Native Flags

Native flags is participatory eco-art project by FIU College of Architecture + The Arts Artist-in-Residence Xavier Cortada.
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Systems

Sunshine State Standards:
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Background

Career Focus:
- Ecologist; Biologist; Conservationist; Pedologist (study of soil)

Objectives:
- Learn the properties of different soils
- Develop the skills for field sampling
- Understand how the aquifer functions

Vocabulary:

- **Aggregation:** The act of collecting together (aggregating); a collection of particulars; summarizing multiple routes into one route.
- **Clay:** A very fine-grained soil that is plastic when moist but hard when fired.
- **Climate:** The long-term weather pattern of an area, including temperature, precipitation, and wind.
- **Erosion:** The mechanical process of wearing or grinding something down
- **Inorganic:** Relating or belonging to the class of compounds not having a carbon basis; lacking the properties characteristic of living organisms.
- **Loam:** A rich soil consisting of a mixture of sand and clay and decaying organic materials.
- **Mineral:** Solid homogeneous inorganic substances occurring in nature having a definite chemical composition.
- **Organic:** Being or relating to or derived from or having properties characteristic of living organisms.
- **Pedogenesis:** The process of soil formation.
- **Porosity:** The property of being porous; being able to absorb fluids.
- **Rock:** Relatively hard, naturally formed mineral or petrified matter.
- **Sand:** Small loose grains of worn or disintegrated rock. A sedimentary material, finer than a granule and coarser than silt, with grains.
- **Silt:** A sedimentary material consisting of very fine particles intermediate in size between sand and clay; sediment suspended in stagnant water or carried by moving water, that often accumulates on the bottom of rivers, bays, etc.
- **Soil:** Soils are complex mixtures of minerals, water, air, and organic matter (both dead and alive), forming at the surface of land. The soil performs many critical functions in almost any terrestrial ecosystem (whether a farm, forest, prairie, or suburban watershed).
- **Soil Horizons (Layers):** The layers in the upper crust of the earth. The differences in the horizons are most easily seen in soils that have not been touched in decades. The top, or O, horizon is the layer of under composed litter; the A horizon is topsoil, where most roots grow; B is the subsoil; and C is the parent rock material, broken into chunks. Although some roots can penetrate into the C horizon, few microorganisms live there.
- **Soil Reservoir:** The amount of water the soil can contain measured down to the plant root.
- **Topography:** The configuration of a surface and the relations among its man-made and natural features.
- **Weathering:** Any of the chemical or mechanical processes by which rocks exposed to the weather undergo changes in character and break down.
- **Aquifer:** an underground layer of permeable rock, sediment (usually sand or gravel, or soil that yields water. The pore spaces in aquifers are filled with water and are interconnected, so that water flows through them. Sandstones, unconsolidated gravels, and porous limestone make the best aquifers. They can range from a few square kilometers to thousands of square kilometers in size.
- **Contamination:** to make impure or unsuitable by contact or mixture with something unclean, bad, etc.

- **Discharge:** to pour forth, emit
- **Floridian aquifer**: is one of the most productive aquifers in the world. This aquifer system underlies an area of about 100,000 square miles in southern Alabama, southeastern Georgia, southern South Carolina, and all of Florida
- **Population:** the total number of persons inhabiting an area
- **Recharge:** the processes by which ground water is absorbed into the zone of saturation
- **Sinkhole:** a natural depression in a land surface formed by the dissolution and collapse of a cavern roof. Sinkholes are roughly funnel-shaped and on the order of tens of meters in size. They generally occur in limestone regions and are connected to subterranean passages.
- **Spring:** a small stream of water flowing naturally from the Earth
- **Surficial aquifer**:are shallow beds of shells and sand that lie less than 100 feet underground
- **Water table:** the upper surface of an area filled with groundwater, separating the zone of aeration (the subsurface region of soil and rocks in which the pores are filled with air and usually some water) from the zone of saturation (the subsurface region in which the pores are filled only with water.) Water tables rise and fall with seasonal moisture, water absorption by vegetation, and the withdrawal of groundwater from wells, among other factors. The water table is not flat but has peaks and valleys that generally conform to the overlying land surface.
- **Well:** a hole or shaft that is excavated, drilled, bored, or but into the earth so as to tap a supply of water, oil, gas, etc.
- **Abiotic factors:** all the non-living factors in an environment, such as rainfall, temperature, soil.
- **Biotic factors:** All the living organisms in an area – such as producers, predators and parasites.
- **Community:** The total of **all** the populations living in an area (i.e. all the biotic factors)
- **Decomposer**: The microbes that respire the molecules in dead & waste matter and so recycle them.
- **Ecosystem:** The community of living organisms and the abiotic factors affecting them in one area.
- **Environment:** All the organisms (biotic) and the conditions (abiotic) which exist in an area
- **Habitat:** The place where an organism lives
- **Niche:** Where an organism fits into the community - covering feeding, nesting, and range of habitat.
- **Population:** All the members of one species living in an area
- **Primary consumer**: A herbivorous heterotroph
- **Producer**: An autotroph i.e. it can make organic molecules from inorganic ones. Normally these are plants. Only about 1% of the Sun’s energy is trapped by photosynthesis in new organic matter, so this, vital, stage of any food web is by far the least efficient.
- **Quadrats** (= a frame of known size – typically 1m or ½m square, which may be divided into 100)
- **Secondary consumer**: A carnivorous heterotroph
- **Transects** (= a straight line. Can be of any length, but samples are taken at uniform intervals along it)

General Information

Introduction to Soil

Soil, the loose material that covers the land surfaces of Earth and supports the growth of plants. In general, soil is an unconsolidated, or loose, combination of inorganic and organic materials. The inorganic components of soil are principally the products of rocks and minerals that have been gradually broken down by weather, chemical action, and other natural processes. The organic materials are composed of debris from plants and from the decomposition of the many tiny life forms that inhabit the soil.

1 Photo Credit - University of Maryland; Soil Judging

Soils vary widely from place to place. Many factors determine the chemical composition and physical structure of the soil at any given location. The different kinds of rocks, minerals, and other geologic materials from which the soil originally formed play a role. The kinds of plants or other vegetation that grow in the soil are also important. Topography—that is, whether the terrain is steep, flat, or some combination—is another factor. In some cases, human activity such as farming or building has caused disruption. Soils also differ in color, texture, chemical makeup, and the kinds of plants they can support.

Soil actually constitutes a living system, combining with air, water, and sunlight to sustain plant life. The essential process of photosynthesis, in which plants convert sunlight into energy, depends on exchanges that take place within the soil. Plants, in turn, serve as a vital part of the food chain for living things, including humans. Without soil there would be no vegetation—no crops for food, no forests, flowers, or grasslands. To a great extent, life on Earth depends on soil.

The study of different soil types and their properties is called soil science or pedology. Soil science plays a key role in agriculture, helping farmers to select and support the crops on their land and to maintain fertile, healthy ground for planting. Understanding soil is also important in engineering and construction. Soil engineers carry out detailed analysis of the soil prior to building roads, houses, industrial and retail complexes, and other structures.

