Soil Study Guide

2002-2003

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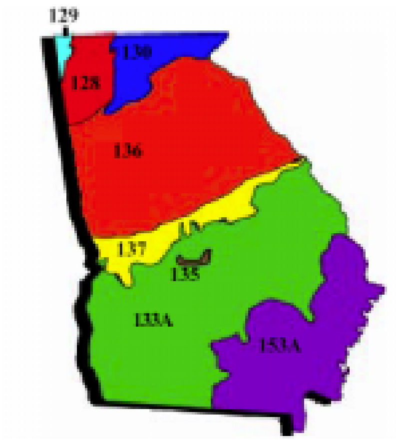
Selected sections of the text in this handbook are from “Soils of Georgia”, Bulletin 662, The Cooperative Extension Service, The University of Georgia College of Agriculture, Revised November 1987; “From the Surface Down”, by USDA Natural Resources Conservation Service; Soil Survey Manual, USDA Soil Survey Division Staff, 1993; Glossary of Soil Science Terms, Soil Science Society of America, 1996; and Biology by Helena Curtis, Second Edition.

Physiographic Regions and Major Land Resource Areas in Georgia

A **physiographic region** is an area that has similar geology and climate, and whose relief or landforms differ significantly from that of adjacent regions. "Major Land Resource Areas" (MLRA's) are similar groupings, which are characterized by soil, water, topography, climate, and land use. The following descriptions are of the six most extensive MLRA's in Georgia.



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The **Southern Appalachian Ridges and Valleys MLRA** (128) consists of many parallel ridges with narrow intervening valleys that contain low, irregular hills. Topsoils are generally sandy and subsoils are loamy or clayey. Soils on ridge tops and slopes are well drained. However, soils in the valleys may be seasonally wet. Crops include hay, pasture, and grain for cattle, and small acreages of row crops.

The **Blue Ridge MLRA** (130) is dominated by steep mountain slopes, exposed bedrock, and narrow stream valleys. Soils are mostly formed from bedrock and many are shallow to rock. Soils are commonly acid, well drained, and have loamy subsoils. Most agriculture and urban areas are found in valleys along streams.

The **Piedmont MLRA** (136) has soils formed in bedrock except along the streams. Landscapes are gently rolling to steep and erosion is a common problem in areas used for crop production. Soils in this region are acid and often have B horizons (subsoil) with high clay contents. Much of the Piedmont is in forests, pasture, or urban areas.

The **Sand Hills MLRA** (137) is a narrow strip extending along the fall line (ancient beach ridge) from Augusta to Columbus. Slopes are often steep and erosion is a problem if soils are left bare. Many of the soils here are formed in deep sand.

The **Southern Coastal Plain MLRA** (133A) is nearly level or gently rolling. Soils here formed in marine sediments that were deposited when this area was the sea floor. Many of the soils have sandy surface horizons. Subsoils in this region are acid and have variable texture ranging from sand to clay. Soils in this MLRA are well suited for a wide variety of crops.

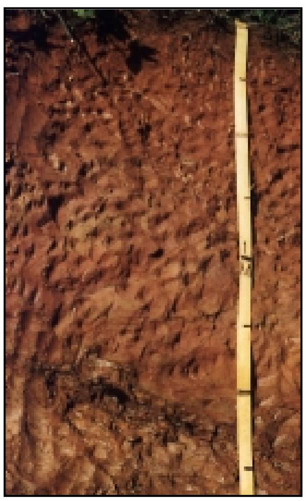
The **Atlantic Coast Flatwoods MLRA** (153A) is located in Southeast Georgia and is characterized by nearly level topography and poorly drained soils. The Okefenokee Swamp is located in this area. Most agricultural activities are limited to the well-drained soils, leaving the majority of the Atlantic Coast Flatwoods in forest.

Ecoregions

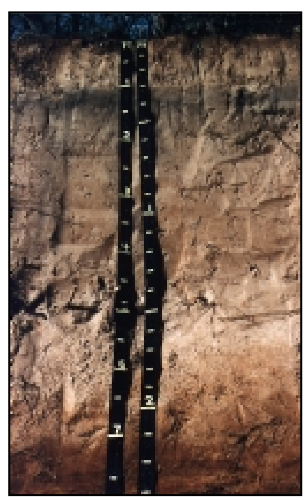
Similar to Major Land Resource Areas (MLRA's), ecoregions are a classification system used to describe areas of the Earth's surface. **Ecoregions** are areas on the surface of the earth in which the ecosystems have similar plant and animal life. They are identified and delineated based on patterns of physiography, geology, soils, vegetation, land use, climate, wildlife, and hydrology. They are designed to serve as a basis for assessing, monitoring, and managing resources.

The ecoregion concept has been used for some time on a broad scale. Recent efforts have been made to develop ecoregions for individual states at a scale of 1:250,000. Plans are for some agencies to use the ecoregions as a framework for water quality and resource management assessment and planning.

Ecoregion classifications and maps are currently under development in Georgia. They are generally subdivisions of MLRA's. As an example, most of South Georgia is in the Southern Coastal Plain MLRA. This area will likely be divided into a number of ecoregions, perhaps 5 to 8, based on differences in topography, hydrology, soils, land use, vegetation, and wildlife.



Evard - *Blue Ridge*

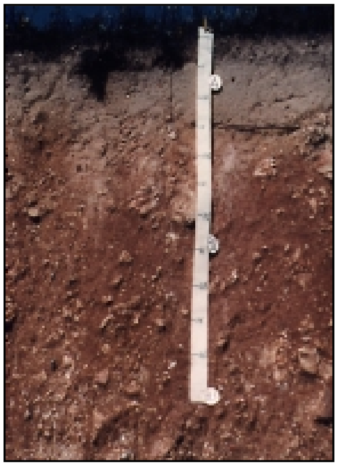


Troup – *Carolina and Georgia Sand Hills*

Cecil - *Southern Piedmont*

Southern Coastal Plain - **Tifton**

Atlantic Coastal Flatwoods - **Pelham**



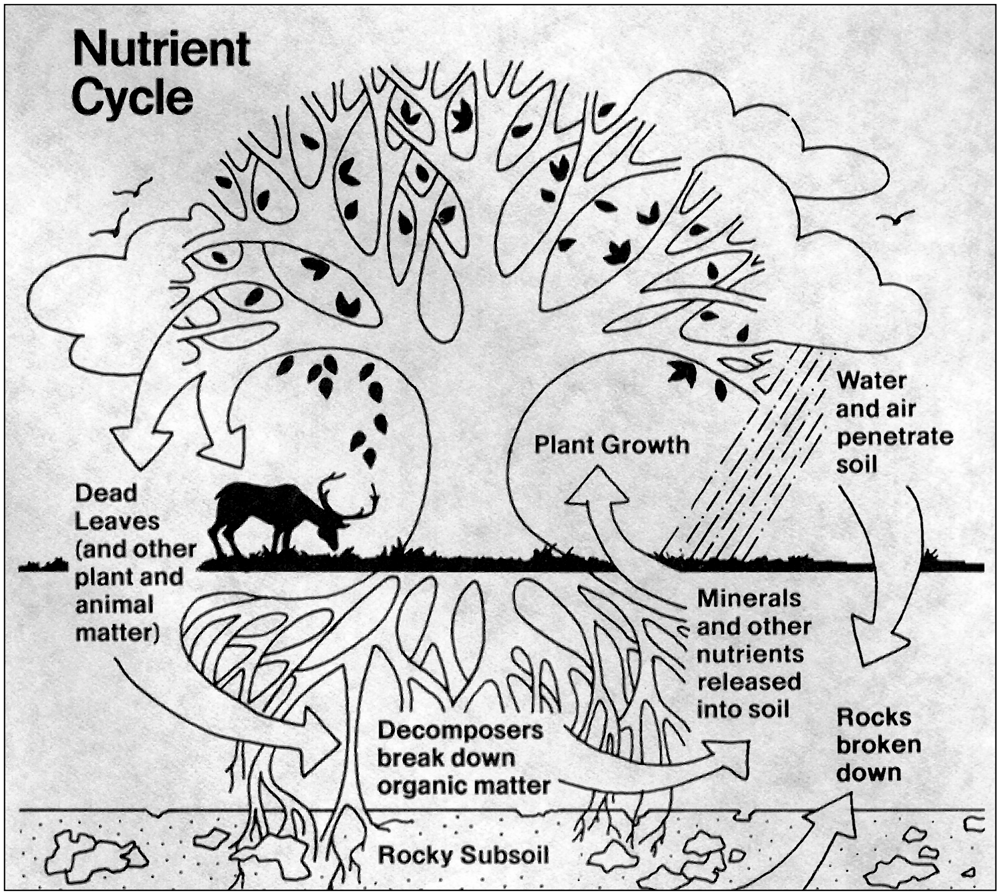
Fullerton - *Southern Appalachian Ridges and Valleys*

What is an Ecosystem?

