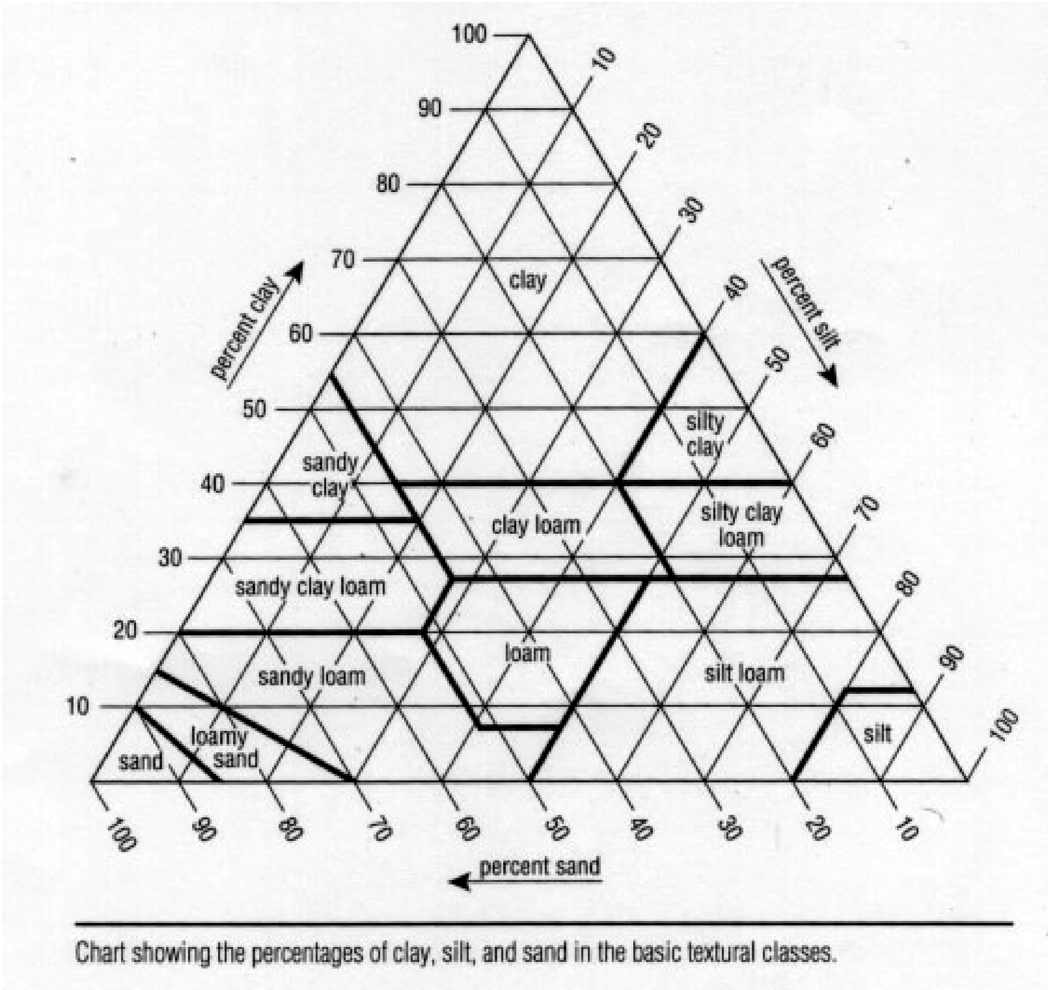

Figure 17. Textural triangle used to determine texture of soil once proportion of sand, silt and clay are known.

soil. Thus, the surface or A horizon may be classed as 'coarse' or 'medium' while the subsoil might be classed as 'medium', 'moderately fine' or 'fine'. Many moderately fine- or fine-textured soils do not allow water to percolate very rapidly, making them poorly suited for septic systems.

Coarse. Coarse-textured soils feel gritty and do not hold together when moist. The sand and loamy sand soils belong in this group. They tend to be droughty and very permeable. However, these soils may contain enough silt and clay to provide some available water and nutrient holding capacity. Thus, under ideal rainfall or irrigation, these soils commonly are used for agriculture. They are preferred for early spring truck crops because they drain quickly (where water tables are not high) and warm rapidly. Irrigation commonly is practiced to ensure timely watering. Where drainage is good, these soils provide adequate sites for septic systems although renovation of the wastewater and ground water contamination may be a problem.

Moderately Coarse. Moderately coarse-textured soils feel gritty but they hold together in a ball or when rolled out under gentle pressure. The sandy loam soils fall into this textural category. These soils hold more water than the coarse-textured soils, but they also are commonly irrigated since they do not have the available water capacity of the medium-textured soils. Moderately coarse-textured soils are highly desirable for crop production, and they also make excellent building sites when well drained.

Medium. Medium-textured soils, such as loams, silt loams and sandy clay loams contain significant proportions of sand, silt and clay. When rubbed between the fingers, medium-textured soils feel smooth but not sticky. A ribbon tends to form when a moistened sample is rubbed out, but this ribbon breaks apart because of insufficient quantities of clay. These textures provide good water and nutrient supplying capacities, and they are usually the most productive agricultural soils. Septic systems usually are long lived if these soils are well drained.

Moderately Fine. Moderately fine-textured soils such as silty clay loams and clay loams contain between 27 to 40 percent clay. When moist, these soils feel slightly sticky and are slightly plastic. When a sample is rubbed between the thumb and forefinger, a ribbon can be formed. The more clay that is present the stickier the sample and the longer and more flexible the ribbons.

Fine. Fine-textured soils are those containing greater than 40 percent clay. When moist samples are rubbed between the forefinger and thumb, a ribbon can be formed. This ribbon will feel stiff and usually has a very shiny appearance. These soils feel sticky or very sticky when moist. Fine-textured soils harden and form clods when dry and are puddled easily if worked when wet. For this reason, they are very difficult to manage and are not the best agricultural soils or best soils for building sites that require septic systems.

Rock fragments

Rock fragment is used as a texture modifier. The size and percentage of rock fragments in the soil are important to land use. Rock fragments within soil layers reduce the amount of water available for plant use and may restrict some tillage operations. Particles larger than 2 millimeters (0.08 in) in diameter are called rock fragments (fig. 19). The following is a list of gravel types.

- Rounded
  - Gravel >2 to 75 mm diameter (0.08 to 3 in.)
  - Cobbles >75 to 250 mm diameter (3 to 10 in.)
  - Stones >250 to 600 mm diameter (10 to 25 in.)
  - Boulders >600 mm diameter (>25 in.)
- Flat
  - Channers >2 to 150 mm long (0.08 to 6 in.)
  - Flagstones >150 to 380 mm long (6 to 15.2 in.)
  - Stones >380 to 600 mm long (15.2 to 25 in.)
  - Boulders >600 mm long (>25 in.)

Figure 19. This soil profile contains cobble size rock fragments in a high enough concentration to put an extremely cobbly modifier on the texture.

If a soil horizon contains more than 15 percent rock fragments a modifier is put on the texture (fig. 19). For example if a soil horizon contains 20 percent gravel size rock fragments and the texture is a sandy loam, the modifier would be gravelly and the texture would be labeled gravelly sandy loam. Table 2 shows modifiers used when the gravel content is greater than 15 percent.

Table 2. Rock fragment texture modifiers.

Fragment Content % by Volume	Rock Fragment Modifier
<15	None
15 to <30	Modifier (i.e. gravelly)
30 to <60	Very + modifier
60 to <90	Extremely + modifier
>= 90	Use noun (i.e. gravel)

Soil Structure

Soil structure is the naturally occurring aggregation of soil particles into units called **peds**. To determine soil structure you must carefully remove soil and shake it gently so that the soil falls apart naturally. Clay and organic compounds are the binding material that creates the peds that form soil structure. The size and type of soil structure is important because it affects water movement in the soil.

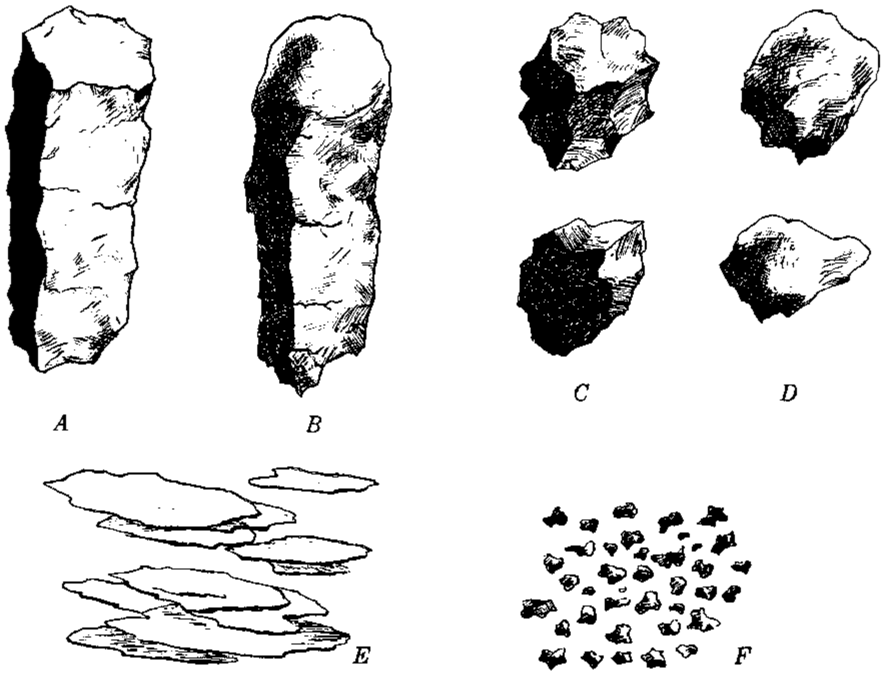

Figure 20. Structures found in Maryland include A. prismatic, C. angular blocky, D. subangular blocky, E. platy, and F. granular. Although not found in Maryland, B. columnar structure is similar to prismatic structure, but is rounded at the top.