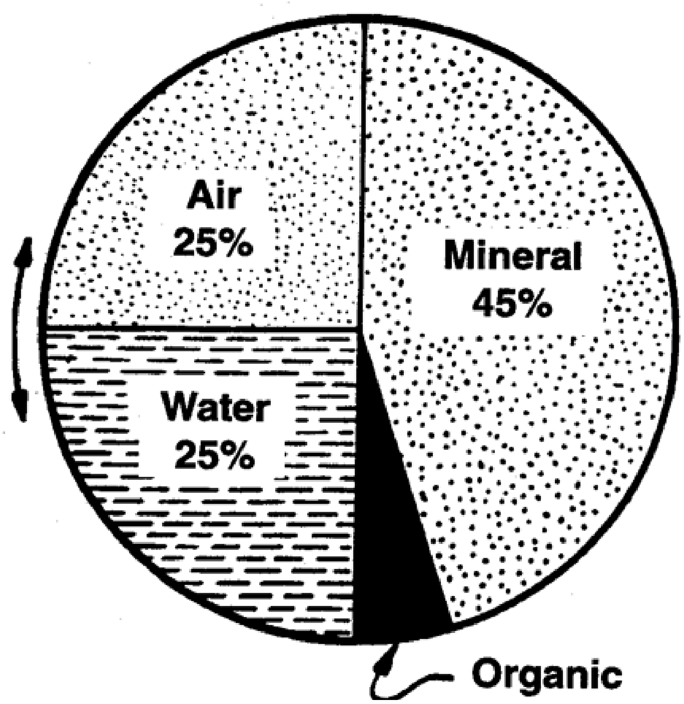
Soil takes a great deal of time to develop—thousands or even millions of years. As such, it is effectively a nonrenewable resource. Yet even now, in many areas of the world, soil is under siege. Deforestation, over-development, and pollution from human made chemicals are just a few of the consequences of human activity and carelessness. As the human population grows, its demand for food from crops increases, making soil conservation crucial.

Composition of Soils

Soils comprise a mixture of inorganic and organic components: minerals, air, water, and plant and animal material. Mineral and organic particles generally compose roughly 50 percent of a soil's volume. The other 50 percent consists of pores—open areas of various shapes and sizes. Networks of pores hold water within the soil and also provide a means of water transport. Oxygen and other gases move through pore spaces in soil. Pores also serve as passageways for small animals and provide room for the growth of plant roots.

Inorganic Material

The mineral component of soil is made up of an arrangement of particles that are less than 2.0 mm (0.08in) in diameter. Soil scientists divide soil particles, also known as soil separates, into three main size groups: sand, silt, and clay. According to the classification scheme used by the United States Department of Agriculture (USDA), the size designations are: sand, 0.05 to 2.00 mm (0.002 to 0.08 in); silt 0.002 to 0.05 mm (0.00008 to 0.002 in); and clay, less than 0.002 mm (0.00008 in). Depending upon the rock materials from which they were derived, these assorted mineral particles ultimately release the chemicals on which plants depend for survival, such as potassium, calcium, magnesium, phosphorus, sulfur, iron, and manganese.



2 Photo Credit - University of Nebraska - Lincoln; Plant & Soil Sciences

Organic Material

Organic materials constitute another essential component of soils. Some of this material comes from the residue of plants—for example, the remains of plant roots deep within the soil, or materials that fall on the ground, such as leaves on a forest floor. These materials become part of a cycle of decomposition and decay, a cycle that provides important nutrients to the soil. In general, soil fertility depends on a high content of organic materials.

Even a small area of soil holds a universe of living things, ranging in size from the fairly large to the microscopic: earthworms, mites, millipedes, centipedes, grubs, termites, lice, springtails, and more. And even a gram of soil might contain as many as a billion microbes—bacteria and fungi too small to be seen with the naked eye. All these living things form a complex chain: Larger creatures eat organic debris and excrete waste into the soil, predators consume living prey, and microbes feed on the bodies of dead animals. Bacteria and fungi, in particular, digest the complex organic compounds that make up living matter and reduce them to simpler compounds that plants can use for food. A typical example of bacterial action is the formation of ammonia from animal and vegetable proteins. Other bacteria oxidize the ammonia to form nitrogen compounds called nitrites, and still other bacteria act on the nitrites to form nitrates, another type of nitrogen compound that can be used by plants. Some types of bacteria are able to fix, or extract, nitrogen directly from the air and make it available in the soil.

Ultimately, the decay of plant and animal material results in the formation of a dark-colored organic matter known as humus. Humus, unlike plant residues, is generally resistant to further decomposition.

(*Mediahex*)

Water

Soil scientists also characterize soils according to how effectively they retain and transport water. Once water enters the soil from rain or irrigation, gravity comes into play, causing water to trickle downward. Water is also taken up in great quantities by the roots of plants: Plants use anywhere from 200 to 1,000 kg (440 to 2,200 lb) of water in the formation of 1 kg (2.2 lb) of dry matter. Soils differ in their capacity to retain moisture against the pull exerted by gravity and by plant roots. Coarse soils, such as those consisting of mostly of sand, tend to hold less water than do soils with finer textures, such as those with a greater proportion of clays.

Water also moves through soil pores independently of gravity. This movement can occur via capillary action, in which water molecules move because they are more attracted to the pore walls than to one another. Such movement tends to occur from wetter to drier areas of the soil. The movement from soil to plant roots can also depend on how tightly water molecules are bound to soil particles. The attraction of water molecules to each other is an example of cohesion. The attraction of water molecules to other materials, such as soil or plant roots, is a type of adhesion. These effects, which determine the so-called matric potential of the soil, depend largely on the size and arrangement of the soil particles. Another factor that can affect water movement is referred to as the osmotic potential. The osmotic potential hinges on the amount of dissolved salts in the soil. Soils high in soluble salt tend to reduce uptake of water by plant roots and seeds. The sum of the matric and osmotic potentials is called the total water potential.

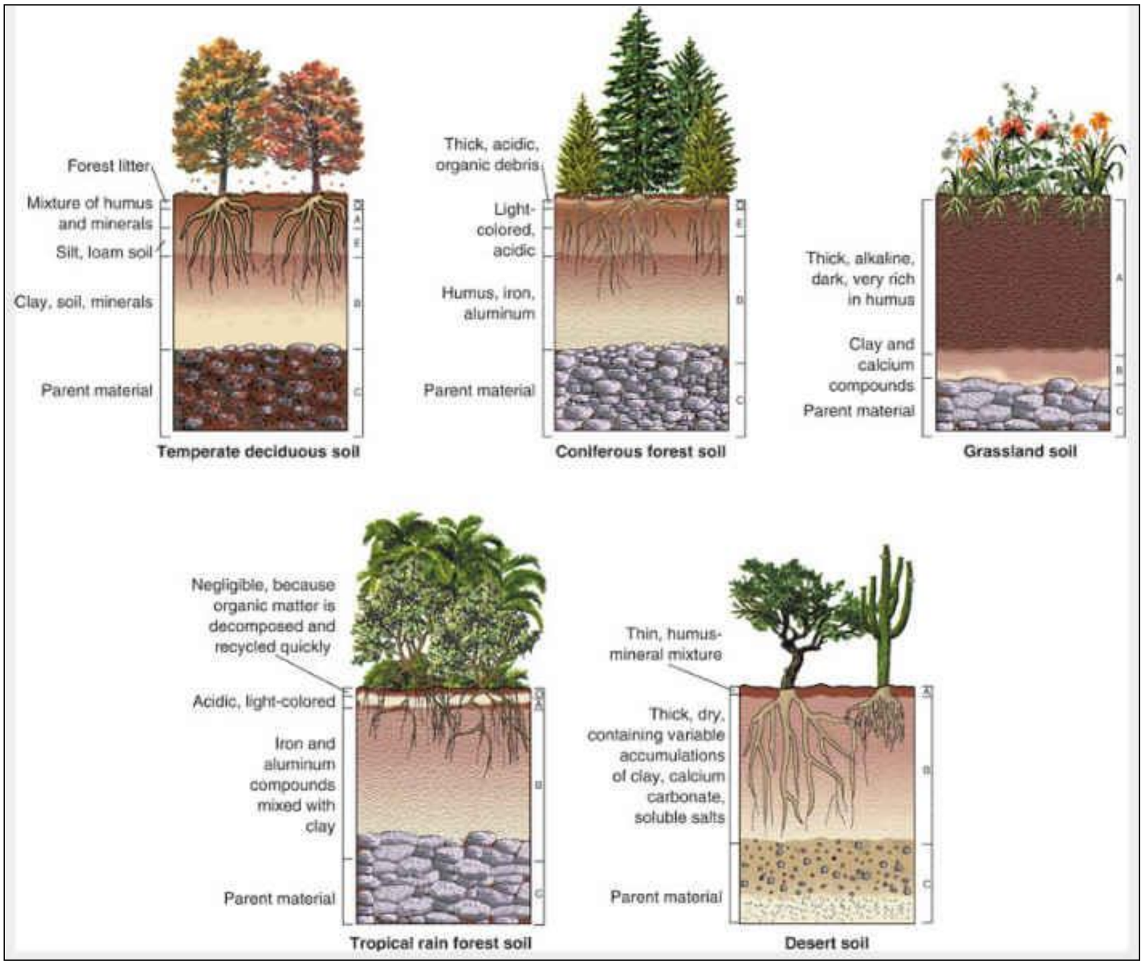
In soil, water carries out the essential function of bringing mineral nutrients to plants. But the balance between water and air in the soil can be delicate. An overabundance of water will saturate the soil and fill pore spaces needed for the transport of oxygen. The resulting oxygen deficiency can kill plants. Fertile soils permit an exchange between plants and the atmosphere, as oxygen diffuses into the soil and is used by roots for respiration. In turn, the resulting carbon dioxide diffuses through pore spaces and returns to the atmosphere. This exchange is most efficient in soils with a high degree of porosity. For farmers, gardeners, landscapers, and others with a professional interest in soil health, the process of aeration—making holes in the soil surface to permit the exchange of air—is a crucial activity. The burrowing of earthworms and other soil inhabitants provides a natural and beneficial form of aeration.