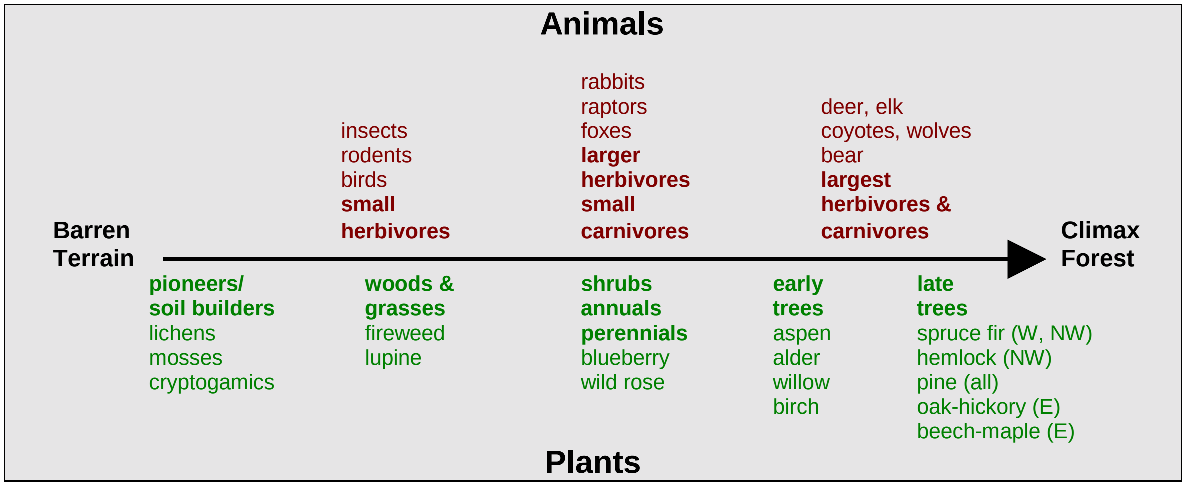
> **"When one component changes, it affects the other components and the system as a whole."**

An **ecosystem** is an organized system of associated living (biotic) and nonliving (abiotic) components, which function as an interdependent unit. In other words, when one component changes, it affects the other components and the system as a whole. In every ecosystem there are two things that always occur: the flow of energy and the cycling of minerals. The ultimate source of energy for every ecosystem is the sun. From the fraction of the sun's energy that reaches the earth, an even smaller fraction enters the food chain of living organisms. The major components in the food chain are the **producers**, **consumers**, and **decomposers**. The primary **producers** are the first link in the chain. These would be green plants on land, and photosynthetic algae in an aquatic system. Producers can convert energy from the sun into food (photosynthesis). The second link occurs when animals or humans eat these plants. These plant eaters are called herbivores. Herbivores can include anything from an elephant to a caterpillar. Carnivores, meat-eating animals, are the next link in the chain. There are many levels of predators and prey, but most carnivores, except those at the very top, fall into both categories. Some organisms can be both herbivores and carnivores, but the important thing to know here is that all of these organisms are called **consumers**. Consumers cannot make their own food. They must consume and use the energy stored by producers and/or other consumers.

Energy takes a one-way course through an ecosystem, but there are many inorganic substances which cycle through the system. These substances include water, nitrogen, carbon, phosphorus, potassium, sulfur, magnesium, sodium, calcium, and other minerals needed by living organisms to sustain life. The movement of inorganic substances involves not only the substances themselves, but also geological and biological components. The geological components include the atmosphere, the lithosphere (Earth's crust), and the hydrosphere (oceans, lakes, rivers, etc.). The biological components include the producers and consumers, as well as a third extremely important group called the **decomposers**. Decomposers (primarily bacteria and fungi) break down dead organic matter, oxidizing the energy-rich compounds formed during photosynthesis, and releasing the chemical components back into the soil or water, where they will once more enter the bodies of plants. Thus, the cycle has come full circle and begins again.

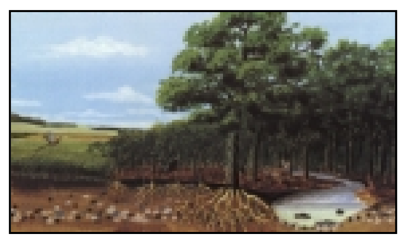


Ecosystems "grow" and change as the communities of living organisms contained in them "grow" and change. Communities of living organisms replace one another in a predictable and orderly sequence. This process is known as **ecological succession**. Many times a natural disaster or even manipulation by man can destroy an ecosystem to the point where it must start over. If the land is laid bare from such an incident, and the resulting environment is not too harsh, the vegetation will slowly recover and bring with it the accompanying animal life. This recovery happens in several stages of natural progression over a period of time. When the area has been modified as much as the environment allows, succession ceases or slows considerably. The community that exists at this time is known as the **climax community**. Even though change is occurring within this community, the new organisms are usually the same species as the ones they are replacing, so the environment is, for the most part, stable. If succession continues at this point, it is very slow. However, if the community or the environment is drastically changed, the cycle begins again.



Ecosystems vary in size, scale, diversity, and in the types of relationships they contain. Some examples of ecosystems include prairie, desert, tropical rain forest, coniferous forest, hardwood forest, wetland, river, ocean, etc. The major factors determining the classification of ecosystems are climate, vegetation, soil types, and water. Moisture and sunlight control the patterns and boundary lines of ecosystems. Sunlight is distributed unevenly across the earth, so some regions receive more sunlight than others. This affects rainfall, winds, ocean currents, and other environmental aspects in a region, ultimately determining the climate of the area and the type of ecosystems that will develop there. Because these factors are dynamic, or continuous, there is a gradual transition from one ecosystem into another.

Relationships between Soil and Other Components in an Ecosystem



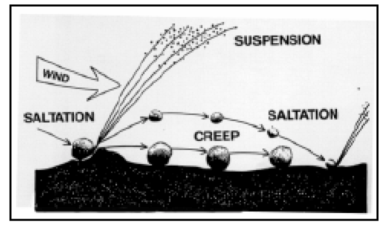
As was already mentioned, if one component in an ecosystem changes, it affects all of the other components, as well as the system as a whole. Let's take a closer look at the role of soil within an ecosystem and its relationship with the other major components.

Soil and Plants

Soil supports plant life. It contains nutrients and water that plants need to live. Sometimes plants can even be used to remove pollutants from soil or break down pollutants in the soil. (This helps to prevent contamination of groundwater.) Underground, the soil provides an environment for growth of plant roots and, in turn, plant roots anchor soil in place, which helps to prevent erosion. Above ground, plant vegetation and leaf litter protect the soil from raindrop impact and wind erosion. When water hits bare soil, the impact of one drop loosens thousands of soil particles on the surface. These loose soil particles may then be carried away away with the water running over the surface of

Rill erosion and soil deposition by water on non-vegetated surface.

the ground (runoff) and deposited somewhere else, either in low areas on the landscape or in our rivers and streams (*see **Soils and Water***). If there is no vegetation on the ground to slow the water movement, surface runoff is faster and can carry more detached soil particles. If there is no vegetation to trap the sediment that is being carried by the runoff, the amount of sediment reaching those depositional areas will be greater.



During wind erosion, smaller soil particles are actually picked up and carried by the wind in **suspension**. These particles may travel for many miles before they are deposited in another place. Some particles "skip" across the surface as they are continuously picked up and dropped again and again, knocking loose more particles each time they "bomb" the surface. This process is called **saltation**. The larger particles that are too heavy to be suspended "**creep**" along the surface as they are pushed by the wind, again loosening particles as they go. There is a cycle within this erosion process as well. Not only are these particles creating this "domino effect" with other soil particles, but they are also being physically worn down themselves. So, they will eventually go through all stages, from creep to saltation to suspension. Vegetation and ground cover prevent particles from getting picked up in the first place, and they trap those particles that are skipping and creeping across the surface, curbing the "domino effect".

Wind erosion

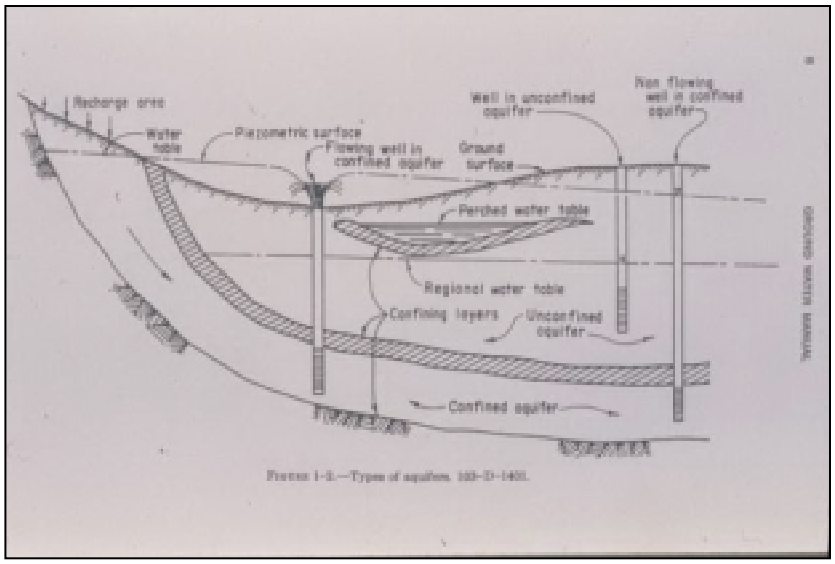
Another benefit of vegetation is the addition of organic matter to the soil during the decomposition of dead plants and leaf litter, which increases infiltration (water moving down into the soil) and increases fertility by returning nutrients to the soil.