Soil structure common to Maryland includes granular, angular blocky, subangular blocky, platy, prismatic, single grain, and massive (fig. 20). Granular structure is small and rounded, usually found in surface horizons. All other structures are usually found in subsurface horizons. Angular blocky has blocky peds that have sharp edges. Subagular blocky has blocky peds with rounded edges. Platy structure is flattened and can impede water movement through the soil. Prismatic is vertically elongated with flat tops. Single grain is found in sands and loamy sands and falls apart into loose grains. Massive is material that is held together, but does not fall apart naturally into any coherent structure.

Permeability

Permeability is the rate at which water and air move through the soil. Permeability is influenced by texture, structure, bulk density, and large pores. Soil structure influences the rate of water movement through saturated soil, in part, by the size and shape of pores. Granular structure readily permits downward water movement, whereas a platy structure requires water to flow over a much longer and slower path (fig. 21). Permeability is used in drainage design, irrigation scheduling, and many conservation practices. Permeability classes are shown in table 3.

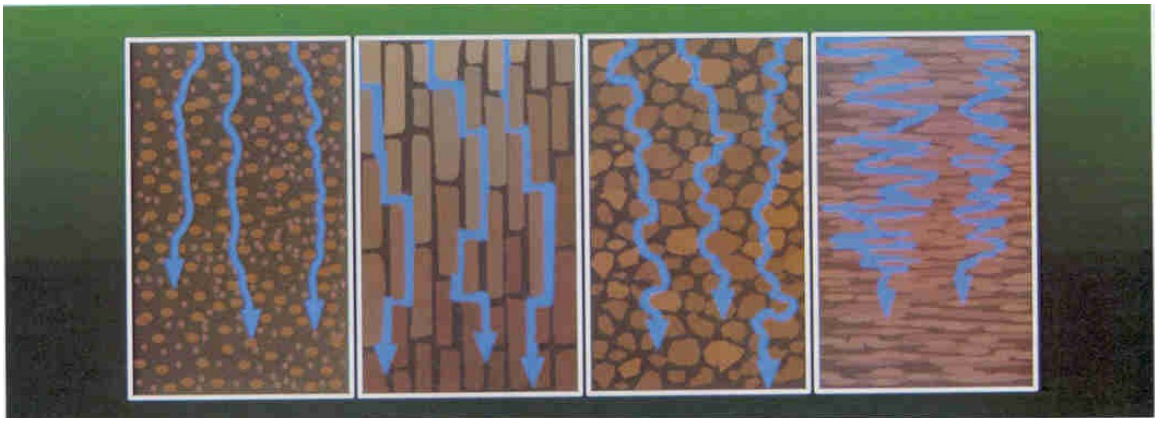

Figure 21. Paths of water flow through soils with granular, prismatic, subangular blocky, and platy structure, respectively

Table 3. Permeability classes

Class	Rate (in/hr)
Very slow	<0.06
Slow	0.06-0.02
Moderately slow	0.02-0.6
Moderate	0.6-2.0
Moderately rapid	2.0-6.0
Rapid	6.0-20
Very rapid	>20

Depth

The depth of a soil is considerably important both for agricultural and nonagricultural uses. A shallow-rooted crop may produce equally well on either a deep or shallow soil. However, deeply rooted plants such as trees or alfalfa require deep soils for best growth. During droughty periods, crops on shallow soils usually are the first to show damage because of the lack of moisture. This results from a soil volume that cannot hold adequate water.

Houses with basements or septic systems should be built on deep, well-drained soils. The lack of deep soil may necessitate a house with a slab or shallow foundation, and a septic system may not be functional or permitted on such soils.

Shallow soils restrict plant growth by impeding root growth and provide only limited water and nutrient re-serves. The processes of soil formation may have been such that only a thin veneer of soil has formed over a very hard or resistant parent material. Erosion may have reduced the thickness of a once-deep soil. Coarse gravel and sand layers also can impede root penetration as can sustain high water tables. In addition, root-restricting horizons or pans may have been formed during soil formation.

Most of the better agricultural soils in Maryland have a thickness of at least 1 m (40 in.). These soils are considered deep for agricultural and judging purposes. A soil that has a thickness of greater than 1.5 m (60 in.) is very deep. Any soil possessing a root-restricting horizon at a depth of less than 0.5 m (20 in.) is considered shallow (fig. 22). Moderately deep soils are those between these two extremes.

In summary, the categories of soil depth are:

Very deep .... greater than 1.5 m (greater than 60 in.)
Deep .... 1 to 1.5 m (40 to 60 in.)
Moderately deep............. 0.5 to 1 m (20 to 40 in.)
Shallow .... 0.25 to 0.5 m (10 to 20 in.)
Very shallow .... less than 0.25 m (less than 10 in.)

Figure 22. The soil on the left is a shallow soil with bedrock starting at 0.35 m (15 in.). The soil on the right is a very deep soil with no bedrock to a depth greater than 1.5 m (60 in.)

Reaction

Soil **pH** is an expression of the degree of acidity or alkalinity of a soil. It influences plant nutrient availability. A very acid soil (pH <5.0) typically has lower levels of nitrogen, phosphorus, calcium, and magnesium available for plants, and higher levels o availability for aluminum, iron, and boron than a net soil at pH 7.0. At the other extreme, if the pH is too high, availability of iron, manganese, copper, zinc, c especially phosphorus and boron may be low. A pH above 8.3 may indicate a significant level of exchangeable sodium.

Drainage

Some soils can be worked soon after heavy rains while others may remain saturated or ponded for long periods. Coarse-textured soils such as sands allow water to drain through the soil very rapidly if outlets are available. Moderately coarse-, medium-, moderately fine-, and fine-textured soils on similar landscape positions usually require correspondingly longer periods before they can be worked. Soils on extensive level areas or those in depressions commonly are poorly drained, and water tables may be at or near the surface for a long time.

Plants require good aeration as well as moisture for optimum growth. Soils that are excessively drained (such as sand) are well aerated but dry out quickly thus restricting crop production. Poorly drained soils that are not artificially drained retard crop production because long periods of water saturation starve roots of required oxygen. Also, these soils do not warm readily in the spring. Thus, the best agricultural soils are those that are deep and allow excess water to readily pass through the profile while retaining enough water to supply crops until the next rain.

Soils that are deep, well drained, moderately coarse and medium textured are preferred for agricultural production because they have a very desirable air-water relationship for many crops. These soils are about half mineral and organic material and half pore space. Ideal conditions exist when approximately half of this pore space is filled with water and half with air. Of course, these proportions fluctuate with the rainfall pattern. Coarse-textured soils (such as sand) contain a much greater proportion of air than water in this pore space, and they must be irrigated for good crop production. On the other hand, fine-textured soils (such as clay) possess a higher proportion of water than air in the pore space.

Well-drained soils also are preferred for many nonagricultural uses. Home sites and housing developments should be located in well-drained soils, especially if basements are to remain dry and septic systems are to function efficiently.

One of the best indicators of drainage class is soil color. The more redoximorphic features (mottling due to wetness) and gray in the subsoil, the poorer the soil drainage, the longer and higher the water tables stand in a soil profile, the more intense is the mottling and the higher it occurs within the profile. Soil scientists recognize six drainage classes in the field. Figure 23 shows the relationship between topography or position on the landscape and the resulting soil drainage. The water table, as indicated on the figure, is shown as it might appear during wet seasons.

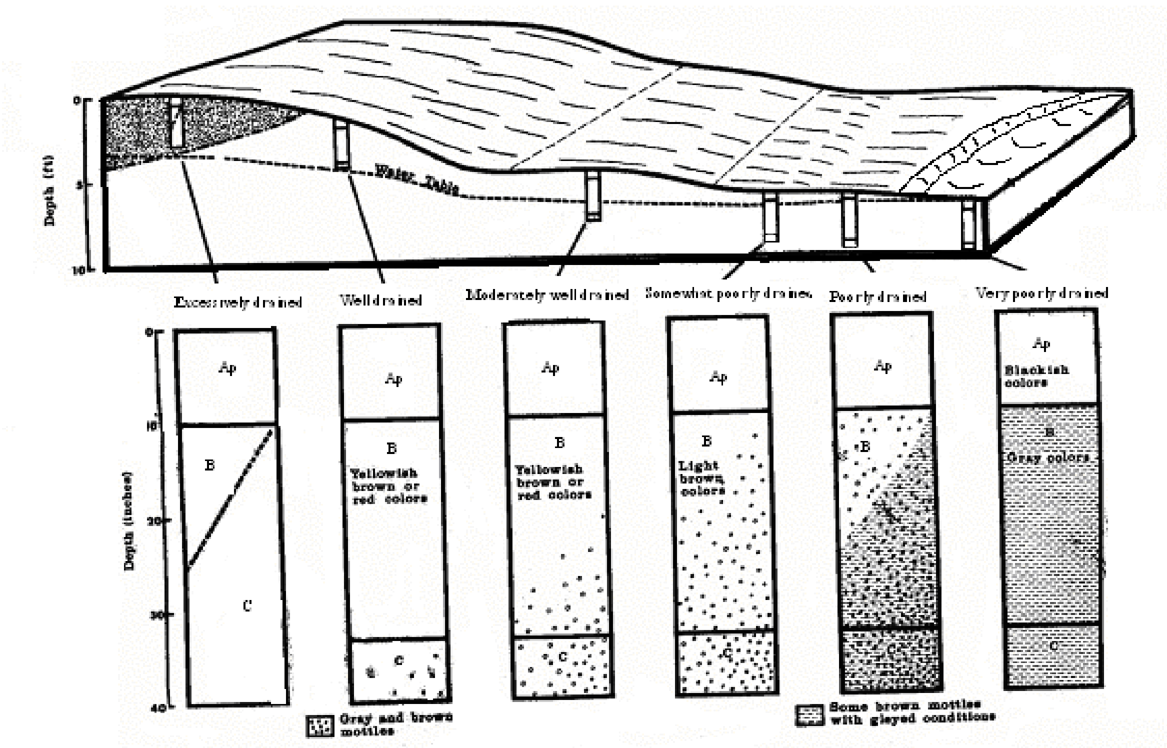

Figure 23. Maryland drainage classes and their location on the landscape.