Soil Formation

Soil formation is an ongoing process that proceeds through the combined effects of five soil-forming factors: parent material, climate, living organisms, topography, and time. Each combination of the five factors produces a unique type of soil that can be identified by its characteristic layers, called horizons. Soil formation is also known as *pedogenesis* (from the Greek words *pedon*, for “ground,” and *genesis*, meaning “birth” or “origin”).

Parent Material

The first step in pedogenesis is the formation of parent material from which the soil itself forms. Roughly 99 percent of the world's soils derive from mineral-based parent materials that are the result of weathering, the physical disintegration and chemical decomposition of exposed bedrock. The small percentage of remaining soils derives from organic parent materials, which are the product of environments where organic matter accumulates faster than it decomposes. This accumulation can occur in marshes, bogs, and wetlands.



3 Photo Credit - City University of New York; Department of Geography

Bedrock itself does not directly give rise to soil. Rather, the gradual weathering of bedrock, through physical and chemical processes, produces a layer of rock debris called regolith. Further weathering of this debris, leading to increasingly smaller and finer particles, ultimately results in the creation of soil.

In some instances, the weathering of bedrock creates parent materials that remain in one place. In other cases, rock materials are transported far from their source—blown by wind, carried by moving water, and borne inside glaciers.

Climate

Climate directly affects soil formation. Water, ice, wind, heat, and cold cause physical weathering by loosening and breaking up rocks. Water in rock crevices expands when it freezes, causing the rocks to crack. Rocks are worn down by water and wind and ground to bits by the slow movement of glaciers. Climate also determines the speed at which parent materials undergo chemical weathering, a process in which existing minerals are broken down into new mineral components. Chemical weathering is fastest in hot, moist climates and slowest in cold, dry climates.

Climate also influences the developing soil by determining the types of plant growth that occur. Low rainfall or recurring drought often discourage the growth of trees but allow the growth of grass. Soils that develop in cool rainy areas suited to pines and other needle-leaf trees are low in humus.

Living Organisms

As the parent material accumulates, living things gradually gain a foothold in it. The arrival of living organisms marks the beginning of the formation of true soil. Mosses, lichens, and lower plant forms appear first. As they die, their remains add to the developing soil until a thin layer of humus is built up. Animals' waste materials add nutrients that are used by plants. Higher forms of plants are eventually able to establish themselves as more and more humus accumulates. The presence of humus in the upper layers of a soil is important because humus contains large amounts of the elements needed by plants.

Living organisms also contribute to the development of soils in other ways. Plants build soils by catching dust from volcanoes and deserts, and plants' growing roots break up rocks and stir the developing soil. Animals also mix soils by tunneling in them.

Topography

Topography, or relief, is another important factor in soil formation. The degree of slope on which a soil forms helps to determine how much rainfall will run off the surface and how much will be retained by the soil. Relief may also affect the average temperature of a soil, depending on whether or not the slope faces the sun most of the day.

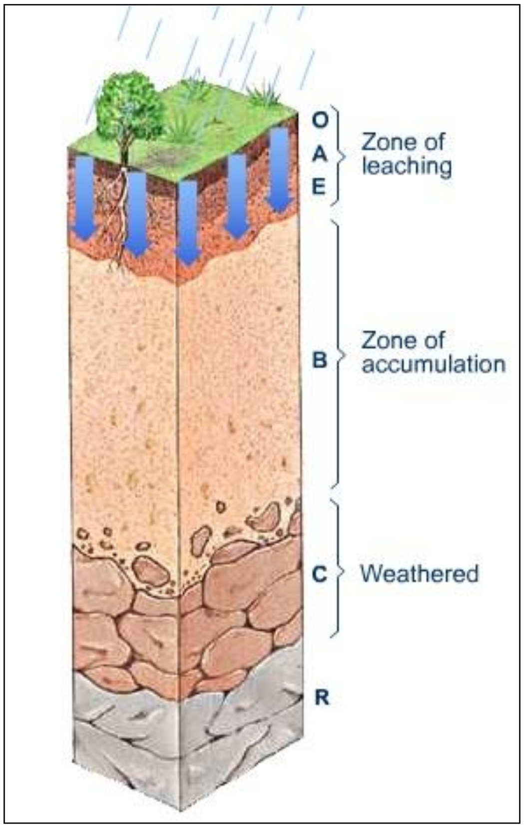
Time

The amount of time a soil requires to develop varies widely according to the action of the other soil-forming factors. Young soils may develop in a few days from the *alluvium* (sediments left by floods) or from the ash from volcanic eruptions. Other soils may take hundreds of thousands of years to form. In some areas, the soils may be more than a million years old.

Horizons

Most soils, as they develop, become arranged in a series of layers, known as horizons. These horizons, starting at the soil surface and proceeding deeper into the ground, reflect different properties and different degrees of weathering.

Soil scientists have designated several main types of horizons. The surface horizon is usually referred to as the O layer; it consists of loose organic matter such as fallen leaves and other biomass. Below that is the



4 Photo Credit - PennState; College of Agricultural Sciences

A horizon, containing a mixture of inorganic mineral materials and organic matter. Next is the E horizon, a layer from which clay, iron, and aluminum oxides have been lost by a process known as *leaching* (when water carries materials in solution down from one soil level to another). Removal of materials in this manner is known as eluviation, the process that gives the E horizon its name. Below E horizon is the B horizon, in which most of the iron, clays, and other leached materials have accumulated. The influx of such materials is called illuviation. Under that layer is the C horizon, consisting of partially weather bedrock, and last, the R horizon of hard bedrock.

Along with these primary designations, soil scientists use many subordinate names to describe the transitional areas between the main horizons, such as Bt horizon or BX2 horizon.

Soil scientists refer to this arrangement of layers atop one another as a soil profile. Soil profiles change constantly but usually very slowly. Under normal conditions, soil at the surface is slowly eroded but is constantly replaced by new soil that is created from the parent material in the C horizon.