Soil and Water

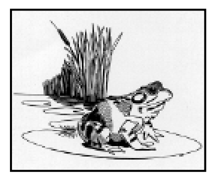
Water plays an important role in the development of soil. Water is the primary transporter of most inorganic and organic substances, as well as soil particles through the soil profile. When water leaches or removes substances or particles from a soil horizon, this is called eluviation (think "E" for "Exit"). When water carries substances or particles into a soil horizon and deposits them there, this is called illuviation (think "I" for "Into"). These two processes in soil development can create diagnostic features or diagnostic horizons that affect soil classification.

The seasonal high water table also plays a very important role in the classification and interpretation of soils. In Georgia, most of our red soils get their color from iron. If water remains in a soil for a long enough period of time, all of the oxygen in the soil is used up, and microbes will chemically alter the iron in a process called "reduction." This turns the soil from red to gray. Water is commonly only present in the soil during wet seasons of the year, meaning the iron is sometimes oxidized (dry) and sometimes reduced (wet). Instead of a dominantly gray color, the soil may have the usual red or brown color with only small portions of the soil having gray colors. These are usually concentrated in the zone(s) or horizon(s) of the soil where the water is concentrated during wet periods. The features that are created by wetness, such as areas of reduced iron or concentrations of oxidized iron are called redoximorphic features. Hydric soils are very wet soils that are saturated to the surface or ponded a significant amount of time. Under such continuous wetness, the iron is almost completely reduced, giving the soil a dominant (more than 50%) gray color.

Seasonal high water tables can occur either as “perched” water tables or as “apparent” water tables. Perched water tables occur when a soil horizon obstructs water flow down through the soil. Rainwater collects on top of this layer and moves laterally under the surface, instead of downward through the soil. A distinctive zone of perching is evident in the soil profile. An apparent water table occurs when the underground water table rises up into the soil. During the wet season, water might actually be found near the surface. During the dry season, water may be much deeper, but gray colors as evidence of the seasonal high water table still remain in horizons seasonally saturated with water.

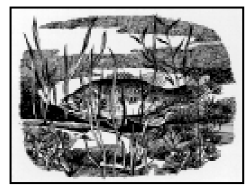


Water plays an important role in the development of soil. Reciprocally, soil plays an important role in the quality of water. Soil filters pollutants out of the water as it passes through. Some pollutants attach themselves to soil particles and are bound by them so water cannot carry them to underground aquifers. Many times plants will react with and absorb these elements. Those pollutants that are soluble and are moving through the soil in the water are “diluted,” not necessarily by the liquid itself, but by the diffusion of the water through this very large maze of soil pores and root channels. Plus, the water can only percolate through the soil as fast as it can move through the pores and root channels. This means that the contaminants in the water have a better chance of being absorbed by plants before the water gets out of reach of the roots. This is not the case when a large fissure is present in the bedrock of a shallow soil, however. Here the pollutants would be concentrated in the water and could quickly and easily reach and contaminate an aquifer. The water and the pollutants would be long out of reach of roots before the plants could absorb anything. Wetlands are very efficient in filtering pollutants because these areas are saturated and/or ponded for extended periods of time. Since most of these pollutants also depend on water movement for transportation, and the water in a wetland is not moving (or at least not very quickly), then the pollutants in the water are not going anywhere either. Wetlands support a unique group of plants (hydrophytes), many of which are very efficient in removing high amounts of common contaminants from the water.

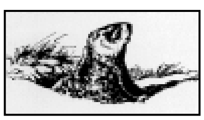


Plants are not the only biological factor. Aerobic (require oxygen) and anaerobic (do not require oxygen) microbes are also breaking down contaminants as they move through the soil. Billions of microbes live in just a teaspoon of soil. Microbes are extremely important in the recycling of waste into usable nutrients. However, this takes time. Soil slows the movement of contaminants and provides the necessary conditions for microbial action to take place. The water provides the transportation for both the microbes and the pollutants. Wetlands are extremely efficient at filtering pollutants because of this reason. Under saturated or ponded conditions, the pollutants are more or less immobile, allowing anaerobic microbes to go to work.

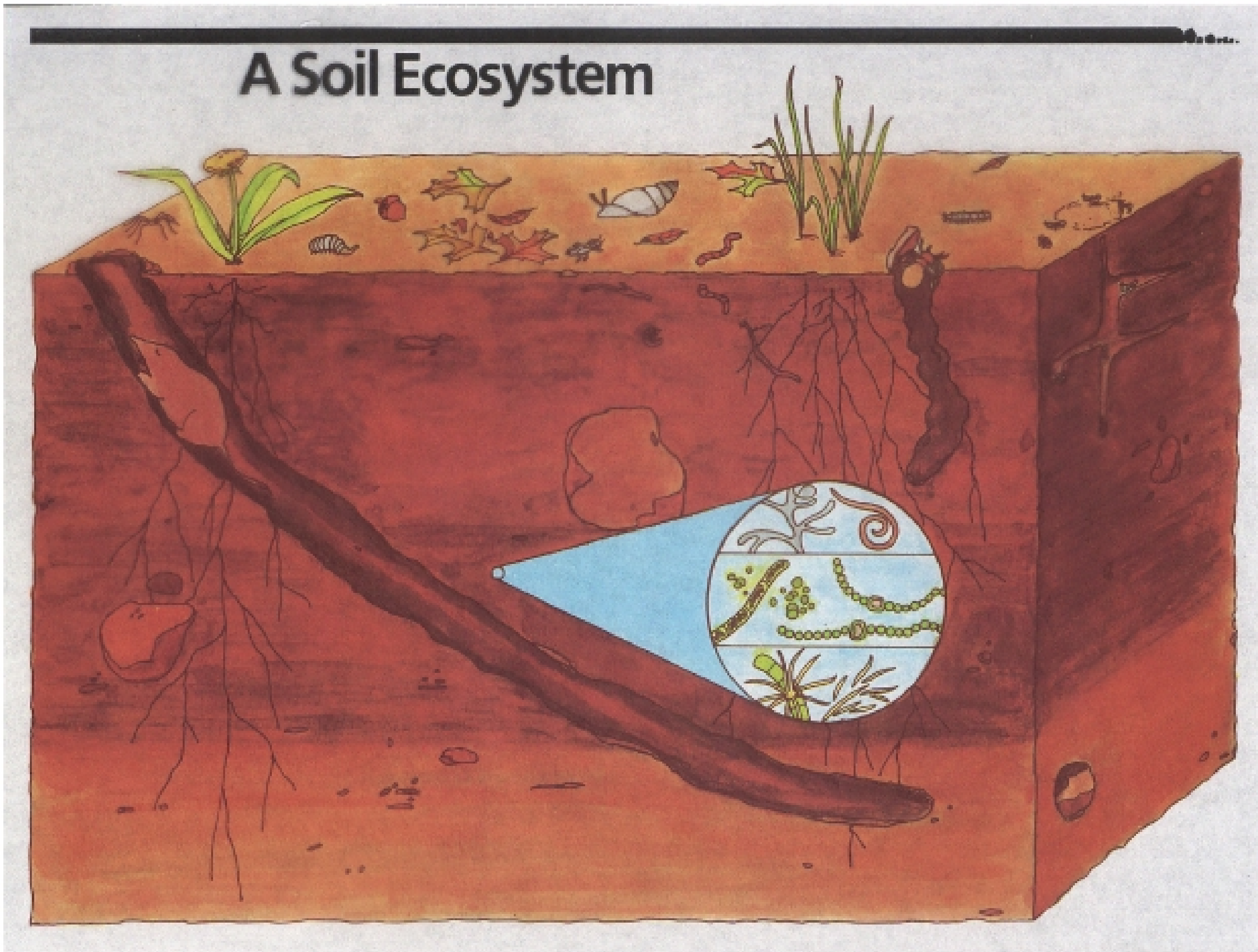
Sometimes water can create havoc on the soil surface. If soil is left unprotected, water can wash away valuable topsoil. Some common types of soil erosion by water include sheet, rill, and gully erosion. Erosion results in not only a loss of fertile, productive topsoil, but it also has adverse effects on other elements within the environment. Erosion leads to excessive sedimentation in rivers, streams, and lakes. This can have a number of ill effects on water quality and aquatic life. It can increase turbidity in the water (effects: raises water temperature, increases algal growth, decreases dissolved oxygen, clogs fish gills, and makes wildlife more susceptible to disease). It can cover spawning areas and food supplies (effect: kills fish). It can displace water, making the lake or stream shallower (effects: increases water temperature, increases algal growth, and decreases dissolved oxygen). Excessive sedimentation can also change the course of rivers and streams.



Soil and Wildlife



The soil is an ecosystem in itself. It is home to many animals, from the tiniest of bugs to large burrowing animals like moles and prairie dogs. These burrowing animals help the soil by aerating it, thus, increasing the percolation of water through the soil. The soil supports plant growth (food source) and contains certain minerals that animals need (like iron). Decomposition of animal carcasses and waste adds organic matter to the soil, which increases fertility, tilth (workability of the soil), and water infiltration (resulting in decreased surface runoff). Also, animals such as squirrels, deer, and birds scatter seeds as they feed, encouraging new plant growth, which will protect the soil from erosion.