Excessively drained. Water is removed from the soil very rapidly because of either coarse textures (such as sand and loamy sand) or shallow, porous profiles on steep slopes. Excessively drained soils are suited poorly to agriculture unless irrigation is practiced. No drainage mottles occur in these soils (fig. 24).

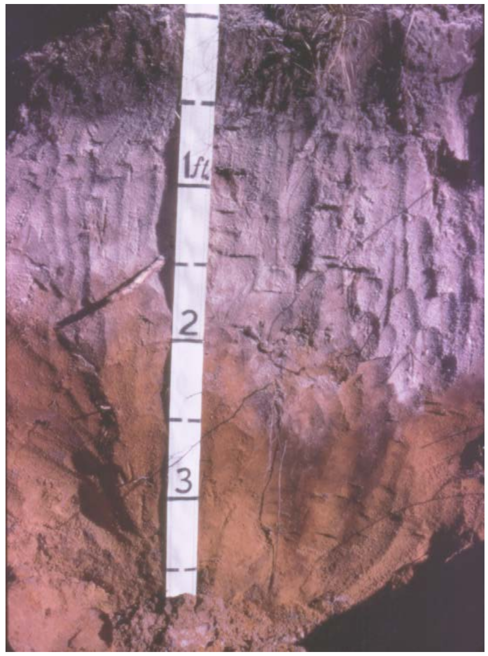

Figure 24. This soil profile shows an excessively drained soil. It is a sandy soil with no redoximorphic **Error! No table of contents entries found.**features.

Well drained. Good aeration occurs. Subsoil colors are bright and the profile lacks redoximorphic features above 1 m (40 in.) (fig. 25). Brown, yellowish brown and reddish brown colors are common.

Figure 25. This soil is a well drained soil with no redoximorphic features in the upper 1 m (40 in.)

Moderately well drained. In these soils, redoximorphic features are present above 1 m (40 in.) indicating that saturated conditions or water tables occur above this depth at various times during the year (fig. 26). Mottles are restricted to the 0.5 to 1 m (20 to 40 in.) zone for classification in this category. These soils may retard crop growth in wet years, but crops may do very well during drought periods. Artificial drainage may be beneficial during wet periods. Septic systems may experience periodic failure during saturated conditions.

Figure 26. This is a moderately well drained soil with redoximorphic features occurring starting at 0.75 m (30 in.)

Somewhat poorly drained. Redoximorphic features occur within the 10 to 20 in. zone, indicating prolonged periods of saturation or high water tables. Serious crop injury or failure may result during wet years (fig. 27). Unless artificial drainage is provided, crop production is restricted and septic systems commonly fail.

Figure 27. This is a somewhat poorly drained soil with a predominantly gray matrix starting at 0.35 m (15 in.)

Poorly drained. These soils have dark surface horizons and gray subsoils with redoximorphic features occurring above 25 cm (10 in.) (fig. 28). They have high water tables or are ponded for long periods or both. These soils usually occupy level areas or footslope positions and are productive only if they are artificially drained. Development of these soils for home sites should be avoided.

Figure 28. This is a poorly drained soil with a predominantly gray matrix due to wetness occurring at the surface.

Very poorly drained. Water is removed so slowly that the water table remains at or on the surface much of the year (fig. 29). These soils usually occupy low-lying and concave or depressed positions on the landscape. They normally have very dark or black, thick surface horizons with relatively high organic matter contents. The subsoils usually are gray. These soils can be used for agriculture, but only if intensive drainage is practiced.

Figure 29. This is a very poorly drained soil with a black surface due to organic matter accumulation underlain by a predominantly gray matrix due to wetness.

Available Water Capacity

The available water capacity of a soil is closely related to texture. As mentioned previously, air and water occupy the pore space between the particles comprising the soil skeleton. The bigger the soil particles (such as sand or gravel), the larger the pores between them. Thus, water drains first and rapidly from these larger pores. This results in droughty soils because the plants are supplied only from the small amount of remaining moisture. Irrigation is necessary on these soils even in humid climates.

As the particles become smaller, the pores between the grains also are reduced in size. This results in the retention of more water for plant use. Therefore, medium-textured and moderately fine-textured soils, such as loam, silt loam and clay loam have much higher available water capacities than coarse-textured soils. The moderately coarse-textured soils (such as sandy loam) are intermediate in those categories. Fine-textured soils (such as clay) have such small pores that plant roots are unable to obtain much more water from these fine soils than is available from medium-textured soils. Moderately coarse-, medium- and moderately fine-textured soils are, therefore, preferred for agricultural use because they provide good, available water capacity and aeration while being easily worked.

To calculate the water available within the soil profile, consider only the first 1 m (40 in.) or to a root limiting layer if it occurs above 1 m (40 in.). The available water capacity of each horizon down to 1 m (40 in.), when added together, will give the total available water for the profile. A deep silt loam will hold more water than a soil with 0.25 m (10 in.) of silt loam surface soil and the remainder sand. Therefore, both the surface and subsoil must be considered in computing the available water

See Table 4 for a general guide when calculating the amount of available water in a 40 in. profile. The range and average water availability are presented in inches of available water per inch of soil depth.

For example, if a soil consists of 20 in. of silt loam over loamy sand, the available water capacity would be affected by both textural classes. In determining the water in the 20 in. of silt loam or medium-textured material, simply multiply the depth (20 in.) by the amount of available water held by the silt loam textural class (0.23 in. of water per inch of soil). This calculation gives 4.6 in. of available water in the 20 in. zone. Now the remaining 20 in. (to complete the 40 in. profile) is loamy sand or coarse-textured material which holds only 0.05 in. of water per in. of soil. Multiplying 20 in. of loamy sand times 0.05 yields a total of 1.0 in. of available water. Therefore, the 40 in. soil profile has an available water capacity of 4.6 in. (silt loam) plus 1.0 in. (loamy sand) or 5.6 in. of available water.

Table 4. Amount of available water by textural class.

Textural class	Available water (in. water/in. soil	
	Range	Average
Coarse (sand, loamy sand)	.02-.09	0.05
Moderately coarse (sandy loam, fine sandy loam	.09-.19	0.14
Medium (loam, sandy clay loam, silt loam	.19-.27	0.23
Moderately fine (clay loam, silty clay loam)	.10-.19	0.15
Fine (silty clay, sandy clay, clay)	.07-.19	0.13

Available Water Capacity Categories	Range in in. H_20 per 40 in. soil
Very Low	Less then 2.5
Low	2.6 to 4.5
Medium	4.6 to 7.0
High	Greater then 7.0

Erosion

Soils under their natural vegetative cover attain equilibrium with their environment. When this vegetative cover is removed and the soils are cultivated, this equilibrium is changed. At certain times of the year the soils are exposed to heavy rains with little or no vegetative cover to break the impact of the rain drops. As a result, soil particles are dislodged and runoff waters carry these particles downslope and deposit them on other parts of the landscape or carry them into streams. Wind also is an effective carrier of particles on sandy soils. Regardless of the process, the removal of soil is called erosion.

Some soils in Maryland have been cultivated for hundreds of years and many of these soils are severely eroded. Often, the entire original surface horizon has been removed, leaving the subsoil exposed. In some parts of the Piedmont, it is estimated that from 60 to

90 cm (24 to 36 in.) of the soil have been lost. The degree or severity of erosion is an important soil property.

The degree of past erosion can be determined by comparing the original soil depth, observed in virgin forests, with the present soil depth. The less surface soil, or the closer the subsoil is to the surface, the more severe the erosion problem.

The amount of past erosion is estimated as a measure of the soil that remains in relation to the given original thickness. The following categories are used to define the severity or degree of erosion in Maryland.

None to slight. Less than 7.5 cm (3 in.) of the original soil have been lost. No mixing of the subsoil into the plow layer is evident.

Moderate. Between 7.5 to 20 cm (3 to 8 in.) of the original soil have been removed. Subsoil material may be mixed with the plow layer, but the plow layer remains darker than the subsoil.

Severe. More than 20 cm (8 in.) of the original soil have been lost. Commonly, subsoil material is mixed with the plow layer, and the plow layer color closely resembles the subsoil color. Where the subsoil is exposed or gullies occur, the soil is severely eroded.

Erosion Potential

Erosion potential is determined by the steepness of the slope, length of slope, the nature of the soil (soil texture, infiltration rate and tilth) and the type of vegetative cover. A soil's susceptibility to erosion will influence greatly how the soil is used. Erosion potential can be determined primarily by evaluating factors such as slope gradient, slope length and soil texture.