Soil Characteristics

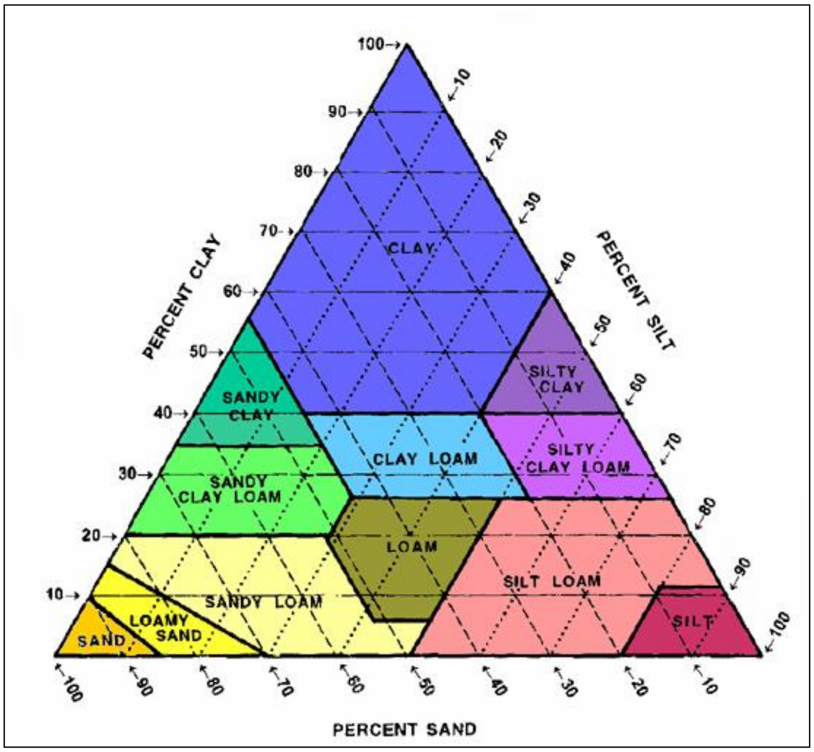
Scientists can learn a lot about a soil's composition and origin by examining various features of the soil. Color, texture, aggregation, porosity, ion content, and pH are all important soil characteristics.

Color

Soils come in a wide range of colors—shades of brown, red, orange, yellow, gray, and even blue or green. Color alone does not affect a soil, but it is often a reliable indicator of other soil properties. In the surface soil horizons, a dark color usually indicates the presence of organic matter. Soils with significant organic material content appear dark brown or black. The most common soil hues are in the red-to-yellow range, getting their color from iron oxide minerals coating soil particles. Red iron oxides dominate highly weathered soils. Soils frequently saturated by water appear gray, blue, or green because the minerals that give them the red and yellow colors have been leached away.

Texture

A soil's texture depends on its content of the three main mineral components of the soil: sand, silt, and clay. Texture is the relative percentage of each particle size in a soil. Texture differences can affect many other physical and chemical properties and are therefore important in measures such as soil productivity. Soils with predominantly large particles tend to drain quickly and have lower fertility. Very fine-textured soils may be poorly drained, tend to become



5 Photo Credit - Colorado State University; Master Gardener Program waterlogged, and are therefore not well-suited for agriculture. Soils with a medium texture and a relatively even proportion of all particle sizes are most versatile. A combination of 10 to 20 percent clay, along with sand and silt in roughly equal amounts, and a good quantity of organic materials, is considered an ideal mixture for productive soil.

Aggregation

Individual soil particles tend to be bound together into larger units referred to as aggregates or soil peds. Aggregation occurs as a result of complex chemical forces acting on small soil components or when organisms and organic matter in soil act as glue binding particles together.

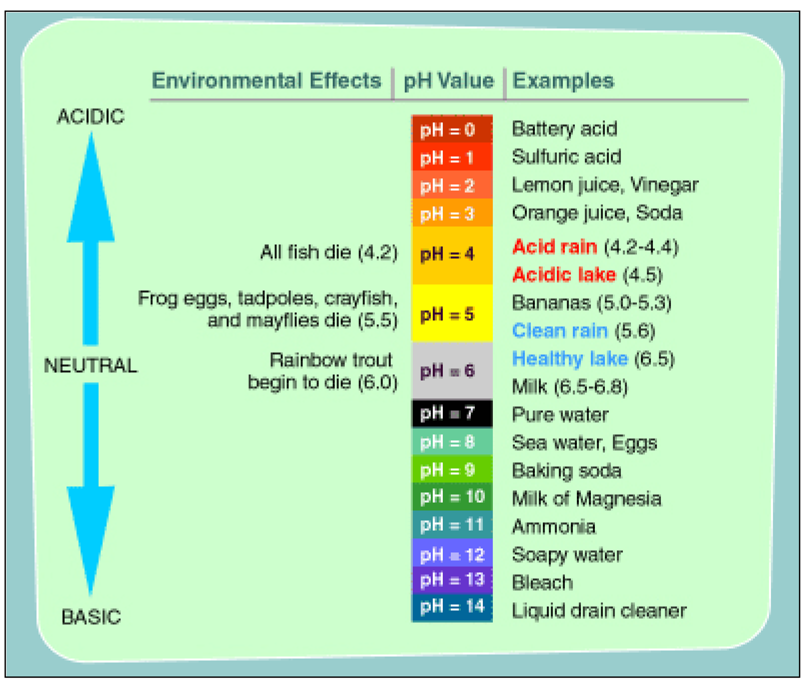
Soil aggregates form soil structure, defined by the shape, size, and strength of the aggregates. There are three main soil shapes: platelike, in which the aggregates are flat and mostly horizontal; prismlike, meaning greater in vertical than in horizontal dimension; and blocklike, roughly equal in horizontal and vertical dimensions and either angular or rounded. Soil peds range in size from very fine—less than 1 mm (0.04 in)—to very coarse—greater than 10 mm (0.4 in). The measure of strength or grade refers to the stability of the structural unit and is ranked as weak, moderate, or strong. Very young or sandy soils may have no discernible structure.

Porosity

The part of the soil that is not solid is made up of pores of various sizes and shapes—sometimes small and separate, sometimes consisting of continuous tubes. Soil scientists refer to the size, number, and arrangement of these pores as the soil's porosity. Porosity greatly affects water movement and gas exchange. Well-aggregated soils have numerous pores, which are important for organisms that live in the soil and require water and oxygen to survive. The transport of nutrients and contaminants will also be affected by soil structure and porosity.

Ion Content

Soils also have key chemical characteristics. The surfaces of certain soil particles, particularly the clays, hold groupings of atoms known as ions. These ions carry a negative charge. Like magnets, these negative ions (called anions) attract positive ions (called cations). Cations, including those from calcium, magnesium, and potassium, then become attached to the soil particles, in a process known as cation exchange. The chemical reactions in cation exchange make it possible for calcium and the other elements to be changed into water-soluble forms that plants can use for food. Therefore, a soil's cation exchange capacity is an important measure of its fertility.



6 Photo Credit - Environmental Protection Agency

pH, Soil's Acidity

Another important chemical

measure is soil pH, which refers to the soil's acidity or alkalinity. This property hinges on the concentration of hydrogen ions in solution. A greater concentration of hydrogen results in a lower pH, meaning greater acidity. Scientists consider pure water, with a pH of 7, neutral. The pH of a soil will often determine whether certain plants can be grown successfully.

Blueberry plants, for example, require acidic soils with a pH of roughly 4 to 4.5. Alfalfa and many grasses, on the other hand, require a neutral or slightly alkaline soil. In agriculture, farmers add limestone to acid soils to neutralize them.

Soil Classification

As yet there is no worldwide, unified classification scheme for soil. Since the birth of the modern discipline of soil science roughly 100 years ago, scientists in different countries have used many systems to organize the various types of soils into groups. For much of the 20th century in the United States, for example, soil scientists at the USDA used a classification scheme patterned after an earlier Russian method. This system recognized some three dozen Great Soil Groups.

In 1975 a new classification scheme known as soil taxonomy was published in the United States and is now used by the USDA. Unlike earlier systems, which organized soils according to various soil formation factors, the new system emphasizes characteristics that can be precisely measured, including diagnostic horizons (which give clues to soil formation), soil moisture, and soil temperature. In a manner similar to the kingdom, phylum, class, order, family, genus, species system used to classify living things, the USDA soil taxonomy employs six categories. From the general to the more specific, its categories are order, suborder, great group, subgroup, family, and series. This system has classified more than 17,000 types of soil in the United States.