What is Soil?

Soil is not dirt! A natural resource of primary importance, **soil** is the weathered outer layer of the earth's crust that supports plant life. Here are just a few uses for soil:

- we grow our crops in soil
- we build houses on soil
- forests grow on soil
- soil filters the water we drink

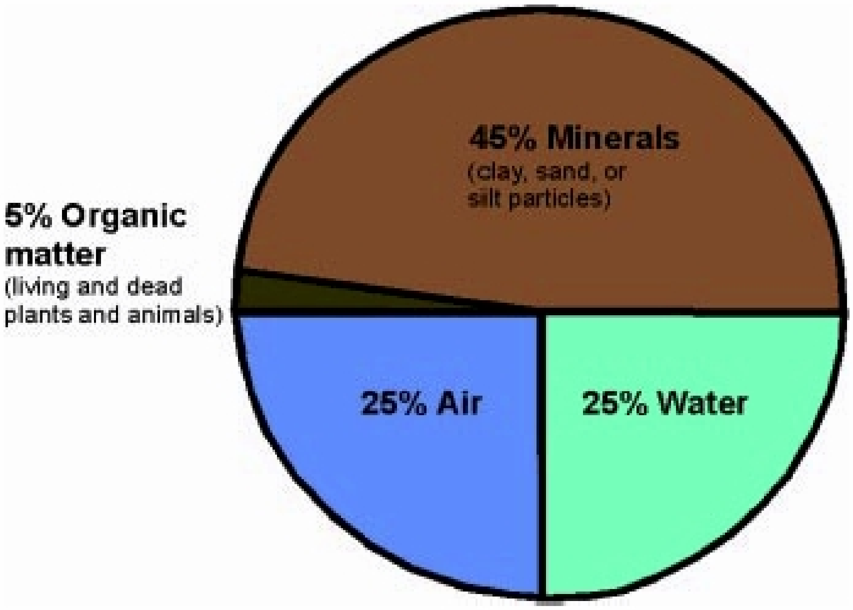
Soil is made up of material derived from disintegrating and decomposing rocks and organic matter. Dirt is soil out of place. Dirt cannot support life.

Increase your awareness of the many different soils around you. Study a soil survey and see what soil you are living on. As you ride down a road, note the different soils and horizons you see on the embankment. Think about the different soil materials (sand, silt, and clay) you see and how the soil might have formed. Think about why some soils are red or yellow, while others are brown or gray.

Always keep in mind that soil is teeming with life: a teaspoon of soil can contain billions of organisms. Consider our soil a complex mixture our world is built on. Get to know your soil.

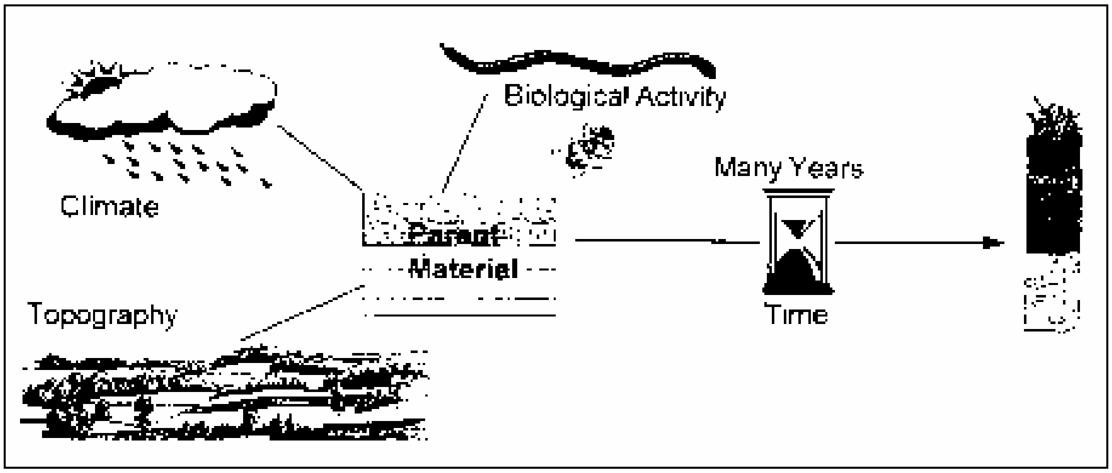
Major Soil Components

Soil consists of four major components: **minerals**, **soil water**, **soil air**, and **organic matter**. The spaces between the minerals and the organic matter in soil are called the pores. At an ideal moisture content, a typical soil contains about 1/2 minerals, 1/4 pore space or air, and 1/4 water in pores. Wet soils have more water in the pores while dry soils have more air in the pores. Organic material makes up the smallest percentage of most soils and is commonly less than 5 percent. In fact, cultivated soils in Georgia commonly have less than 2 percent organic matter. Despite its small proportion, organic matter is very important because it contains nutrients, improves tilth, and holds water.



How Soils are Formed

The development of soils from the original rock material is a long-term process that involves physical and chemical weathering along with biological activity. Since this process is continuous, soils are dynamic systems. Characteristics of each soil depend on five soil forming factors that reflect the environment in which the soil developed. These factors are: **parent material**, **climate**, **biological activity**, **topography**, and **time**. Each soil has its own formation story that makes it unique. For instance, granite rock (parent material) is exposed in North Georgia. The winters are cool and wet while the summers are hot and humid (climate) for many years (time). Lichen and mosses begin to grow on the rock, the granite rock breaks down into smaller particles in which larger plants grow and animals burrow (biological activity). Flat areas develop into deeper soils than steep areas because erosion does not carry away newly formed soils (topography). Would the same soil form if only one of the factors was changed (i.e., sandy marine deposit instead of granite for the parent material)? Even one factor makes all the difference in what type of soil is formed.



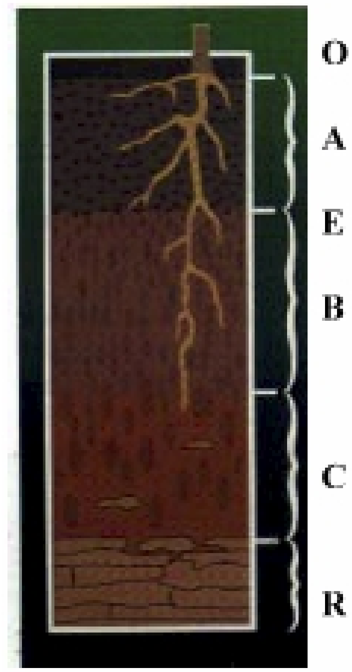
There are several different types of parent material. Most soils in Georgia are developed from parent material that is either **residual** (weathered in place from bedrock), **alluvial** (deposited by a river or stream), or **marine** (deposited by the ocean). Some soils are formed from or contain layers of **colluvial** (transported or deposited by a mass movement usually due to gravity) parent material. Most of the upland soils in the Piedmont and Blue Ridge are weathered from residual parent material, consisting mainly of granite and schist. In the Ridge and Valley MLRA, many soils are developed from residual limestone and slates. Some soils are formed from colluvial sediments that have been deposited at the base of the mountains from geologic erosion and gravitational action. The soils of the South Georgia Coastal Plain are formed in marine sediments, and the floodplains of rivers and streams throughout the state are formed from recent alluvial sediments. Soils in other parts of the country and the world are formed from other parent materials such as volcanic and glacial sediments**.**

In residual soil formation, the initial weathering on the parent rock is largely mechanical. As the rock slowly disintegrates into smaller rock fragments, the total surface area exposed to atmosphere increases. Chemical actions of water, carbon dioxide and various acids continue to reduce the size of the rock fragments. Finally, the action of microorganisms, higher plants, and animal life contributes organic matter to weathered rock material. To obtain the soil we now observe, these processes have gone on for hundreds, thousands, or even millions of years.

The Soil Profile

Exposed soil surfaces are common on almost any landscape not dominated by rock or covered with vegetation. Since soil is three dimensional, the surface view of a soil reveals very little about the depth or its subsoil characteristics. To get a view of the soil, you must expose a vertical section. The cross-sectional view of a soil is called a **soil profile**. Each horizontal layer that can be seen in the vertical section is called a soil **horizon**. An understanding of soil horizons and their chemical and physical characteristics is necessary to plan effective soil management programs.

Soil Horizons



The horizon sequence in a soil describes the current features of the three - dimensional body and may suggest the developmental history of a soil. The major soil horizons, called master horizons, are designated by the letter: *O, A, E, B, C, R*.

O horizon: layer of accumulated organic matter such as leaves, grass, twigs, etc.

A horizon (surface layer or topsoil): a surface mineral horizon enriched with organic matter. Generally, this is the soil's most productive horizon and is a zone of leaching, as well as the most climatically and biologically influenced layer. It is usually the darkest colored soil horizon due to accumulation of organic matter.

E horizon: main feature is loss of silicate clay, iron, aluminum, humus, or some combination of these, leaving a concentration of sand and silt particles that is light colored.