Land Capability Classification

Land capability classes and in most cases, subclasses are assigned to each soil. They suggest the suitability of the soil for field crops or pasture and provide a general indication of the need for conservation treatment and management. There are 8 capability classes. Capability classes are designated by either Arabic or Roman numerals (I through VIII), which represent progressively greater limitations and narrower choices for practical land use (fig. 30). Capability subclasses are noted with an e, w, s, or c following the capability class; for example, IIe. The "e" indicates that the soil is erosive. A "w" signifies a wetness limitation. An "s" denotes a shallow, droughty, or stony soil. A "c" indicates a climatic limitation. No subclasses are shown for capability class I because these soils have few limitations. Figure   illustrates some of the capability classes on a landscape.

Of the eight capability classes, only the first four are considered usable for cropland. Class I land has little or no hazard for crop production and is the best agricultural land. Classes II, III and IV need progressively more care and protection when cultivated crops are grown. Soils in classes V, VI and VII are suited for adapted native plants (such as forests), although some soils in classes V and VI are capable of producing specialized crops such as fruit trees and ornamentals. Soils in class VIII do not respond to management without major reclamation since they include the very steep and rocky areas of the mountain regions and the very wet tidal marshes in Maryland.

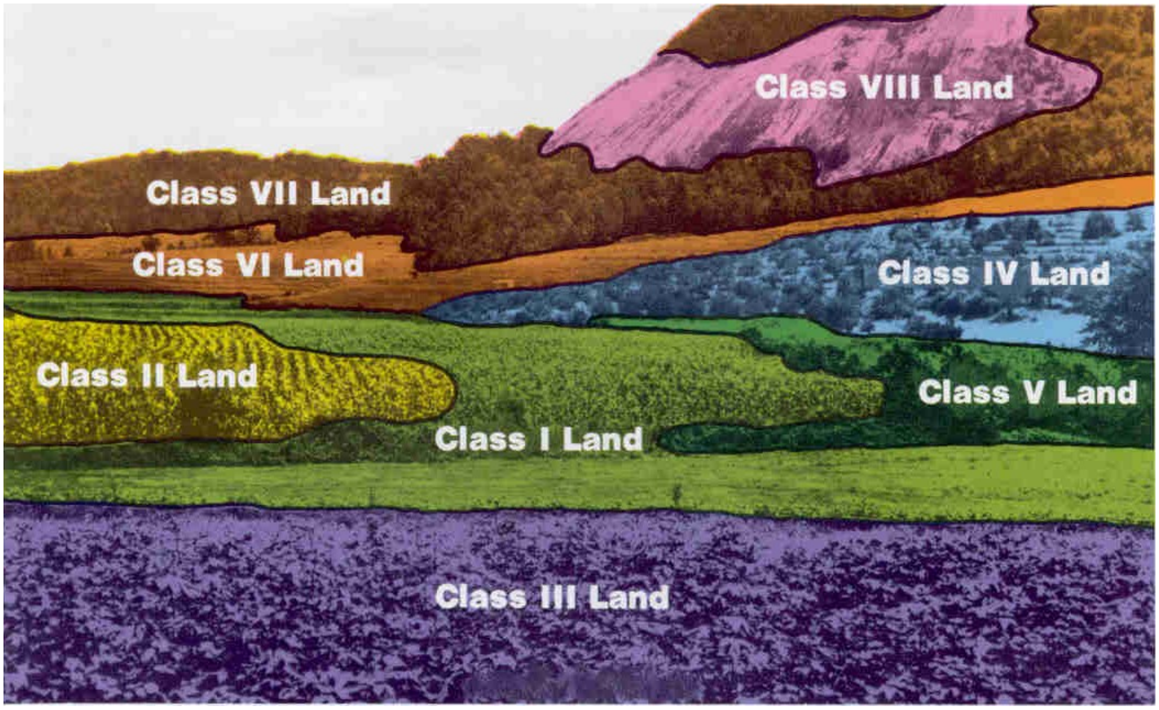

Figure 30. Location of different land capability classes in the landscape.

Capability Classes Suitable for Cultivation of Row Crops

Class I

Soils In this class have few limitations that restrict their use.

These soils are the best in nearly all respects for both agricultural production and nonagricultural uses. They are deep (1 m (40 in. or more)), well drained and medium textured with medium to high available water capacities, moderate permeability and none to moderate erosion. These soils are easily worked and are among the most productive in the state. Slopes should not exceed 2 percent in the Coastal Plain or 3 percent in the Piedmont and Appalachian provinces. Management should include maintenance of proper plant nutrient balance and tilth.

Class II

Soils in this class have some limitations that reduce the choice of plants or require moderate conservation practices.

Although these soils are rated good and usually are productive, some physical conditions render them less desirable than class I land. Likewise, the drainage class, soil depth, permeability or available water capacity maybe less desirable than class I soils. In general, slopes ranging between 2 and 5 percent in the Coastal Plain, and 3 and 8 percent in the remainder of the state would place this soil in class II. Drainage may be the limiting factor with mottling within the 20 to 40 in. zone of the profile. A slow or rapid permeability, low available water capacity or moderate soil depth (0.5 to 1 m (20 to 40 in.)) also could eliminate this soil from class I. Although several limitations may exist, only one is necessary to place this soil in class n. Management practices, in addition to those for class I, should include moderate erosion control (including rotations with sod or cover crops), contour fanning, moisture retention methods or drainage depending on the type of limitation.

Class III

Soils in this class have severe limitations that reduce the choice of plants or require special conservation practices, or both.

Limitations similar to class II soils may be present in these soils, but these limitations are more severe, restricting the use of these soils. Large acreages of class III land are strongly sloping and subject to moderate to severe erosion. Slope limits for this class range between 5 and 10 percent for the Coastal Plain and 8 and 15 percent for the remainder of the state. If drainage is the limiting factor, mottling should occur within the 20 in. zone, indicating that saturated conditions or high water tables are present at some time during the year .Shallow soils (less than 0.5 m (20 in.)), coarse-textured surface layers, fine-textured subsoils with slow permeability or very low available water capacity also can limit the use of soils to the extent that they are placed in this class. The very coarse soils with very low available water capacities also fit into this class and require irrigation to realize production.

The soils in this class require more intense management than the previous classes. Management practices should include intensive erosion control measures such as terracing and strip-cropping. Where excessive water is limiting, drainage practices are necessary to make these soils productive.

Class IV

Soils In this class have very severe limitations that restrict the choice of plants or require very careful management, or both.

Where erosion is limiting, this land is good for only occasional cultivation under careful management. Sod crops should occupy a large portion of the rotation be- cause of the severe erosion hazard. Slope limits for this class range between 10 and 15 percent in the Coastal Plain, and 15 and 25 percent in the Piedmont and Appalachian sections of the state. Very poorly drained soils in depressions have such high water tables, or are saturated for such long periods, that only very intensive drainage management can make these soils productive.

Soils that are severely eroded or gullied with little or no surface soil must be placed in this capability class, even though these soils may occur on slopes similar to those required for class III soils (see note on Figure 9).

Very intensive management practices are required for production on these soils. Where erosion is the hazard, cultivated crops may be grown only once in several sea- sons. Sod crops such as hay, pasture or cover crops are necessary to minimize the erosion loss. Even under excel- lent management, crop failures or severe yield reductions can be expected occasionally.

Capability Classes Unsuited for Cultivation

Class V

Soils in this class are nearly level and not subject to erosion, but because of excessive wetness resulting from frequent flooding or some permanent obstruction like rock outcrops, they are not suited for cultivation.

Streams that overflow frequently, excessive seepage, very stony soils or numerous outcroppings of bedrock make these soils unsuited for cultivation. Many of these soils are deep, however, and they have few limitations for pasture or forestry. These soils respond to good management, which is necessary for satisfactory production.

<u>Class VI</u>

Soils in this class have severe limitations that make them generally unsuited for cultivation, and that limit their use largely to pasture, woodland, or wildlife food and cover.

These soils have continuing limitations that cannot be corrected economically such as steep slopes (15 to 25 percent in the Coastal Plain and 25 to 50 percent in the Piedmont and Appalachian provinces), a severe erosion hazard, effects of past erosion, or stoniness. These factors produce some limitation for pasture and forestry .It should be pointed out that even for most of these uses, the better classes are preferred for maximum protection.

<u>Class VII</u>

Soils in this class have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland or wildlife.

Although not suited for cultivation, intensive management can make productive pasture and woodland possible. Even in rough, timbered areas, special care is required to prevent excessive erosion. Soils on very steep slopes, very shallow soils and very stony soils that occur on slopes greater than 25 percent in the Coastal Plain and greater than 50 percent in the Piedmont are the most common members of this class. This class includes the least capable soils with regard to pasture and woodland.

<u>Class VIII</u>

Soils and landforms in this class have limitations that preclude their use for commercial production of plants and restrict their use to recreation, water supply, wildlife or esthetic purposes.

Tidal marshes that are flooded daily, continuously ponded areas (areas containing water for more than 6 months of a year), and areas with greater than 90 percent rock outcrop, stones or boulders are included in this class as well as borrow pits, barren mine dumps and sandy beaches. These land areas have few or none of the physical soil features (found in class I soils) necessary to support any type of agriculture.

Other management interpretations

Some soil surveys, or addenda to the surveys, have special tables on important agronomic soil interpretations. A few tables may be in the form of a soil's potential for a specified use, such as its potential for cropland. Other tables group soils for specific programs; such as prime or unique farmland, land capability classification, highly erodible lands, and hydric soils.