The top level of the system consists of 12 orders: alfisols, andisols, aridisols, entisols, gelisols, histosols, inceptisols, mollisols, oxisols, spodosols, ultisols, and vertisols. Each term employs a Latin or Greek word root to describe a range of soil characteristics. Mollisols, for example (from the Latin *mollis*, for “soft”) are soils with thick, dark surface horizons that have a high proportion of organic matter. Such soils can be found in the midwestern United States stretching up into Canada and in portions of northwestern North America. Regions in New England and the eastern portion of Canada, meanwhile, contain spodosols (from the Greek *spodos*, meaning “wood ash”), which are characterized by a light-colored, grayish topsoil and subsoil accumulation of aluminum, organic matter, and iron. Soil scientists classify soils in many of the southern United States as ultisols (from the Latin for “last”), heavily weathered soils with high concentrations of aluminum. In the southwest, meanwhile, aridisols (from the Latin *aridus*, for “dry”), featuring little organic matter, are found, as their name implies, in arid lands with little plant growth.

The suborder and great group names of the soil taxonomy provide increasing levels of detail. The suborder aqualf, for example, combines *aqu* from the Latin *aqua*, for “water,” and *alf* from alfisol to describe wet soils. Using assorted roots and combining them in different ways, scientists describe soils in a highly specialized and specific language. Aeric fragiaqualfs, for example, are wet, well-developed soils with aerated surface layers and restrictive subsoils.

Soil Use

For most of human history, soil has not been treated as the valuable and essentially nonrenewable resource that it is. Erosion has devastated soils worldwide as a result of overuse and misuse. In recent years, however, farmers and agricultural experts have become increasingly concerned with soil management.

Erosion

Erosion is the wearing away of material on the surface of the land by wind, water, or gravity. In nature, erosion occurs very slowly, as natural weathering and geologic processes remove rock, parent material, or soil from the land surface. Human activity, on the other hand, greatly increases the rate of erosion. In the United States, the farming of crops accounts for the loss of over 3 billion metric tons of soil each year.

7 Photo Credit - MICHAEL FAY/National Geographic Stock

In a cultivated field from which crops have been harvested, the soil is often left bare, without protection from the elements, particularly water. Raindrops smash into the soil, dislodging soil particles. Water then carries these particles away. This movement may take the form of broad overland flows known as sheet erosion. More often, the eroding soil is concentrated into small channels, or rills, producing so-called rill erosion. Gravity intensifies water erosion. Landslides, in which large masses of water-loosened soil slide down an incline, are a particularly extreme example.

Wind erosion occurs where soils are dry, bare, and exposed to winds. Very small soil particles can be suspended in the air and carried away with the wind. Larger particles bounce along the ground in a process called saltation.

Soil Management

To prevent exposure of bare soil, farmers can use techniques such as leaving crop residue in the soil after harvesting or planting temporary growths, such as grasses, to protect the soil from rain between crop-growing seasons. Farmers can also control water runoff by planting crops along the slope of a hill (on the contour) instead of in rows that go up and down.

Soil faces many threats throughout the world. Deforestation, overgrazing by livestock, and agricultural practices that fail to conserve soil are three main causes of accelerated soil loss. Other acts of human carelessness also damage soil. These include pollution from agricultural pesticides, chemical spills, liquid and solid wastes, and acidification from the fall of acid rain. Loss of green spaces, such as grassland and forested areas, in favor of impermeable surfaces, such as pavement, buildings, and developed land, reduces the amount of soil and increases pressure on what soil remains. Soil is also compacted by heavy machinery and off-road vehicles. Compaction rearranges soil particles, increasing the density of the soil and reducing porosity. Crusts form on compacted soils, preventing water movement into the soil and increasing runoff and erosion.

With the world's population now numbering upwards of 6 billion people—a figure that may rise to 10 billion or more within three decades—humans will depend more than ever on soil for the growth of food crops. Yet the rapidly increasing population, the intensity of agriculture, and the replacement of soil with concrete and buildings all reduce the capacity of the soil to fulfill this need.

As a result of an increased awareness of soil's importance, many changes are being made to protect soil. Recent interest in soil conservation holds the promise that humanity will take better care of this precious resource.

The Soil Reservoir
Soil is a reservoir that stores moisture and nutrients needed by plants to grow well. Plant roots are the pipes that transfer water and nutrients from the soil to plant leaves.

How well roots do their job depends on soil quality. In soils that are loose and rich in organic material, roots spread freely and can pull water and nutrients from a large area. Water is able to enter loose soils easily, and is stored in organic matter until plants need it. Poor and compacted soils inhibit roots from spreading to reach nutrients and water. Water runs off compacted soils rather than entering the soil. Plants grown in poor soils can be stunted, and are susceptible to damage from disease, insects and drought.

(*Encarta*)

What is Soil Science?
Soil science is the study of the earth’s skin. It includes (micro)biology, (bio)chemistry, soil physical and fertility properties, soil formation, and soil classification. Fundamental knowledge of soil science is imperative not only in agriculture, but also in natural resources management, environmental policy, and civil/environmental engineering. Soil is much more than just “dirt.” Soil is the ultimate natural resource for growing plants and crops. It is crucial for raising livestock, building the foundations of homes and recreational facilities such as golf courses and athletic fields. The ever-increasing world population could not possibly be sustained without soils. In any terrestrial environment, soils play five key roles.

First, soil supports the growth of higher plants, mainly by providing a medium for plant roots and supplying nutrient elements. Second, soil properties are the principal factor controlling the fate of water in the hydrologic system (e.g., water loss, utilization, contamination, and purification). Third, soil recycles organic residues (e.g., the waste products and dead bodies of plants and animals) to make them available for re-use by the next generation of life. Fourth, soils provide habitats for a myriad of living fauna and flora, from micron-sized microbes and fungi to macrofauna, such as arthropods and small mammals. Lastly, soil plays an important role as an engineering medium as it provides the foundation for virtually every road, airport, and house built.

(*Soil Sciences at Clemson University*)

What Kind of Soil Do You Have?
The only way to find out how well your soil is providing for plant roots is to dig in and check. Dig a one foot deep hole and remove a slice of soil from the side. How does it look and feel? Not compacted layers.

Clay and silt	Loam	Sandy
Clay and silt soils are made of very small particles. They feel slick and sticky when wet. Clay and silt hold moisture well, but resist water infiltration, especially when they are dry. Often puddles form on clay or silt soils, and they easily become compacted.	Loam soil is a mix of sand, silt or clay, and organic matter. Loam soils are loose and look rich. When squeezed in your fist, moist loam will form a ball which crumbles when poked with a finger. Loam soils normally absorb water and store moisture well. Loam soils can be sandy or clay based, and will vary in moisture absorbtion and retention accordingly.	Sandy soils contain large particles which are visible to the unaided eye, and are usually light in color. Sand feels coarse when wet or dry, and will not form a ball when squeezed in your fist. Sandy soils stay loose and allow moisture to penetrate easily, but do not retain it for long term use.

Few gardens start with the "rich sandy loam" that gardening books recommend for planting. The soil improvement and planting practices outlined below can help plant roots do better in any soil.
(Soil Types)

Improving soil structure
Even very poor soil can be dramatically improved, and your efforts will be well rewarded. With their roots in healthy soil, your plants will be more vigorous and more productive.

Sandy Soil
Sand particles are large, irregularly shaped bits of rock. In a sandy soil, large air spaces between the sand particles allow water to drain very quickly. Nutrients tend to drain away with the water, often before plants have a chance to absorb them. For this reason, sandy soils are usually nutrient-poor. A sandy soil also has so much air it it that microbes consume organic matter very quickly. Because sandy soils usually contain very little clay or organic matter, they don't have much of a crumb structure. The soil particles don't stick together, even when they're wet.

Clay Soil
Clay particles are small and flat. They tend to pack together so tightly that there is hardly any pore space at all. When clay soils are wet, they are sticky and practically unworkable. They drain slowly and can stay waterlogged well into the spring. Once they finally dry out, they often become hard and cloddy, and the surface cracks into flat plates.Lack of pore space means that clay soils are generally low in both organic matter and microbial activity. Plant

roots are stunted because it is too hard for them to push their way through the soil. Foot traffic and garden equipment can cause compaction problems. Fortunately, most clay soils are rich in minerals which will become available to your plants once you improve the texture of the soil.