B horizon (subsoil): as water moves down through the topsoil, many soluble minerals and nutrients dissolve and leach into the subsoil. This horizon has an accumulation of leached clays and nutrients. The transition from topsoil to subsoil can usually be determined at a by a change of color and texture.

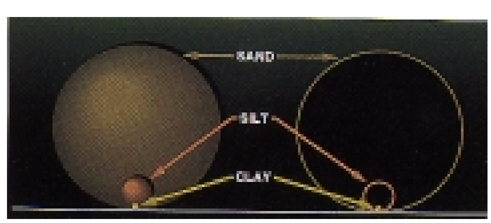
C horizon (weathered parent material or saprolite): unconsolidated material from which the soil above it is developed.

R horizon (hard bedrock): bedrock underlying a soil.

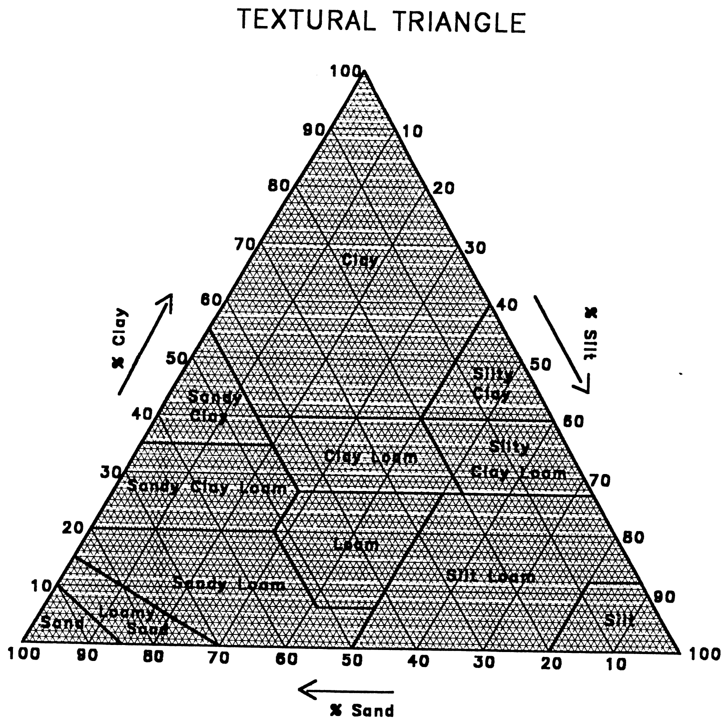
Soil Properties

Soil Texture

Soil texture is determined by the relative proportion of primary particles within the soil. These primary particles are **sand**, **silt** and **clay**. Texture can be field estimated or determined by lab analysis. The measured percent sand, silt, and clay can be plotted on the textural triangle (shown) to place the soil into a textural class. Sands are the largest particles of the fine earth fraction, silts are intermediate, and clays are the smallest sized particles of a soil. Ounce-for-ounce, clays have the greatest surface area because of their small size. In addition to their greater surface area, clays have a negative electrical charge which attractions and holds cations (ion carrying a positive electrical charge such as calcium and potassium). Nutrients and pesticides tend to be



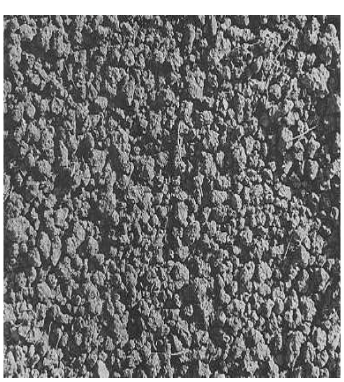
adsorbed mostly on clays and organic matter. Sands have a sugary feel where the individual particles can be felt. Silts have a flour-like feel. Individual particles are not felt in clays, which tend to have a plastic texture when moist.



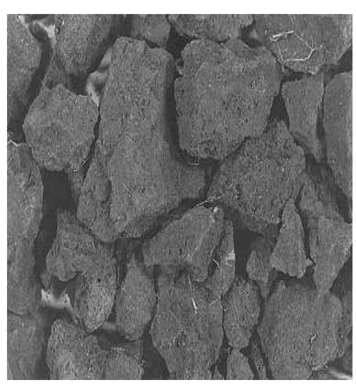
Soil Structure

Soil structure is the arrangement of primary soil particles into secondary units or **peds**. Soil structure can have different sizes, shapes, and grades, but shape is the most important to recognize. Granular structure is characterized by generally spherical units. Angular and subangular blocky structures are characterized by block-like, nearly equidimensional units. Angular blocky structure has relatively sharp angled sides, and subangular blocky structure has rounded sides. Platy structure is characterized by horizontally oriented, flat plate-like units. Soils can also have prismatic or columnar structure, both of which are vertically oriented and angular. Prismatic structure has flat tops, while columnar structure has distinctively round tops.

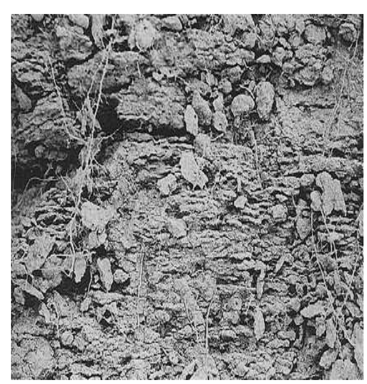
Granular Structure



Blocky Structure

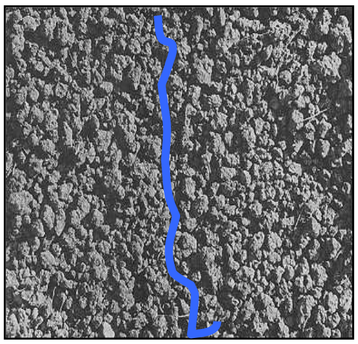


Platy Structure

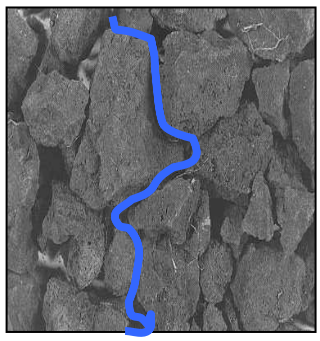


Permeability of Soils

Permeability is a measurement of how fast air and water can move through a soil. Both soil texture and structure influence the permeability of a soil. Sands have rapid permeability while clays have slower permeability. Clays reduce permeability because of their small size and flat shape. In addition, movement of clay in the soil can fill the voids clogging the pathways for air and water movement. The slow permeability of heavy clay soils makes them well adapted for pond and lagoon seals where slow water movement is desired but poorly adapted for septic system drainage fields where moderate rates of water movement are needed. Because the permeability of sands is so fast they retain the least amount of water making irrigation necessary for some crops on sandy soils. A loamy soil has moderate permeability, which is well suited to most any land use. Granular and blocky structure generally have moderate permeability, where platy structure has slower permeability. The following pictures show how structure affects water movement through the soil.



Granular Structure

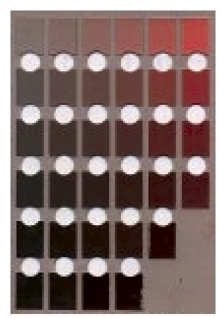


Blocky Structure

Platy Structure

Soil Color

Examining the colors in a soil tell us something about the characteristics of a particular soil. Dark colors usually note zones of organic enrichment. Red and yellow colors indicate good drainage, where poorly drained soils exhibit gray colors. Soil color is merely one facet of many that affect soil classification. The adjacent picture shows a page from the Munsell Color Chart, a universal standard for measuring soil color. Soil colors are described in the Munsell system by specifying their hue, value, and chroma.



Soil pH

Although color is a relatively obvious physical characteristic of a soil, other characteristics are not apparent to the casual observer. The soil pH is a chemical measure of how acid or alkaline a soil is. A neutral soil has a pH of 7. The more acid a soil is the lower the pH. Conversely, the higher the pH the more alkaline a soil is. Different plants grow better at different pHs. For example, blueberries like acid soils while alfalfa does better at higher pHs. Some plants add chemicals that might change the pH of a soil. Pine trees produce acid in the soil. Most timber stands are left for a number of years before harvest. This means that the soil will likely be more acid at harvest than it was at planting. Many times lime must be used to adjust the pH of a soil for optimum growing conditions, depending upon the desired crop or plant.