Hydric soils are wet soils defined as a group for the purpose of implementation of legislation for preserving wetlands and for assessing the potential habitat for wildlife. The soils considered to be hydric were selected on the basis of flooding, water table, and drainage class criteria. Hydric soils developed under wet conditions (anaerobic within 30 cm (12 in.)) and can support the growth and regeneration of hydrophytic vegetation. Indicators we look for in the field to identify hydric soils include organic soils, 40 cm (16 in.) of organic soil material in the upper 80 cm (32 in.); histic epipedon, 20 cm (8 in.) of organic soil material in the upper 40 cm (16 in.); gleyed or low chroma colors, a predominance of gray colors due to wetness; high organic matter in sandy soils; and organic streaking in sandy soils.

You can also identify the soil series and look to see if it is listed on the county hydric soils list. The hydric soils list, developed for the 1982 Farm Bill, is included in the Soil Conservation Service Field Office Technical Guide, Section II. Some map units that have inclusions of soils that meet the hydric soil criteria are added to the field office listing.

Highly erodible soil and potentially highly erodible soil are also listed in Section II of the Soil Conservation Service Field Office Technical Guide. The criteria used to group highly erodible soils were formulated using the Universal Soil Loss Equation and the wind erosion equation. The criteria are in the National Food Security Act Manual. Soil use, including tillage practices, is not a consideration.

Areas defined as highly erodible can be held to an acceptable level of erosion by following approved practices in a conservation plan. Various conservation practices, such as residue management, reseeding to grasses, contour farming, and terraces, are used in conservation planning to reduce soil loss, maintain productivity, and improve water quality.

Prime farmland soils are listed by map unit name in the tables or the "Prime Farmland" section of the soil survey. These soils have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oil seed crops. Unique farmland is land other than prime farmland that is used for the production of specific high value crops, such as citrus, tree nuts, olives, cranberries, fruit, and vegetables.

SOIL SURVEYS

Like snowflakes, no two soils are exactly the same. Surface as well as below the surface soil features change across landscapes. A grouping of soils having similar properties and similar behavior is called a series. A series generally is named for a town or local landmark. For example, the Elkton series is named for a town in Cecil County, Maryland. More than 17,000 soil series have been named and described in the United States, and more are being defined each year.

In mapping, a soil series is further divided into a phase of a series by properties that are important to soil use, such as surface texture and slope. These phases of soil series, once identified, all have a characteristic behavior. The behavior for that kind of soil and individual phase is applicable no matter where the soil is observed.

One of the main references available to help land users determine the potentials and limitations of soils is a soil survey. Copies of a soil survey for a specific county are available from the Soil Conservation Service office responsible for that county. Reference copies are also available in the county or depository libraries. A soil survey is prepared by soil scientists who determine the properties of soil and predict soil behavior for a host of uses. These predictions, often called soil interpretations, are developed to help users of soils manage the resource.

A soil survey generally contains soils data for one county, parish, or other geographic area, such as a major land resource area. During a soil survey, soil scientists walk over the landscapes, bore holes with soil augers, and examine cross sections of soil profiles. They determine the texture, color, structure, and reaction of the soil and the relationship and thickness of the different soil horizons. Some soils are sampled and tested at soil survey laboratories for certain soil property determinations, such as cation-exchange capacity and bulk density. To be proficient in using soil survey data, a basic understanding of the concepts of soil development and of soil-landscape relationships is imperative.

General soil information

The general soil map is near the back of the soil survey publication. This generalized map of the soils for the soil survey area is color coded to show major soil associations (or groupings) of the major soils. Soils within a soil association may vary greatly in slope, depth, drainage, and other characteristics that affect management. Descriptions of each of the soil associations are near the front of the soil survey report immediately following the short introductions to cultural and natural features of the area. This section is labeled "General soil map units" in the Contents.

The general soil map can be used to compare the suitability of large areas for general land uses. Because of the scale, it is not intended to be used to make management decisions on specific sites. Each color-coded area on the map has a corresponding description. For example, on the general soil map illustrated by figure 9 areas coded 1 and shaded light yellow designate the Lamoni-Shelby soil association. As the name of the unit implies, Lamoni and Shelby soils are the major soils that occupy the landscape in this area. Likewise, the description of association 1 gives general information about this section of the county.

Some soil surveys include three-dimensional drawings depicting the relationships of soils, parent material, and landscape position for the major soils. Figure 10 illustrates the dominant Lamoni and Shelby soils and the minor Colo soils as they occur in association 1. Note the relationship of parent material and landscape positions to the different soils. Please refer to Section II "How is Soil Formed?" and to figure 3 for additional insights on these relationships.

Detailed soil information

To obtain information about a particular plot of land from a soil survey, locate the general area on the "Index to Map Sheets", and select the appropriate map sheet number. The sheets are in numerical order in the soil survey. After selecting the correct sheet, a specific parcel of land is located on the aerial map by using section numbers, roads, streams and drainage- ways, towns, or the imagery on the map sheet. Areas on the aerial photograph are delineated for individual soil map units and each contains a unique map unit symbol.

The symbols on the detailed maps are listed on the back of the "Index to Map Sheets" with the names of each soil they represent. Some soil names include terms for the surface texture, slope range, and erosion. Detailed information can be obtained about each unit by referring to the map unit description or soil interpretive tables. Each unit is easily located by using the Index to Map Units or Summary of Tables in the front of the publication. Both the map unit descriptions and soil survey interpretive tables have information about the soils.

In each map unit description, soil information is given for the common uses. Major limitations or hazards affecting these uses are stated. Also listed are possible alternatives to help overcome each major limitation or hazard.

Areas delineated on the soil maps are not necessarily made up of just one soil, but include smaller areas of similar or different soils. The composition of soils in the map unit is explained in each map unit description.

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Agricultural Best Management Practices

The following will discuss a few of the Best Management Practices (BMP's) that can address soil conservation and water quality and improved production on agricultural land.

Each practice is based on USDA Natural Resource Conservation Service (NRCS) technical standards.

Each practice will work most effectively in combination with others as part of a farm plan. All of the BMP's that will be discussed in this section provide multiple benefits. The following pages will describe each BMP and identify their benefits with the symbols below.

Benefit Symbols

	Helps reduce soil erosion & sediment runoff; or may add to the soil organic matter		Provides wildlife habitat or food.
	Helps protect or improve water quality		Helps improve air quality by reducing odor and other problems
	May help increase profits by reducing costs, increasing production or both		May qualify for state or federal cost-share assistance.

Grassed waterway

Shaping and establishing grass in a natural drainageway to prevent gullies from farming

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How it works

A natural drainageway is graded and shaped to form a smooth, bowl-shaped channel. This area is seeded to sod-forming grasses. Runoff water that flows down the drainageway flows across the grass rather than tearing away soil and forming a larger gully. An outlet is often installed at the base of the drainageway to stabilize the waterway and prevent a new gully from forming.

How it helps

- Grass cover protects the drainageway from gully erosion.
- Vegetation may act as a filter, absorbing some of the chemicals and nutrients in runoff water.
- Vegetation provides cover for small birds and animals.

Contour farming

Farming with row patterns nearly level around the hill – not up and down hill

How it works

Crop row ridges built by tilling and planting on the contour create hundreds of small dams. These ridges or dams slow water flow and increase infiltration, which reduces erosion. Can also be used with stripcropping, whereby the crop is alternated with strips of meadow or small grain planted on the contour. The small grain/meadow strip slows runoff, increases infiltration, traps sediment and provides overall cover. Crop rotation with legumes may also be included to add nitrogen as part of the stripcropping measure.

How it helps

- Contouring can reduce soil erosion by as much as 50% compared with up and down hill farming.
- By reducing sediment and runoff, and increasing water infiltration, contouring promotes better water quality.

Crop residue management

Leaving last year's crop residue on the soil surface by limiting tillage. Includes no-till and ridge till

How it works

Leaving last year's crop residue on the surface before and during planting operations provides cover for the soil at a critical time of the year. The residue is left on the surface by reducing tillage operations and turning the soil less. Pieces of crop residue shield soil particles from rain and wind until plants can produce a protective canopy.

How it helps

- Ground cover prevents soil erosion and protects water quality.

- Residue improves soil tilth and adds organic matter to the soil as it decomposes.

- Fewer trips and less tillage reduces soil compaction.

- Time, energy and labor savings are possible with fewer tillage trips.

Measuring crop residues

You can estimate residue levels by using a line that has 50 or 100 equally divided marks. Stretch the line diagonally across crop rows. Count the number of marks that have residue under the leading edge when looking from directly above the mark. Walk the entire length of the rope. The total number of marks with residue under them is the percent of residue cover. If the line has only 50 marks, multiply your count by two. Repeat this three to five times in a representative area of the field.

Crop rotation

Changing the crops grown in a field, usually year by year.

How it works

Crops are changed year by year in a planned sequence. Crop rotation is a common practice on sloping soils because of its potential for soil saving. Rotation also reduces fertilizer needs because alfalfa and other legumes replace some of the nitrogen corn and other grain crops remove.

How it helps

- Pesticide costs may be reduced by naturally breaking the cycles of weeds, insects and diseases.
- Grass and legumes in a rotation protect water quality by preventing excess nutrients or chemicals from entering water supplies.
- Meadow or small grains cut soil erosion dramatically. Crop rotations add diversity to an operation.

Cover crop

A small grain crop used in the fall primarily to uptake any leftover nitrogen from the root zone as well as prevent soil erosion.

How it works

Small grain crops such as cereal rye, oats and winter wheat are planted in early fall immediately following or before the harvest of corn or soybeans to reduce the leaching of unused crop nutrients to the groundwater during the fall and winter months. Erosion control is a secondary benefit.

How it helps

- Cover crops tie up unused crop nutrients and prevent leaching. Cover crops also protect the soil from wind and water erosion, add organic matter to the soil, improve soil tilth, reduce weed competition and may reduce fertilizer requirements in the spring.