Silty Soil
Silty soils contain small irregularly shaped particles of weathered rock, which means they are usually quite dense and have relatively small pore spaces and poor drainage. They tend to be more fertile than either sandy or clayey soils.

Soil pH
The pH level of your soil indicates its relative acidity or alkalinity. A pH test measures the ratio of hydrogen (positive) ions to hydroxyl (negative) ions in the soil water. When hydrogen and hydroxyl ions are present in equal amounts, the pH is said to be neutral (pH 7). When the hydrogen ions prevail, the soil is acidic (pH 1 to pH 6.5). And when the hydroxyl ions tip the balance, the pH is alkaline (pH 6.8 to pH 14).

Most essential plant nutrients are soluble at pH levels of 6.5 to 6.8, which is why most plants grow best in this range. If the pH of your soil is much higher or lower, soil nutrients start to become chemically bound to the soil particles, which makes them unavailable to your plants. Plant health suffers because the roots are unable to absorb the nutrients they require.

To improve the fertility of your soil, you need to get the pH of your soil within the 6.5 to 6.8 range. You can't, and shouldn't try, to change the pH of your soil overnight. Instead, gradually alter it over one or two growing seasons and then maintain it every year thereafter. Liberal applications of organic matter is a good idea too, because it helps to moderate pH imbalances.

Correcting soils that are too acidic.
If the pH of your soil is less than 6.5, it may be too acidic for most garden plants (although some, such as blueberries and azaleas require acidic soil). Soils in the eastern half of the U.S. are usually on the acidic side.

The most common way to raise the pH of your soil (make it less acidic) is to add powdered limestone. Dolomitic limestone will also add manganese to the soil. Apply it in the fall because it takes several months to alter the pH.

Wood ash will also raise the pH, and it works more quickly than limestone and contains potassium and trace elements. But if you add too much wood ash, you can drastically alter the pH and cause nutrient imbalances. For best results, apply wood ash in the winter, and apply no more than 2 pounds per 100 square feet, every two to three years.

To raise the pH of your soil by about one point:
In sandy soil: add 3 to 4 pounds of ground limestone per 100 square feet.
In loam (good garden soil): add 7 to 8 pounds per 100 square feet.
In heavy clay: ad d 8 to 10 pounds per 100 square feet.

Correcting soils that are too alkaline.

If your soil is higher than 6.8, you will need to acidify your soil. Soils in the western U.S., especially in arid regions, are typically alkaline. Soil is usually acidified by adding ground sulfur. You can also incorporate naturally acidic organic materials such as conifer needles, sawdust, peat moss and oak leaves.

Soil testing

A professional soil test will provide you with a wealth of information about your soil, including the pH and amount of different nutrients.

8 Photo Credit - Oklahoma State University

Your local Cooperative Extension Service office may offer a professional soil testing service. The advantage is low cost and results that are specifically geared to your location. If this service is not available, you can also have your soil tested by an independent soil lab. If possible, choose one in your own region of the country.

Soil test results usually rate the levels of soil pH, phosphorus, potassium, magnesium, calcium, and sometimes nitrogen. (Most labs do not test for nitrogen because it is so unstable in the soil.) Some labs also offer tests for micronutrients such as boron, zinc and manganese. Unless you feel there may be a deficiency problem, you probably won't need micronutrient testing. As a preventative measure, you can apply organic fertilizers that include micronutrients (such as greensand and kelp meal).

To get the most accurate test results, take a soil sample from each garden area: lawn, flower garden, and vegetable garden. Spring and fall are the best times to perform a soil test. The soil is more stable, and these are good times to incorporate any recommended fertilizers. Many labs will give recommendations for specific organic amendments upon request. If not, you will have to compare labels to find organic substitutes for the chemical fertilizers that may be suggested.

Improvement, Planting & Mulching

Good soil preparation and proper planting are keys to healthy plants and efficient use of water in the garden. Deep cultivation and the addition of compost or other organic materials enhance the soil's ability to absorb and store rainfall or irrigation water fro plants to use later. Good planting practices allow plants to develop healthy, wide spreading roots which draw water from a large area. These practices contribute to a healthy garden which resists drought and thrives with minimal maintenance and watering.

(LaLiberte)

Soil in a Nutshell

Soil makes up the outermost layer of our planet.
Topsoil is the most productive soil layer.
Soil has varying amounts of organic matter (living and dead organisms), minerals, and nutrients.
Five tons of topsoil spread over an acre is only as thick as a dime.
Natural processes can take more than 500 years to form one inch of topsoil.
Soil scientists have identified over 70,000 kinds of soil in the United States.
Soil is formed from rocks and decaying plants and animals.
An average soil sample is 45 percent minerals, 25 percent water, 25 percent air, and five percent organic matter.
Different-sized mineral particles, such as sand, silt, and clay, give soil its texture.
Fungi and bacteria help break down organic matter in the soil.
Plant roots and lichens break up rocks which become part of new soil.
Roots loosen the soil, allowing oxygen to penetrate. This benefits animals living in the soil.
Roots hold soil together and help prevent erosion.
Five to 10 tons of animal life can live in an acre of soil.
Earthworms digest organic matter, recycle nutrients, and make the surface soil richer.
Mice take seeds and other plant materials into underground burrows, where this material eventually decays and becomes part of the soil.
Mice, moles, and shrews dig burrows which help aerate the soil.

Field Sampling

9 Photo Credit - Saint Francis University

Counting populations

Because it is impossible to count all the members of a large community, some form of sampling has to be used. The **size of the sample depends on the area to be investigated,** but can be shown on a graph as shown (down):

Beyond this point, more samples (= more work) does not increase the **reliability** of the results.

AQA are very keen that you should know the importance of **random sampling**. This is essential **to avoid bias.** In fieldwork, this is done by:

1. Lay out two tapes at right-angles

2. Use random number tables to pick co-ordinates

3. Place a quadrat (of suitable size) at that point and count the organisms within it

4. Repeat this process until enough samples have been obtained **(30 or more)**

5. The edge effect: What to do with plants which touch the edge? The rule is **if they touch the right side or the top, count them "in".** If they touch the bottom or the left side, count them "out".

Quadrats

Quadrats (= a frame of known size – typically 1m or ½m square, which may be divided into 100)

These can be used to estimate a population in an **area which is fairly uniform.** Examples include lawns, woods and open ground. They can produce three estimates of population size:

1. **Density** (organisms per m^2);

2. **Frequency** (number of quadrats that contain the organism)

3. **Percentage cover** (estimated by the sampler)

Transects

Transects (= a straight line. Can be of any length, but samples are taken at uniform intervals along it)

These are used when **the abiotic factors gradually vary**, causing a change to the organisms living there. Examples include **seashores** (low → high tide); across streams; up hillsides. Can be used with a quadrat to sample in more detail, otherwise **population estimates are limited to frequency.**

Mark-release-recapture

Since animals are mobile, it is difficult to use quadrats or transects to count them. Instead, the mark-release-recapture technique is used.

1. A (large) sample group of the animal is caught (without injury)

2. They are **all** marked (usually underneath, with paint) such that their survival is not affected

3. They are released back **into the same area they were captured**

4. They are allowed time to mix with the rest of the population, but not to reproduce

5. A second, **unbiased,** sample group is captured and divided into

a. those that are marked (i.e. have been recaptured) and

b. those that are unmarked (i.e. have been caught for the first time).