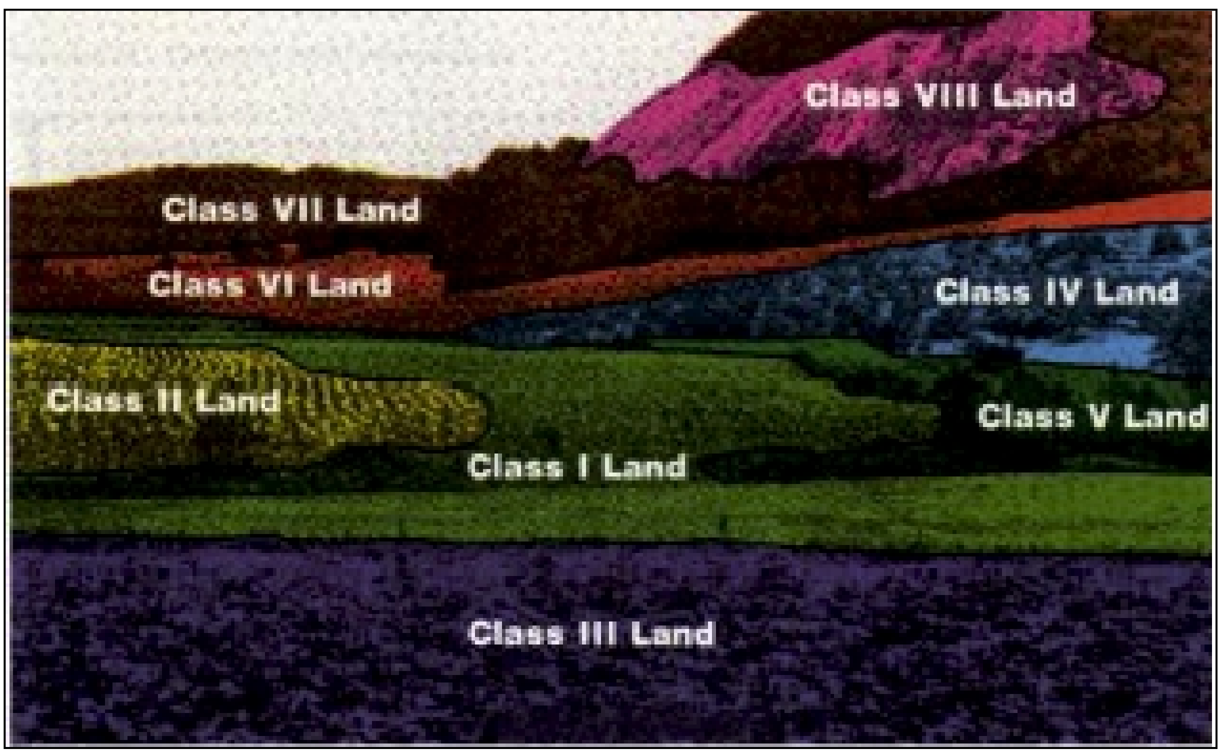
Effective Rooting Depth

Effective rooting depth is how far the roots can penetrate through the soil. Roots can be restricted by a plow pan, a hard pan, a cemented layer, or bedrock. When roots reach a restrictive layer, they usually turn and start growing horizontally. Most of the time, if a soil has shallow effective rooting depth, the evidence can be seen in the stunted vegetation on the surface.

Soil Interpretations

Land Capability Classification System

Land capability is an interpretive classification that describes the suitability of a soil for growing field crops, excluding those crops that require special management. Soils are placed into classes according to their inherent limitations, risk of soil damage, and response to management when used for farming. Capability classes are designated by Roman numerals I through VIII. The higher numerals indicate progressively greater limitations and fewer management choices. Capability subclasses are groups within a class. They are identified by adding a letter (e, w, s, or c) to the Roman numeral. The letters indicate the main hazard to using the soil for cropland. The limitation associated with each letter are: e - erosion, w - wetness, s - a soil condition such as shallow, droughty, or stony, and c - a climate that is very cold or very dry.

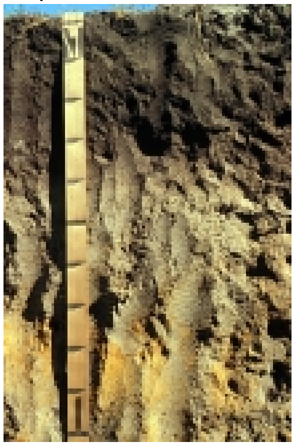


Landscape with land capability classes outlined.

Other important soil interpretations for land use management include crop and pasture, woodland management and productivity, recreation, wildlife habitat, and engineering interpretations.

Hydric Soils and Wetlands

A **hydric soil** is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic (no oxygen) conditions in the upper part. Certain bacteria can use elements and ions other than addition to oxygen as electron acceptors in respiration (oxygen is preferred and will be used as long as it is present). Under saturated or ponded conditions, the available oxygen is used up quickly, forcing the bacteria to use other elements and ions, such as nitrate, iron, and sulfate, as electron acceptors which reduces them and changes their chemical properties. Reduction of nitrate (denitrification) changes nitrate to nitrogen gas which removes nitrate from the water (loss of nitrogen fertilizer or removal of nitrate contamination in the water). Oxidized iron is red and is one of the things that gives "Georgia Red Clay" its name. Under anaerobic conditions, however, microbes reduce the iron in the soil, turning it gray. The gray color is a commonly used indicator of hydric soils. However, there is more to a hydric soil than just its color. The concept of a hydric soil includes criteria that the soil developed under sufficiently wet conditions to support the growth and regeneration of **hydrophytic** (water-loving) **vegetation**.



Hydric soils are significant to land-use planning, conservation planning, and assessment of potential wildlife habitat. A combination of the **hydric soil**, **hydrophytic vegetation**, and **wetland hydrology** criteria defines a wetland as described in the National Food Security Act Manual (Soil Conservation Service, 1994) and the Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory, 1987). Therefore an area that meets the hydric soil criteria must also meet the hydrophytic vegetation and wetland hydrology criteria in order for it to be classified as a jurisdictional wetland.

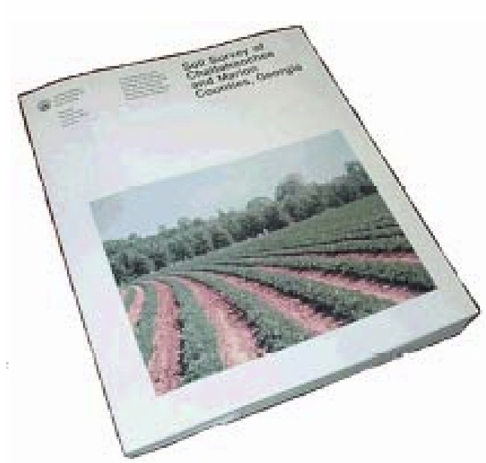
Soil Survey

As an inventory of soil resources within a county, the Soil Survey is the primary reference available to help land users and planners determine the potentials and limitations of soil. Soil surveys are compilations of maps, data, and interpretations made by professional soil scientists who have analyzed the soil properties across all landscapes within an area. The USDA Natural Resources Conservation Service (NRCS) conducts Soil Surveys throughout the nation and releases their findings to the public, traditionally as a published Soil Survey book.

Soil Surveys are also useful for interpreting soil suitability for crop production, forestry, and wildlife habitat improvement. The survey is also helpful in the proper selection of sanitary landfill sites, homesteads, recreation areas, and construction material such as sand and gravel.

What information does a published Soil Survey contain?

- a complete set of soil maps for the survey area, printed over an aerial photo base
- a color-keyed general soils map
- technical and nontechnical descriptions of all soils that exist within the survey area
- interpretations, or predictions, of how each soil type reacts to specific land uses
- detail descriptions of the physical and mineral characteristics of soil



How is Soil Survey information helpful to community planners?

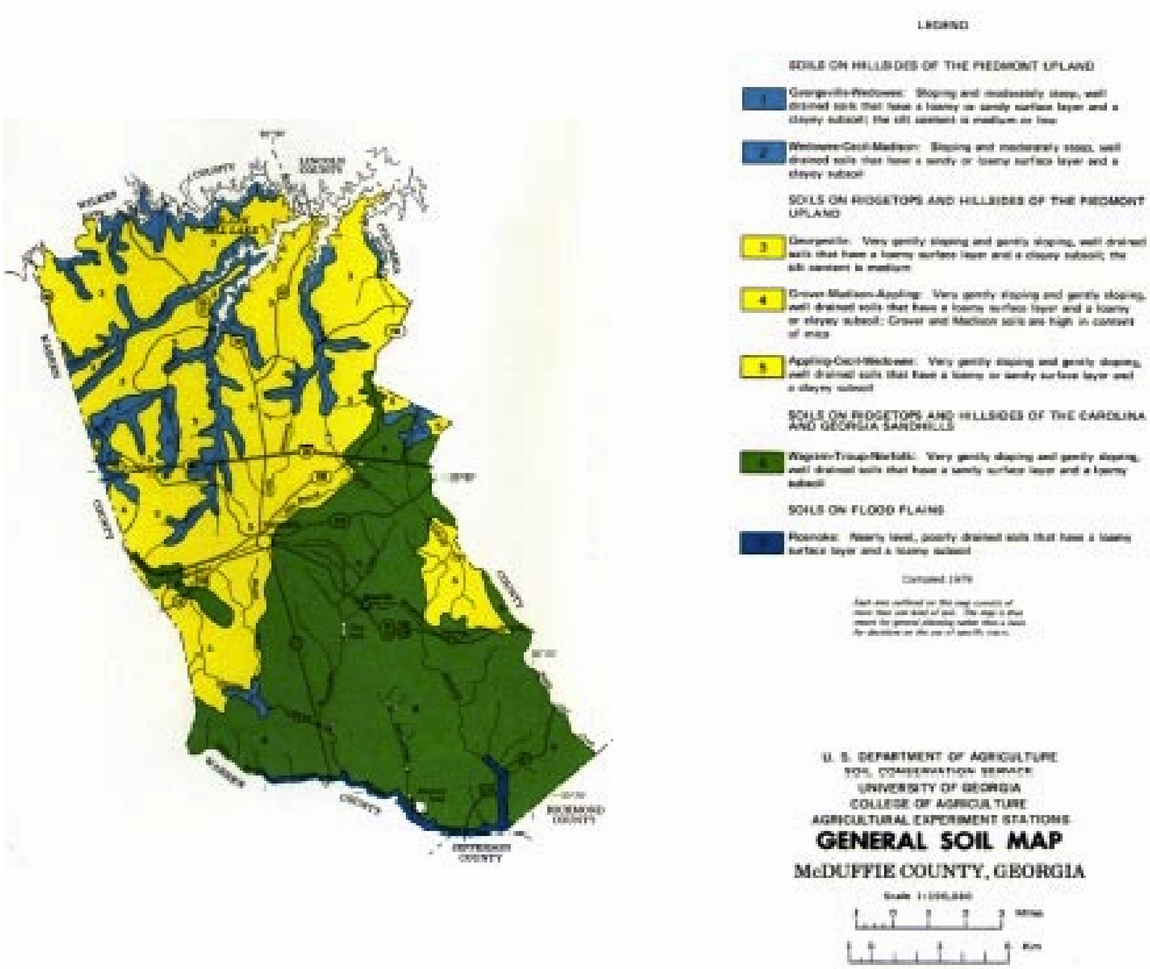
A Soil Survey will indicate which soils may be suitable for home and commercial building sites, septic tank absorption fields, landfills, roads and highways, recreation areas, and many other land uses. Access to soil resource data helps planners make good decisions—decisions about zoning ordinances, building permits, sewer authorizations, floodplain designations, tax assessments, and other regulations that safeguard community development