Nutrient management

Applying the correct amount and form of plant nutrients for optimum yield and minimum impact on water quality.

How it works

After taking a soil test, setting realistic yield goals, and taking credit for contributions from previous years' crops and manure applications, crop nutrient needs are determined. Nutrients are then applied at the proper time by the proper application method. Nutrient sources include animal manure, biosolids and commercial fertilizers. These steps reduce the potential for nutrients to go unused and wash or infiltrate into water supplies.

How it helps

- Sound nutrient management reduces input costs and protects water quality by preventing over-application of commercial fertilizers and animal manure.
- Correct manure and biosolids application on all fields can improve soil tilth and organic matter.

No-till farming

A method of farming where the soil is not tilled between each year's crops.

How it works

This method of farming includes no seedbed preparation other than opening a small slit for the purpose of placing the seed at the intended depth.

How it helps

- Ground cover prevents soil erosion and protects water quality.
- Residue improves soil tilth and adds organic matter to the soil as it decomposes.
- Fewer trips and less tillage reduce soil compaction.
- Time, energy and labor savings are possible with fewer tillage trips.

Soil Health – It's Alive

Many people don't realize that soil, especially healthy soil, is full of life. Millions of species and billions of organisms make up a complex and diverse mix of microscopic and macroscopic life that represents the greatest concentration of biomass anywhere on the planet. Bacteria, algae, microscopic insects, earthworms, beetles, ants, mites, and fungi are among them. Estimates vary, but if you could weigh all the organisms in the top six inches of soil on an acre of land, you'd find they would weigh between 2,500 pounds to more than 5,000 pounds, depending on how healthy the soil is. That is a LOT of life.

What these low-lying creatures lack in size, they make up for in numbers. Consider bacteria, the soil microbes with the highest numbers, for example. You can fit 40 million of them on the end of one pin. In fact, there are more soil microorganisms (microbes for short) in a teaspoonful of soil than there are people on the earth.

These microbes, which make up only one-half of one percent of the total soil mass, are the yeasts, algae, protozoa, bacteria, nematodes, and fungi that process soil into rich, dark, stable humus.

Like other living creatures, the organisms in the soil also need food and shelter. Some feed on dead organic matter, and some eat other microbes. As a group, they cycle nutrients, build the soil and give it structure.

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. For those producers, farming centers around feeding the organisms that build healthy soils.

These farmers understand that tillage, the turning of the soil that has been the standard for growing crops for years and years, is disruptive to soil microbes and destructive to the soil system.

Instead, they disturb the soil as little as possible. And, they grow a diversity of living plants in the soil as much of the time as practical covering the soil and offering food to soil microbes through living roots. Those soil organisms, in turn, cycle nutrients back to the plant, allowing it to grow and flourish.

It's a natural, symbiotic system that leads to healthy soils and more sustainable and profitable agriculture.

ORGANISM	WHAT DOES IT DO?
BACTERIA	Feed on organic matter, store and cycle nitrogen, and decompose pesticides.
FUNGI	Up to 3,000 species of fungi are in the soil. Some feed on dead organic matter like crop residues that are more difficult to break down–others are parasites that attack other microbes. Some fan out from the root to get more nutrients and hold more water for the plant, delivering nutrients to the plant in exchange for carbon.
PROTOZOA	Eat bacteria, fungi, and algae. When they eat bacteria, their main food source, they unlock nitrogen that's released into the soil environment slowly. They convert organic nitrogen to inorganic nitrogen that's available to plants.
NEMATODES	These microscopic worms are an important part of the nitrogen cycle. Most are non-pathogenic and don't cause disease. They eat other organisms in the soil.
EARTHWORMS	Expel partially decomposed organic matter, produce nutrient-rich casts, and make lubricated tunnels that aid soil structure and water movement in the soil.

Note: It's important to know how these organisms contribute to building healthy soil, but it's also important to know what harms them. Both tillage and the non-judicious use of pesticides can harm these important organisms.

Soil Health – Organic Matter

Organic matter matters. In fact, there may be no other component that's more important to a healthy soil than organic matter.

The tiny fraction of soil composed of anything and everything that once lived—organic matter—is more than an indicator of healthy soils.

The carbon in organic matter is the main source of energy for the all-important soil microbes and is also the key for making nutrients available to plants. The list of positive influences high levels of organic matter have on healthy soils includes:

1. Provides a carbon and energy source for soil microbes
2. Stabilizes and holds soil particles together
3. Supplies, stores, and retains such nutrients as nitrogen, phosphorus and sulfur
4. Improves the soil's ability to store and move air and water
5. Contributes to lower soil bulk density and less compaction
6. Makes soil more friable, less sticky, and easier to work
7. Retains carbon from the atmosphere and other sources
8. Reduces the negative environmental effects of pesticides, heavy metals and other pollutants

9. Improves soil tilth in surface horizons
10. Increases water infiltration rates
11. Reduces crusting
12. Reduces water runoff
13. Encourages plant root development and penetration
14. Reduces soil erosion

Cover crops, green manure crops, and perennial forage crops add organic matter, as do compost and manure. Growing crops and roots add biomass above and below the soil surface. However, not all that biomass is converted to soil organic matter—much of it is released as carbon dioxide and water. It can take 20,000 pounds of organic inputs such as crop residue to increase the actual soil organic matter from 4 percent to 5 percent.

Compost in particular breaks down more slowly and improves soil structure more quickly than other organic materials. Manure breaks down quickly to add nutrients for crops, but takes longer to improve the soil than compost.

Soil Health – Soil Structure

"Soft and crumbly." "Like cottage cheese." "Like a sponge." "Loose and full of holes."

Those and other common descriptions of what healthy soil looks and feels like refer to good soil structure.

Soil structure, the arrangement of the solid parts of the soil and the pore space between them, is critical to how the soil functions. When the solid parts—sand, silt and clay particles—cling together as coarse, granular aggregates, the soil has a good balance of solid parts and pore space.

Highly aggregated soils—those granular, durable, distinct aggregates in the topsoil that leave large pore spaces between them—are soils with good tilth and good structure.

Well-structured soils have both macropores (large soil pores generally greater than 0.08 mm in diameter) and micropores (small soil pores with diameters less than 0.08 mm that are usually found within structural aggregates).

An interconnected network of pores associated with loosely packed, crumbly, highly aggregated soils allows rapid infiltration and easy movement of both water and air through the soil and provides habitat for soil organisms.

Chemical and physical factors play a prominent role in small aggregate formation in clay soils, while biological processes drive development of large aggregates and macropores. Earthworms, for instance, produce both new aggregates and pores. Their binding agents are responsible for the formation of water-stable, macro-aggregates, and their burrowing creates continuous pores linking surface to subsurface soil layers. As they feed, earthworms also speed plant residue decomposition, nutrient cycling, and redistribution of nutrients in the soil profile.

Soil organic matter also helps develop stable soil aggregates. Soil microorganisms that are fed with organic matter secrete a gooey protein called glomalin, an effective short-term cementing agent for large aggregates. Organic glues are produced by fungi and bacteria as they decompose plant residues. Water-resistant substances produced by microorganisms, roots, and other organic matter, provide long-term aggregate stability from a few months to a few years.

TILAGE DESTROYS STRUCTURE

Management practices that reduce soil cover, disrupt continuous pore space, compact soil, or reduce soil organic matter, negatively impact soil structure. Since tillage negatively affects all of these properties, it's high on the list of practices damaging to healthy soils.

When tillage loosens the soil, it leaves soil particles exposed to the forces of wind and water. Transported by wind and water, detached soil particles settle into pores, causing surface sealing, compaction and reduced infiltration. When this happens less water is available to plants and runoff and erosion increases.

By contrast, soils that are not tilled and are covered with diverse, high residue crops throughout the year have better soil structure, are highly aggregated, with high levels of organic matter and microorganism activity, high water holding capacity, high infiltration rates, and little compaction.

Soil in the Urban Landscape

Soil is the foundation upon which we build our homes, schools, businesses, workplaces, streets and highways. How we treat this soil resource as we build homes, construct highways and other structures, as well as how we treat the soil as we go about our daily activities after construction is complete, has a direct impact on the quality of our water and our lives.

Urban construction activity generates considerable potential for soil erosion, which may impact water quality as a result of construction runoff.

Clearing of vegetation such as grasses and trees exposes large site areas to erosion processes, which in turn can pollute streams with sediment and nutrients that wash off the areas not covered with vegetation. This type of pollution is referred to as a type of Non-Point Source Pollution because there is no specific point of discharge to streams and other waterways such as pipe discharge or Point Source Pollution.

The basic principles of control for soil erosion are to:

- Keep disturbed areas as small as practicable.
- Stabilize and protect disturbed areas from raindrop and runoff energies as soon as practicable.
- Retain sediment within the construction site.
- Reduce the time that soil is exposed with no vegetation.

After the construction activities are completed it is still essential that urban residents maintain their soil resources by being sure that erosion does not occur around their homes or business. Maintaining a healthy lawn and incorporating appropriate plantings of tree and shrub species ensures that the soil will stay in place for many years into the future.

Parts of this section have been adapted from a booklet produced by the United States Department of Agriculture, Natural Resources Conservation Service, Iowa State Office. For more information on practices described in this section, contact your local soil conservation district or the Maryland Department of Agriculture, 50 Harry S. Truman Parkway, Annapolis, MD 21401. Phone 410.841.5863

Maryland Envirothon SOILS Exam Guidance Information

Objective: To test students' knowledge and awareness of basic soil science and its application in wise land-use planning and therefore conserving, protecting and enhancing the soil resource base. This is accomplished through a practical hands-on type of exam requiring the ability to make basic soil property observations, apply these observations to make suitability interpretations and the ability to use soil survey reports.