6. The population is calculated from:

Population = <u>Overall total in second sample (5) x Total number marked (2)</u>
Total number of marked individuals in second sample (5a)

This formula assumes that:

1. The population does not change between samples, due to migration, predation or breeding.

2. The marked individuals mix freely (and randomly) with the rest of the population

3. Marking does not affect the animal in any way.

Diversity

This describes a community, both by the total number of species present and by the number of organisms present. The **index of diversity (d)** is given by:

$$d = \frac{N(N-1)}{\Sigma\, n(n-1)}$$

Where:

• **N** = total number of organisms in the area (i.e. the community, or sum of the populations)

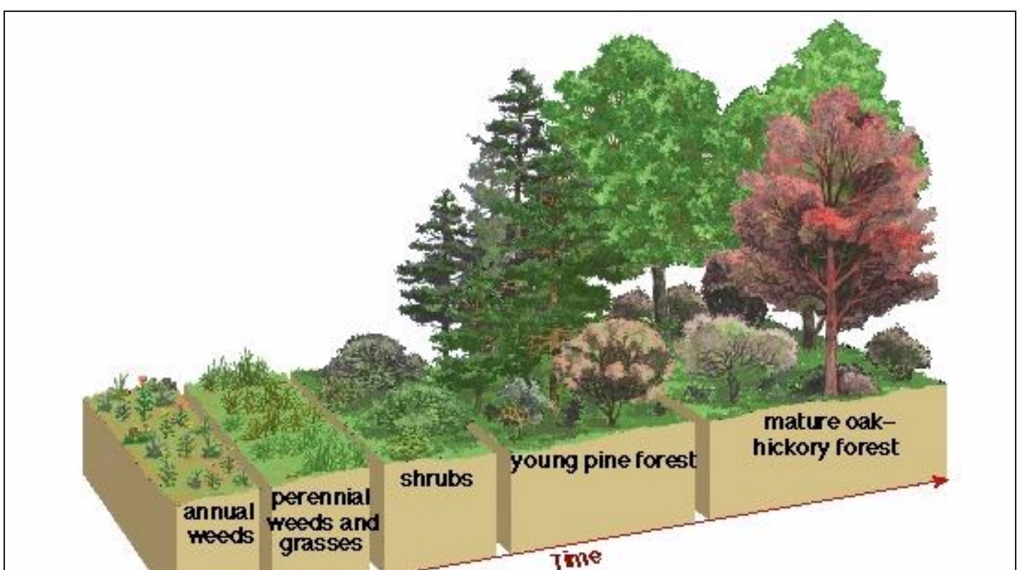
• **n** = total number of each organism (i.e. each individual population)

• **Σ** = 'sum of' (i.e. calculate each value, and then add them together.

It follows that the bottom line can involve quite a lot of calculating! When looking at the final index of diversity total (the value is generally between 2 and 10), remember that:

• **The harsher the environment, the lower diversity**. **Abiotic factors dominate**.

• **The less harsh the environment, the greater the diversity** and **biotic factors dominate**.



10 Photo Credit - Eastern Kentucky University; Succession

Succession
Some of the organisms in an area are gradually replaced over time

by new species. This **succession** is a **result of the changes to the environment brought about by the organisms themselves**. Through succession, the **organisms tend to get bigger and more complex, whilst the biodiversity also rises.**

Pioneer species are those that first colonize bare soil or rock. They can withstand the harsh environment, and include lichens and mosses and Marram Grass on sand dunes. The process continues in stages until the **climax community** is reached, which will remain **stable until the abiotic factors change.**
If succession is halted (e.g. by fire, flood or by Man's actions – such as pouching), then a **secondary succession** will start. **This is much faster** than **primary succession** as there are many seeds in the soil from which new plants can grow, whilst animals readily colonize the area as soon as the plants appear.

Ultimately, it does not matter very much what the starting point for succession is - rock, bog or pond - as eventually the **climax community will be much the same,** since the climate is the main influence on it.

Food Chains and Food Webs
Only about 10% of the energy at any level in a food chain is passed on to the next level. This is because:

- Not all of the 'prey' organism is actually eaten

- Only the energy eaten, **assimilated and used for growth** by the 'prey' is available to the 'predator'. Most of the 'missing' 90% of energy is **lost in respiration**, but also in keeping warm, moving etc.

For these reasons, food chains are usually short and big, fierce animals are rare.

(Chapter 4)

Background (6-12th grade)

WHY DO WE NEED TO SAMPLE?

If we want to know what kind of plants and animals are in a particular habitat and how many there are of each species, it is usually impossible to go and count each and every one present. It would be like trying to count different sizes and colors of grains of sand on the beach.

This problem is usually solved by taking a number of samples from around the habitat, making the necessary assumption that these samples are representative of the habitat in general. In order to be reasonably sure that the results from the samples do represent the habitat as closely as possible, careful planning beforehand is essential.

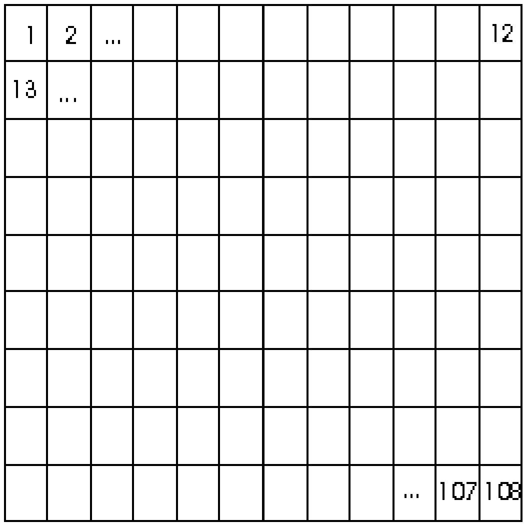
Samples are usually taken using a standard sampling unit of some kind. This ensures that all of the samples represent the same area or volume (water) of the habitat each time.

The usual sampling unit is a quadrat. Quadrats normally consist of a square frame, the most frequently used size being 1m. The purpose of using a quadrat is to enable comparable samples to be obtained from areas of consistent size and shape. Rectangular quadrats and even circular quadrats have been used in some surveys. It does not really matter what shape of quadrat is used, provided it is a standard sampling unit and its shape and measurements are stated in any write-up. It may however be better to stick to the traditional square frame unless there are very good reasons not to, because this yields data that is more readily comparable to other published research. (For instance, you cannot compare data obtained using a circular quadrat, with data obtained using a square quadrat. The difference in shape of the sampling units will introduce variations in the results obtained.)

11Photo Credit - University of Idaho

Choice of quadrat size depends to a large extent on the type of survey being conducted. For instance, it would be difficult to gain any meaningful results using a 0.5m2 quadrat in a study of a woodland canopy! Small quadrats are much quicker to survey, but are likely to yield somewhat less reliable data than large ones. However, larger quadrats require more time and effort to examine properly. A balance is therefore necessary between what is ideal and what is practical. As a general guideline, 0.5 - 1.0m2 quadrats would be suggested for short grassland or dwarf heath, taller grasslands and shrubby habitats might require 2m quadrats, while quadrats of 20m2 or larger, would be needed for woodland habitats. At the other end of the scale, if you are sampling moss on a bank covered with a very diverse range of moss species, you might choose to use a 0.25m2 quadrat.

To record percentage cover of species in a quadrat, look down on the quadrat from above and estimate the percentage cover occupied by each species (e.g. species A - D *left*). Species often overlap and there may be several different vertical layers. Percentage cover may therefore add up to well over 100% for an individual quadrat.