A soil survey does not indicate what you can or cannot do with soils. It is simply an inventory of soil resources. It will point out problems or limitations such as high water tables, slow permeability, flooding potential, as well as various other factors. Using a soil survey improves understanding of the soils and subsequent management considerations.

General Soil Map

The general soil survey map is found in the Soil Survey publication. This generalization map of the soils for the soil survey area is color coded to show associations (or groupings) of the major soils. Because of its small map scale (typically 1:60,000 to 1:100,000), soils within an association shown on the map may vary greatly in slope, depth, drainage, and other characteristics that affect management.

Descriptions of each soil associations are included in the Soil Survey that give, in general terms, the properties of and range of characteristics of soils that are found in each association. The general soil map can be used to compare the suitability of large areas for general land use. Because of the scale, it is not intended to be used to make management decisions on specific sites. For example, on the general soil map illustrated below, areas coded 3 are designated as Georgeville soil association. However, other soils with different properties are included in the association. (Contact your local USDA Natural Resources Conservation Service or USDA Service Center for a copy of your county soil survey.)



Soil Survey Geographic Data Base

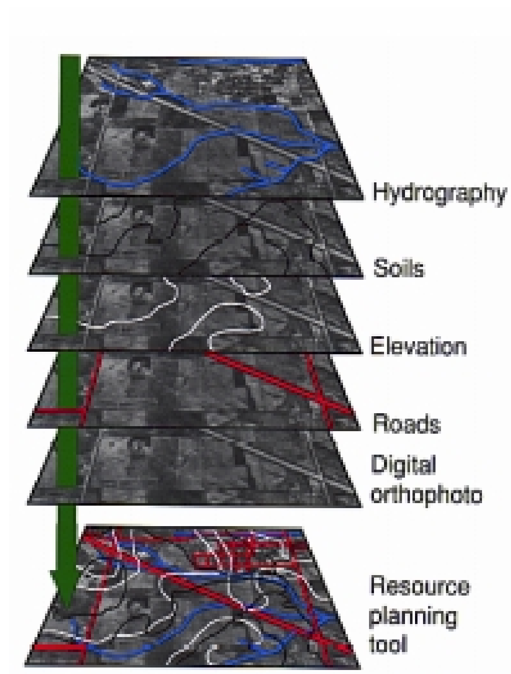
With common usage of computers and geographic information systems (GIS), soil surveys are being made available in a digital form that can be meshed with other information as an aid to resource management decisions. The digital soil surveys are referred to as the Soil Survey Geographic Data Base. In this data base, the soil maps are linked to files containing detailed information and interpretations for each soil. This data base can be linked in a GIS to other data layers including digital ortho (scale is correct) photography, roads, streams, and other features that can be manipulated and analyzed for resource management decisions.

Typical data and interpretations included for each soil in the soil survey data base include:

Data for each major horizon:
- particle size distribution
- bulk density
- available water capacity
- soil reaction
- organic matter

Data for each soil:
- flood hazard
- seasonal water table depth
- depth to bedrock
- soil subsidence

Use and management data:
- sanitary facilities
- building site development
- recreational development
- water management
- rangeland potential
- construction material
- crops
- woodland suitability
- wildlife suitability



DOQ Used as Framework for Geospatial Data

How do all the layers of the data work together?

The layers of the maps and their linked files combine to form a comprehensive resource planning tool for GIS users. The diagram at the top illustrates how layers can be overlaid on one another and then projected onto a base map. The final image depicts the county's hydrography, elevation, roads, soils, and special features in one picture. By combining data layers, the user creates a comprehensive map that is ideal for comparison and analysis needed for proper resource management planning and application.

Global Positioning System and Soil Surveys

A **Global Positioning System** (GPS) can improve accuracy and efficiency of any activity where rapid and accurate determination of a location is needed. This technology is based on a processor receiving signals from a constellation of satellites whose exact location is known at all times. Based on these known satellite locations and signal travel time, the processor can calculate its position on the Earth's surface by triangulation techniques. A few examples of GPS applications follow.

GPS and Soil Surveys

A significant part of making Soil Surveys involves collecting data in the field, recording the location of data, and displaying the information on a map. GPS receivers are used to quickly and accurately record the locations of data gathered in the field, such as soil profile descriptions, transects, and soil sampling sites. This data can be saved to provide a permanent record of the area and loaded into a Geographic Information System (GIS) system, plotted out, and overlain onto a photograph. The receivers can also be used to return to the same location at a later date for further sampling, studying, and monitoring.

GPS and Wetland Delineations

GPS receivers are used to record wetland boundaries in the field. A wetland delineator can walk along the wetland boundary and rapidly record point locations along the way. The data collected can be saved to provide a permanent record of the area. Points can also be loaded into a Geographic Information System (GIS) system, plotted out, and overlain onto a photograph. This is especially useful for recording and plotting boundaries in areas that have been significantly altered. The location can be revisited and boundaries easily relocated using the GPS equipment.

Precision Farming

Precision farming uses a Geographic Information System (GIS), the Global Positioning System (GPS), and Variable Rate Technology (VRT) to effectively address variability in a cropped field. Soils vary across an area with regards to fertility, water holding capacity, clay content, organic matter content, and other properties. This variability can be georeferenced across a field using GPS. The field can then be managed according to its variability when applying fertilizer and herbicides, by using a combination of GPS, GIS, and VRT. This type of management can be more efficient and environmentally sound than treating the entire field the same.

Terms to Know

Aerobic. Having molecular oxygen as a part of the environment.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Anaerobic. The absence of molecular oxygen.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60- inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

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

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

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

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

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Classification, soil. The systematic arrangement of soils into groups or categories on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties. The USDA soil classification system of soil taxonomy was adapted for use in publications by the National Cooperative Soil Survey on Jan. 1, 1965.

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

Colluvium. Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

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

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistencies are as follows:

Loose. Noncoherent when dry or moist; does not hold together in a mass.

Friable. When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm. When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctively noticeable.

Plastic. When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a “wire” when rolled between thumb and forefinger.

Sticky. When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard. When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft. When dry, breaks into powder or individual grains under very slight pressure.

Cemented. Hard; little affected by moistening.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coarse textured soil. Sand, loamy sand.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or
irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained. Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained. Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained. Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained. Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained. Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained. Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained. Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Effective rooting depth. The depth that roots can penetrate through a soil down to a root restrictive layer or 60 inches. The effective rooting depth classes are expressed in inches as follows:

Very Shallow	less than 10
Shallow	10 to 20
Moderately Deep	20 to 40
Deep	40 to 60
Very Deep	greater than 60

Eluviation. The removal of soil material in suspension (or in solution) from a layer or layers of a soil. Usually, the loss of material in solution is described by the term "leaching."

Eolian. Pertaining to earth material transported and deposited by the wind.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents.

Gully erosion. The erosion process whereby water accumulates and often recurs in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, often defined for agricultural land in terms of channels too deep to till.

Rill erosion. An erosion process on sloping fields in which numerous and randomly occurring small channels of only several inches in depth are formed; occurs mainly on recently cultivated soils.

Saltation. A particular type of momentum-dependent transport involving the rolling, bouncing or jumping action of soil particles by wind, water, or gravitational forces above the soil surface, for relatively short distances.