Outline to Soils Exam:

Section I. Soil and Surrounding Features (76 points)

Part A. Landscape Features (8 pts.)

1. Position (2 pts.)
2. Parent Material (2 pts.)
3. Slope Characteristics (2 pts.)
4. Surface Stoniness or Rockiness (2 pts.)

Part B. Soil Profile Features in Pit (35 pts.)

1. Major Soil Horizons (4 pts.)
2. Topsoil Layer – O and A horizon(s) thickness (2 pts.)
3. Past Soil Erosion (3 pts.)
4. Soil Color - Topsoil and Subsoil/Substratum (4 pts.)
5. Soil Drainage (6 pts.)
6. Soil Depth (4 pts.)
7. Soil Texture (6 pts.) and Tie Breaker
8. Soil Permeability - Topsoil and Subsoil (4 pts.)
9. Soil Reaction - pH (2 pts.)

Part C. Soil and Site Interpretations (33 pts.)

Agricultural Suitability

1. Major Limiting Factors (2 pts.)
2. Land Capability Class (3 pts.)
3. Prime Farmland (2 pts.)
4. Hydric Soil (2 pts.)
5. Potential Future Erosion (2 pts.)
6. Best Management Practices (3 pts.)

Soil Health

7. Munsell Soil Chart Notation (2 pts.)
8. Pin Flag – Compaction (2 pts.)
9. Structure and Aggregation of Topsoil (2 pts.)
10. Nutrient Management Needs (5 pts.)

Urban Suitability

11. Suitability for Septic tank Absorption Field (2pts.)
12. Suitability for Lawns (2 pts.)
13. Suitability for Dwellings with Basements (2 pts.)

Wildlife Suitability

14. Wildlife Habitat (2 pts.)

Section II. Soil Survey Use (15 pts.)

Section III. Fifth Issue Related to Soils (9 pts.)

Guidance to Soil Exam (page number indicates location in Maryland Envirothon Soil Study Guide)

Section I. Soil and Surrounding Features - This section pertains to the exposed soil profile and the area to be evaluated as provided by the information sign or the pit proctor.

Part A. Landscape Features – based on area surrounding the soil pit

1. Position (page 11) - requires understanding of kinds of landscape positions and the ability to differentiate in field.
   - **Upland:** usually level, rolling or convex, unaffected by stream activity
   - **Upland depression or drainageway:** concave landforms or at the heads of drainage ways, surface water retarded, sometimes ponded, usually thick dark surface (black), at least three sides are sloping to the bottom, parent material may be accumulated depositional material, may not be poorly drained.
   - **Terrace:** above zone of current flooding, usually gravel lines or coarse sands in profile, older alluvium parent material
   - **Floodplain:** near stream, has flood frequency, recent alluvium parent material

2. Parent Material (page 8) - requires knowledge of characteristics of 5 major types and ability to differentiate in field. Soil profiles may contain multiple types.
   - **Residual:** soils formed in place from bedrock (bedrock may not be present in profile)
   - **Colluvium:** generally located on lower part of slopes, moved down slope by gravity and water, soil material and angular coarse fragments, some maybe rounded.
   - **Recent alluvium:** fresh or recent deposits, floodplain position or an upland depression with ≥20 inches depositional material, poorly developed profile in the recent alluvial material.
   - **Old alluvium:** water worn (rounded) coarse fragments in the soil profile, stream terrace position, should have a developed profile, never or rarely flooded, no fresh materials
   - **Coastal Plain sediments:** on coastal plain region, can have silty cap (loess)

3. Slope Characteristics (page 13) - requires the ability to use clinometers or Abney levels to determine slope percentage and place in appropriate class based on physiographic province of the State. Guidance to appropriate physiographic province will be provided in training and/or by site proctor. The participant may need to know the exact percentage of slope for urban interpretations.

SLOPE CLASS	**COASTAL PLAIN**	**PIEDMONT OR MOUNTAIN**	**SOIL SURVEY LETTER SYMBOL**
Nearly level	0 to 2%	0 to 3%	A
Gently sloping	>2 to 5%	>3 to 8%	B
Strongly sloping	>5 to 10%	>8 to 15%	C
Moderately steep	>10 to 15%	>15 to 25%	D
Steep	>15 to 25%	>25 to 50%	E
Very steep	>25%	>50%	F

4. Surface Stoniness or Rockiness (page 32) - must be able to recognize stoniness or rock outcrops and assess quantities present to determine significance.

- **None:** less than listed below
- **Very stony:** tillage of intertilled crops impracticable, hay or pasture possible, no better than class V, stones exposed on soil surface that are ≥10 inches in diameter and are less than 30 feet apart, not gravel or cobble
- **Rock outcrop:** bedrock exposures, intertilled crops impracticable, hay or pasture possible, no better than class V, two or more bedrock exposures less than 100 feet apart within designated area to be judged, commonly found in limestone valleys

Part B. Soil Profile Features - based on exposed soil profile in the pit and provided samples

1. Major soil horizons (page 19) - requires knowledge of characteristics of major soil horizon and ability to differentiate in field. Will be asked to circle soil horizons visible in the profile (wall of the pit). Possible horizons are O, A, E, B, C, R.
2. Topsoil layer thickness - requires measurement to nearest inch of the A horizon(s) in cropland or of any O horizons plus A horizon(s) in forested or grass areas.
3. Past Soil Erosion (page 45) - The appropriate class is determined by measuring the thickness of existing topsoil layer, A horizon(s) in cropland or O horizon plus A horizon(s) in forested or grass areas, and comparing this measured thickness to the original topsoil thickness given on the information sign. This is determined by subtracting the measured thickness from the original thickness. The answer could be a loss of topsoil due to erosion or an increase of topsoil due to a deposition of soil material. Class criteria are included on the exam.

- **None to slight**: <3" original soil lost (no mixing of subsoil)
- **Moderate:** 3-8" original soil lost (some subsoil layer mixed with surface, but still darker then subsoil)
- **Severe:** >8" original soil lost (surface layer and subsoil layer similar in color)

4. Soil Color (page 23) - influenced by organic matter content, drainage condition, or eroded condition. Requires assessment of color of both the A horizon and subsoil and substratum horizons.

Topsoil (A-horizon)--dominant moisten color of horizon

- **Brown or dark brown:** normal
- **Reddish brown:** eroded soil surface, subsoil closer to surface, inherited from parent material
- **Gray or grayish brown:** usually poor drainage condition and usually gray below
- **Black:** high organic matter content could be very poorly drained

Subsoil and Substratum (B and/or C horizons) -- from bottom of surface layer to bottom of pit (look at as a whole), mainly iron compound coatings responsible for color, generally these colors reflect the drainage class of the soil. The more gray colors (redox depletions) and the higher in the soil profile, the wetter the condition of the soil (saturation), which is indicating the seasonal high water table in the soil profile.

- **Yellowish brown or red, no redox depletions (gray mottling due to wetness):** usually well drained condition, oxygen readily available, some gray colors may be due to parent material

- **Yellowish brown or red, some redox depletions (gray mottling due to wetness)**
- **Gray, some redox concentrations (brown mottling):** these colors indicate a wet condition, wetter than the above colors; only for poorly drained or very poorly drained soils and should be directly under surface layer.

5. Soil Drainage (page 37) - soil color is a good indicator; based on entire profile. Requires ability to recognize redox depletions (gray soil colors attributable to wetness), measure the depth these colors first appear below the surface, place in appropriate depth class and place the profile into its appropriate natural drainage class.

- **Excessively drained:** all coarse textures or shallow to bedrock porous profiles on steep slopes; no redoximorphic features (mottles due to wetness)
- **Well drained:** no redoximorphic features (mottles due to wetness) above 40"
- **Moderately well drained:** redoximorphic features (mottles due to wetness) between 20-40"
- **Somewhat poorly drained:** redoximorphic features (mottles due to wetness) between 10-20"
- **Poorly drained:** redoximorphic features (mottles due to wetness) are dominantly directly below the surface layer
- **Very poorly drained:** low-lying and concave or depressions, very dark or black, thick surface layer (high organic matter), gray subsoil, usually ponded

6. Soil Depth (page 35) - root restricting or affecting basements or septic systems interpretations. Both effective rooting depth and depth to bedrock is required. Criteria for both depth classes are given on exam. Effective rooting depth is the same as depth to bedrock unless a fragipan (hardpan), sustained (permanent) high water table, or significant layer of coarse gravel and sand (greater than 60% gravel) occurs above bedrock. Information sign and/or proctor will provide guidance as to depth to these restrictions.

- **Very deep:** >60"
- **Deep:** 40-60"
- **Moderately deep:** 20-40"
- **Shallow:** 10-20"
- **Very shallow:** <10"

7. Soil Texture (page 28) - requires the ability to determine texture by feel on both topsoil and subsoil horizons and place in one of the 5 broad textural groups. USDA textural classes are provided on exam for further guidance. Texture samples may be provided or a depth increment may be designated for extraction of texture samples from the profile.

Topsoil (A-horizon)--organic matter may increase feeling of smoothness

- **Coarse:** sand, loamy sand, very gritty, none to very little ribbon, poorly formed stable ball (if at all)
- **Moderately coarse:** sandy loam, fine sandy loam, gritty, some ribboning, stable ball

- **Medium:** loam, silt loam, sandy clay loam, maybe gritty or smooth, good ribbon (>2"), (if real gritty then must be sticky also)
- **Moderately fine:** clay loam, silty clay loam, smooth, excellent ribbon, sticky
- **Fine:** clay, sandy clay, silty clay, hard to work up, very sticky, long ribbon (>3")

Subsoil (B horizon)—see individual textural group information above

- **Coarse**
- **Moderately coarse**
- **Medium**
- **Moderately fine**
- **Fine**

8. <u>Soil Permeability</u> (page 34) - is required on both the topsoil and subsoil layers and is primarily dependent upon textural group of each of these layers. Textural groups are given on exam and correlated to respective permeability rates. **Caution** - textural group defines permeability unless the soil contains a fragipan (hardpan) or it is formed in a limestone or similar parent material where structure is strongly expressed. Soils with fragipans have slow permeability in the subsoil regardless of texture and soils developed from limestone have moderate permeability although subsoil texture may be in the "fine" textural group.

- **Rapid:** >6.0 in./hr., coarse textures
- **Moderately rapid:** 2.0-6.0 in./hr., moderately coarse textures
- **Moderate:** 0.6-2.0 in./hr., medium textures
- **Moderately slow:** 0.2-0.6 in./hr., moderately fine textures
- **Slow:** <0.2 in./hr., fine textures or fragipan present

9. <u>Soil Reaction</u> (page 37) - requires the ability to properly use Hellige -Truog or other test kits as demonstrated in training session to determine pH on both topsoil and subsoil layers. More precise information may or may not be provided by proctor for sampling locations. pH should be estimated to the nearest tenth, i.e. 5.7. In most cases, a 1 to 1 1/2 pH range, bracketing the measured pH, is allowed for full credit.

Part C. <u>Soil and Site Interpretations</u> - these responses are based on landscape features and soil property decisions made in the preceding Parts A and B.

Agriculture Suitability

1. <u>Major limiting factors</u> - can check more than one; limiting to crop growth. Check all that apply, based on previous determinations and information provided on the information sign. Limiting criteria for each factor are given on the exam.

    - **None:** Land Capability Class I
    - **Flooding or ponding**: check if occasional or frequent; will be noted on pit information sign
    - **Slope:** check for any >2%
    - **Past Erosion:** check only if severe
    - **Effective rooting depth:** check for any <40" deep

- **Drainage:** check when redox depletions, gray mottles due to wetness are found <40" deep, this includes all drainage classes except well and excessively drained
- **Permeability:** check if rapid or slow
- **Available water capacity:** check if all coarse textures
- **Stoniness or rock outcrop**: check if found at soil pit site

2. Land Capability Class (page 47) - while technical criteria for Land Capability Class and subclass as provided in soil survey reports, can be quite complex, only the major Land Capability Class is requested based upon criteria listed on the exam. **Caution** - carefully heed the meaning of the words, "and" and "or" in these criteria.
3. Prime Farmland (page 52) - based on Land Capability Classification; check if Land Cap. Class is I or II from answer above.
4. Hydric Soil (page 52) - is included to illustrate relationship to poorly drained and very poorly drained soils, as identified in question Part B #5, and possible wetland implications.
5. Potential Future Erosion (page 46) - is included to emphasize the significance of future erosion potential on the site if cultivated for agricultural purposes, or otherwise disturbed in timber harvest operations, or in other urban related uses. For this exam it is based strictly on slope class determined in question Part A. #3.
    - **Slight**-- nearly level slopes (0 to 2% or 0 to 3%)
    - **Moderate**--gently slopes (2 to 5% or 3 to 8%)
    - **Severe**-- strongly sloping to very steep (>5% or >8%)

6. Best Management Practices (page 57) - while there are numerous BMP's available for erosion control and water quality improvement, this question uses drainage class, slope, and Land Cap. Class to identify needed BMP's for the soil and site. Criteria are given on the exam.
    - **Drainage**: would be needed for moderately well drained, or somewhat poorly drained, or poorly drained, or very poorly drained soils, and Land Cap. Class ≤ IV.
    - **Irrigation:** would be needed for excessively well drained soils and Land Cap. Class ≤ IV.
    - **Contour farming:** gently sloping soils and Land Cap. Class II
    - **Contour stripcropping**: strongly sloping or moderately steep soils and Land Cap. Class ≤ IV.
    - **Grassed waterways**: site is located in a drainageway or swale which conveys concentrated runoff and Land Cap. Class ≤ IV
    - **No-till Farming**: Land Cap. Class ≤ IV
    - **Permanent vegetation**: Land Cap. class V, VI, VII, or VIII
    - **Cover crops:** Land Cap. Class ≤ IV

Soil Health (page 66)

7. Munsell Soil Chart Notation – the color of the topsoil layer can be used to infer organic matter content which is related to soil health. The darker the soil color the higher the organic matter content, the better the health of the soil.
    - **Good**: Soil is dark brown or black in color; organic matter is visible in the topsoil layer. Value ≤ 3 and chroma ≤ 3.
    - **Fair**: Soil is somewhat dark in color; little organic matter is visible in the topsoil layer. Value = 4 and chroma = 4

- **Poor**: Soil is bright to dull colored; no organic matter is visible in the topsoil layer. Value > 4 and chroma > 4

8. Pin Flag – Compaction – the amount of compaction of the topsoil layer is related to soil health and root growth. The more compaction the worst the health of the soil is. Insertion of a pin flag, into the topsoil, can infer the amount of compaction.
    - **Good**: Wire flag enters soil easily to a depth below the topsoil layer; unrestricted root penetration.
    - **Fair**: Wire flag enters soil, but requires force to reach a depth below the topsoil layer; root growth restricted.
    - **Poor**: Wire flag enters soil with force, but does not penetrate through the topsoil layer; roots growing laterally.

9. Structure and Aggregation of Topsoil – the amount of aggregation/structure of the topsoil layer is related to soil health. The more aggregation and fine roots in the layer the better the soil health.
    - **Good**: Soil is granular, soft and crumbly, held together with many fine roots. Looks like cottage cheese.
    - **Fair**: Soil is blocky and firmer with some fine roots.
    - **Poor**: Soil is single grain, massive or platy and hard to break apart. It has few or no fine roots.

10. Nutrient Management (page 64) - requires basic knowledge of types of crops (legumes vs. non legumes), soil test results, and when nutrients as well as lime should be applied. Legume crops such as soybeans, alfalfa, and clovers do not require nitrogen. All other crops such as corn, small grains, and grasses for hay or pasture require supplemental nitrogen for optimum productivity. Recommendations are given for the crop indicated on information sign irrespective of what might actually be growing on the site. Soil tests for magnesium, phosphorus, and potassium will be given on information sign as VL = Very low, L = Low, M = Medium, H = High or VH = Very high. These nutrients are needed or recommended if the soil test is VL, L or M. Lime is recommended if the pH of the topsoil layer is less than 6.5.
    - **Lime**: check if pH <6.5
    - **Nitrogen**: check if anything other than legumes
    - **Phosphorus (Phosphate)**: check if not high or very high
    - **Potassium (Potash)**: check if not high or very high
    - **Magnesium**: check if not high or very high

Urban Suitability

11. Suitability for Septic Tank Absorption Fields - requires the ability to apply soil properties, determined from exposed soil profile and site in previous parts of the exam, to arrive at a suitability rating for this use. Soil features include slope, flooding, depth to bedrock, depth to redox features (wetness), and subsoil permeability. The most limiting level of any of the five soil properties dictates the overall degree of suitability. Example, if the site were nearly level, no flooding, with bedrock > 72 inches, depth to redox depletions (gray colors/wetness) in the 40 - 72 inch range and slow permeability, the suitability would be SEVERE because of the slow permeability. **Caution** - since many soil pits, for safety purposes are seldom excavated to a depth of 72 inches or more, it is presumed that conditions evident at the bottom of the exposed profile, i.e. at 60 inches for example, also represent conditions at > 72 inches unless specific guidance to the contrary is provided on the information sign or by the proctor.

12. Suitability for Lawns - is similar in format to suitability for septic tank absorption fields except that key soil properties are different as are some criteria depth ranges, i.e. depth to redox depletions (wetness). This suitability rating also requires the estimation of % rock fragment (gravel) by volume in the surface layer. Representative samples of varying gravel contents should be carefully evaluated during training sessions for reference. Soil properties include slope, soil surface texture, rock fragments in or on surface, past erosion, and, depth to redox depletions (gray colors/wetness)

13. Suitability for Dwellings with basements - is similar in format to other suitability questions except soil features and criteria change. Again, soil features determined in earlier portion of exam are used to arrive at an overall suitability. Soil features include slope, flooding, depth to bedrock, depth to redox depletions (gray colors/wetness).

Wildlife Suitability

14. Suitability for Wildlife habitat -

Section II. Soil Survey Use (page 53) - this portion of exam is intended to expose the participant to the soil survey report and how to find soils information contained in it. The participant will be given a real-life scenario and a soils map with a legend of the mapping units. They will be required to use the report to find the answers to questions related to the soil map. Some questions may be related to soil interpretations others to specific soil properties. In most cases the questions will be the same across the county or state but responses will change depending upon the soil survey area. An example of a scenario is: "*You have just purchased a piece of property in ??????? County. The following is the soils map and soil legend for the property you just purchased. You're unsure of what you want to do. You may want to develop it, do some farming, or change some areas to attract wildlife. Using the soil survey, answer the following questions to help you decide where the most appropriate places are to do these things on your property.*"

NOTE: Although the "official" soil surveys for Maryland are all on the NRCS Web Soil Survey internet site (http://websoilsurvey.nrcs.usda.gov/app/), for the contest, soil survey information reports will be provided to the students for answering questions.

Section III. Fifth Issue as Related to Soils - this portion of the exam consists of general knowledge questions of the current Fifth Issue subject as it is related to soils. The questions are usually taken from reference materials posted on the State Envirothon web page or from handouts provided by the soil instructors.