Sheet erosion. The removal of a relatively uniform, thin layer of soil from the land surface by rainfall and largely unchanneled surface runoff (sheet flow).

Surface creep. The rolling of dislodged soil particles by wind along the soil surface.

Suspension. The containment or support in fluid media (usually air or water) of soil particles or aggregates, allowing their transport in the fluid when it is flowing. In wind, this usually refers to very small particles traveling through the air above the soil surface for relatively long distances.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called normal field capacity, normal moisture capacity, or capillary capacity.

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

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

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon. An organic layer of fresh and decaying plant residue.

A horizon. The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon. This horizon is bleached or whitish in appearance. As water moves down the horizon, soluble minerals and nutrients wash through leaving a concentration of sand and silt particles.

B horizon. The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon. The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Hydric soils. Soils that are wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants.

Illuviation. The process of deposition of soil material removed from one horizon to another in the soil; usually from an upper to a lower horizon in the soil profile.

Land capability. An expression of the effect of physical land conditions, including climate, on the total suitability for use without permanent damage.

Marine sediments. These sediments settled out of the sea and commonly were reworked by currents and tides, later becoming exposed. They vary widely in composition.

Redox concentrations. Zones of apparent accumulation of Fe-Mn oxides in soils.

Redox depletions. Zones of low-chroma (2 or less) where Fe-Mn oxides alone or both Fe-Mn oxides and clay have been stripped out of the soil.

Redoximorphic features. Soil properties associated with wetness that result from the reduction and oxidation of iron and manganese compounds in the soil after saturation with water and desaturation, respectively.

Residuum. Unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place.

Runoff. That portion of precipitation or irrigation on an area which does not infiltrate, but instead is discharged from the area. That which is lost without entering the soil is called surface runoff (typically used in soil science). That which enters the soil before reaching a stream channel is called ground water runoff or seepage flow from ground water (typically used in geology and hydraulics).

Sand. As a soil separate, individual mineral particles that range in diameter from the upper limit of silt (0.05 millimeters) to the lower limit of gravel (2 millimeters). As a soil textural class, soil that is 85 percent or more of sand, where the percentage of silt plus 1.5 times the percentage of clay shall not exceed 15.

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

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

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are: platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

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

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

Soil reference materials, such as the *Soil Quality Information Sheets* (which have been included in this publication in the past) can be found on the web. The web site for this series of publications is listed on the following pages and is noted with an asterisk.

References and Web Sites

Soil and Environmental Education Web Sites for Students and Teachers

http://www.georgiaenvirothon.org/ (GA Envirothon for high school students)
http://www.envirothon.org/ (National Envirothon for high school students)
http://stallion.abac.peachnet.edu/eoyc/dnr.htm (Natural Resources Conservation Workshop for high school students)
http://www.sciseek.com/ (Science search engine)
http://www.pbs.org/neighborhoods/science/ (P.B.S. – Science and Technology)
http://books.nap.edu/v3/makepage.phtml?val1=coolsciencearc#top (Science resources)
http://geography.about.com/science/geography/library/weekly/aa090699.htm (Soil Stuff)
http://www.uga.edu/alec/ga.htm (Ag Education in Georgia)
http://www.statlab.iastate.edu/soils/nssc/educ/Edpage.html (NSSC Soil Education)
http://www.educationplanet.com/search/Environment/Agriculture/Soil_Management/ (Soil Management)
http://www.teachnet.org/ (Resources for Teachers)
http://www.epa.gov/students/ (EPA Student Center)
http://www.nceet.snre.umich.edu/ (Environmental Education)
http://www.blm.gov/education/00_resources/index.html (EE – Teacher Resources)
http://ask.usgs.gov/education.html (Ask USGS – Education)
http://www.epa.gov/teachers/ (EPA Teacher Center)
http://www.epa.gov/enviroed/ftfee.html (EPA Environmental Education)
http://museum.nhm.uga.edu/~GAWildlife/GAWW.html (Georgia Wildlife Web Site)
http://fsc.fernbank.edu/GSTA (Georgia Science Teachers Association)
http://ga.water.usgs.gov/edu (Water Science for Schools)
*http://www.statlab.iastate.edu/survey/SQI/sqinfo.shtml (Soil Quality Institute – Soil Quality Information Sheets, Soil Biology Primer and other resources for teachers, classroom activities)
http://interactive.usask.ca/skinteractive/modules/agriculture/soils/soilwht/soilwht_biol.html (Study on Canadian soils, but great site for general info on soil formation, properties, physics, etc.)
http://homepages.which.net/~fred.moor/soil/links/l0103.htm (Soil biology links and search site)
http://www.hintze-online.com/sos/soils-online.html (Soil basics and biology)
http://ltpwww.gsfc.nasa.gov/globe/index.htm (NASA Soil Science Education Page)
http://www.oldgrowth.org/compost (Composting)
http://www.agri.upm.edu.my/jst/drsoil.html (Dr. Soil Surfs – soil links and search site)
http://soilweb.tripod.com (Soil and Water Web – links)
http://www.seafriends.org.nz/enviro/soil (Soil Use, Sustainability, and Conservation)
http://www.swcs.org/f_pubs_education.htm (Soil and Water Conservation Society – Educational Resources)
http://www.swcs.org/t_resources.htm (SWCS – Soil Resources on the Web)
http://www.asa-cssa-sssa.org/education/k12.html (American Society of Agronomy Education Initiative)

Soil Survey, Soil Technology and GIS, Other Useful Photo/Topo Web Sites

http://www.statlab.iastate.edu/soils/soildiv/sslists/sslisthome.html (National List of Published Soil Surveys)
http://www.statlab.iastate.edu/soils/osd/ (Official Soil Series Descriptions)
http://www.ftw.nrcs.usda.gov/ssur_data.html (National SSURGO Database - download or order digital soil surveys)
http://www.oneplan.state.id.us/wetlands/wl_01.htm (Wetland Identification E-Z Guide)
http://www.ncdc.noaa.gov/ (National Climatic Data Center)
http://www.spatialhydrology.com/ (Spatial Hydrology)
http://www.geocomm.com/channel/esri/ (Geo Community – GIS Resources)
http://www.gisdatadepot.com/ (GIS Data Depot)
http://www.ftw.nrcs.usda.gov/ncg/ncg_technote.html (National Cartography and Geospatial Center)
http://www.gis.state.ga.us/ (GIS Data Clearinghouse)
http://www.terraserver.com/ (Terra Server – photo site)
http://csat.gatech.edu/csat/statewide/statewide.html (Statewide GIS Atlas)
http://www.topozone.com/ (Topographic Maps)
http://libraryspot.com/maps.htm (Map resources)
http://csat.gatech.edu/csat/statewide/statewide.html (Georgia Environmental Resources Digital Data Atlas)
http://www.lib.utexas.edu/Libs/PCL/Map_collection/georgia.html (Georgia Maps)

USDA Web Sites

http://www.usda.gov/nass/ (National Agricultural Statistics Service)
http://www.info.usda.gov (USDA Home Page)
http://www.reeusda.gov (USDA Extension Service)
http://www.usda.gov/oc/photo/opchomeahtm (USDA Photography Center)
http://plants.usda.gov (Plants)
http://www.nrcs.usda.gov (Natural Resources Conservation Service)
http://www.ga.nrcs.usda.gov/ga/ (Natural Resources Conservation Service GA State Office)
http://www.ga.nrcs.usda.gov/ga/gapi/index.html (Georgia NRCS Public Information Web Site)

Georgia Web Sites

http://www.state.ga.us (State of Georgia)
http://www.agr.state.ga.us/ (Georgia Department of Agriculture)
http://www.dnr.state.ga.us/ (Georgia Department of Natural Resources)
http://mars.cropsoil.uga.edu (University of Georgia Department of Crop and Soil Sciences)
http://www.gfc.state.ga.us/ (Georgia Forestry Commission)

Contact Info for Obtaining Publications

45 Suggested Environmental Education Lesson Plans – produced by Field Information Staff, USDA-NRCS, Fort Worth, Texas (you can contact public information official at the USDA-NRCS Georgia State Office in Athens to find out how to obtain a copy)

Conserving Soil – National Association of Conservation Districts, P.O. Box 855, League City, TX 77574-0855

Teaching Soil and Water Conservation, A Classroom and Field Guide – USDA-NRCS, Program Aid Number 341 (you can contact public information official at the USDA-NRCS Georgia State Office in Athens to find out how to obtain a copy)

Various soil biology resources, including *Soil Biology Primer* and classroom activities – http://www.statlab.iastate.edu/survey/SQI/sqinfo.shtml

Guidelines and Features for Outdoor Classrooms – Indiana Department of Natural Resources, Division of Forestry, 402 W. Washington, Room 296, Indianapolis, IN 46204, (317) 232-4105 or go to http://www.state.in.us/dnr/forestry/htmldocs/forpubs.htm

For information about the **Natural Resources Conservation Workshop**, which is a scholarship opportunity (web site is listed above), contact Wanda Morgan, USDA Service Center, Crisp County Ag. Center, 110 W. 13th Ave., Cordele, GA 31015-4251; phone: 229-273-4148; e-mail: wanda.morgan@gacordele.fsc.usda.gov