12 Photo Credit - Oregon State University; Example of a grid of quadrats

The estimation can be improved by dividing the quadrat into a grid of 100 squares each representing 1% cover. This can either be done mentally by imagining 10 longitudinal and 10 horizontal lines of equal size superimposed on the quadrat, or physically by actually dividing the quadrat by means of string or wire attached to the frame at standard intervals. This is only practical if the vegetation in the area to be sampled is very short, otherwise the string/wire will impede the laying down

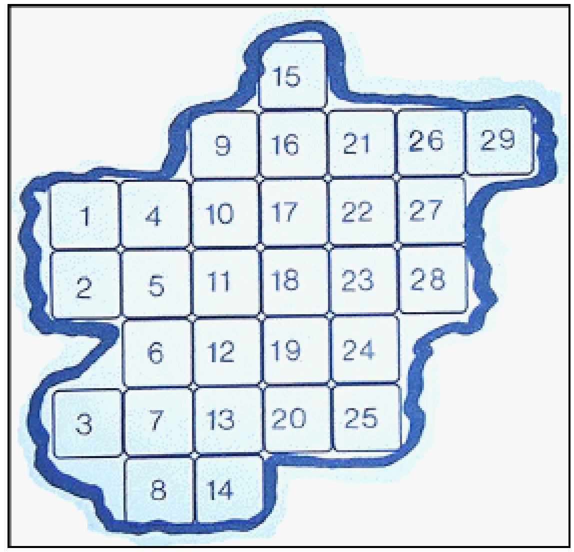
Quadrats are most often used for sampling, but are not the only type of sampling units. It depends what you are sampling. If you are sampling aquatic microorganisms or studying water chemistry, then you will most likely collect water samples in standard sized bottles or containers. If you are looking at parasites on fish, then an individual fish will most likely be your sampling unit. Similarly, studies of leaf miners would probably involve collecting individual leaves as sampling units. In these last two cases, the sampling units will not be of standard size. This problem can be overcome by using a weighted mean, which takes into account different sizes of sampling unit, to arrive at the mean number of organisms per sampling unit.

RANDOM SAMPLING

Random sampling is usually carried out when the area under study is fairly uniform, very large, and or there is limited time available. When using random sampling techniques, large numbers of samples/records are taken from different positions within the habitat. A quadrat frame is most often used for this type of sampling. The frame is placed on the ground (or on whatever is being investigated) and the animals, and/ or plants inside it counted, measured, or collected, depending on what the survey is for. This is done many times at different points within the habitat to give a large number of different samples.

In the simplest form of random sampling, the quadrat is thrown to fall at ‘random’ within the site. However, this is usually unsatisfactory because a personal element inevitably enters into the throwing and it is not truly random. True randomness is an important element in ecology, because statistics are widely used to process the results of sampling. Many of the common statistical techniques used are only valid on data that is truly randomly collected. This technique is also only possible if quadrats of small size are being used. It would be impossible to throw anything larger than a $1m^2$ quadrat and even this might pose problems. Within habitats such as woodlands or scrub areas, it is also often not possible to physically lay quadrat frames down, because tree trunks and shrubs get in the way. In this case, an area the same size as the quadrat has to be measured out instead and the corners marked to indicate the quadrat area to be sampled.

A better method of random sampling is to map the area and then to lay a numbered grid over the map. A (computer generated) random number table is then used to select which squares to sample in. (Random number Table). For example, if we have mapped our habitat, and have then laid a numbered grid over it as shown (Figure - below), we could then choose which squares we should sample in by using the random number table.



If we look at the top of the first column in the random number table, our first number is 20. Moving downwards, the next two numbers in the random number table would be 74 and 94, but our highest numbered square on our grid is only 29 (Figure above). We would therefore ignore 74 and 94 and move on to the next number which is 22. We would then sample in Square 22. Continuing down the figures in this column, we would soon come across the number 20 again. As we have already selected this grid for sampling we would similarly ignore this number and continue on to the next. We would continue in this fashion until we had obtained enough samples to be representative of the habitat. There are other methods for selecting numbers from a random number table, but this is the simplest.

In some habitats it may be difficult to set up numbered grids (e.g. in woodland) and in these a ‘random walk’ may be used. In this method, each sample point is located by taking a random number between 0 and 360, to give a compass bearing, followed by another random number which indicates the number of paces which should be taken in that direction.

Many ecological surveys are carried out over extended periods of time, with sampling taking place at regular intervals within a particular habitat. In such cases, it is necessary to estimate the number of samples which should be taken at each sampling period. The minimum number of samples which should be taken to be truly representative of a particular habitat can be ascertained by graphing the number of species recorded, as a function of the number of samples examined.

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Systematic sampling is when samples are taken at fixed intervals, usually along a line. This normally involves doing transects, where a sampling line is set up across areas where there are clear environmental gradients. For example you might use a transect to show the changes of plant species as you moved from grassland into woodland, or to investigate the effect on species composition of a pollutant radiating out from a particular source .

Line Transect Method

A transect line can be made using a nylon rope marked and numbered at 0.5m, or 1m intervals, all the way along its length. This is laid across the area you wish to study. The position of the transect line is very important and it depends on the direction of the environmental gradient you wish to study. It should be thought about carefully before it is placed. You may otherwise end up without clear results because the line has been wrongly placed. For example, if the source of the pollutant was wrongly identified in the example given above, it is likely that the transect line would be laid in the wrong area and the results would be very confusing. Time is usually money, so it is worth while thinking about it before starting.

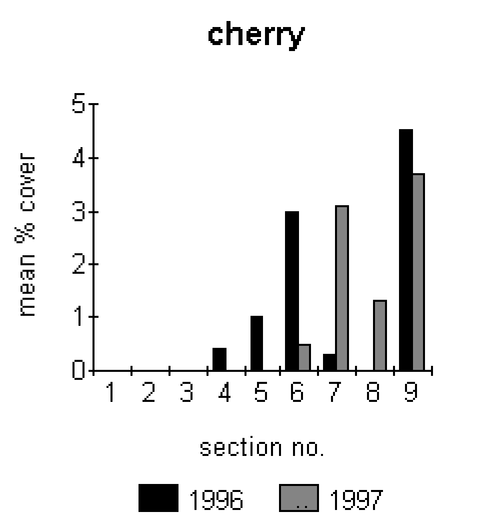
A line transect is carried out by unrolling the transect line along the gradient identified. The species touching the line may be recorded along the whole length of the line (continuous sampling). Alternatively, the presence, or absence of species at each marked point is recorded (systematic sampling). If the slope along the transect line is measured as well, the results can then be inserted onto this profile.

Belt Transect Method

This is similar to the line transect method but gives information on abundance as well as presence, or absence of species. It may be considered as a widening of the line transect to form a continuous belt, or series of quadrats.

In this method, the transect line is laid out across the area to be surveyed and a quadrat is placed on the first marked point on the line. The plants and/or animals inside the quadrat are then identified and their abundance estimated. Animals can be counted (if they will sit still!), or collected, while it is usual to estimate the percentage cover of plant species. Cover is the area of the quadrat occupied by the above-ground parts of a species when viewed from above. The canopies of the plants inside the quadrat will often overlap each other, so the total percentage cover of plants in a single quadrat will frequently add up to more than 100%.

Quadrats are sampled all the way down the transect line, at each marked point on the line, or at some other predetermined interval (or even randomly) if time is short. It is important that the same person should do the estimations of cover in each quadrat, because the estimation is likely to vary from person to person. If different people estimate percentage cover in different quadrats, then an element of personal variation is introduced which will lead to less accurate results. The height of plants in the quadrat can be recorded and the biomass of plants can also be measured by harvesting all the plants inside the quadrat and then weighing either fresh, or dry weight in the laboratory. This is obviously a very destructive method of sampling which could not be used too often in the same place. Sampling should always be as least destructive as possible and you should try not to trample an area too much when carrying out your survey.



STRATIFIED SAMPLING

Stratified sampling is used to take into account different areas (or strata) which are identified within the main body of a habitat. These strata are sampled separately from the main part of the habitat. The name 'stratified sampling' comes from the term 'strata' (plural) or stratum (singular). For ease of understanding, the term 'unit' will be used in the following explanation, rather than stratum.

Individual habitats are rarely uniform throughout their extent. There are often smaller identifiable areas within a habitat which are substantially different from the main part of the habitat. For example, scrub patches within a heathland area, or areas of bracken in a grassland.

One of the problems with random sampling is that random samples may not cover all areas of a habitat equally. To continue with the example of bracken patches in a grassland, if the area was random sampled, it is possible that none of the samples might fall within the bracken patches. The results would then not show any bracken in the habitat. Clearly this would not be an accurate reflection of the habitat. In this sort of situation, stratified random sampling would be used to avoid missing out on important areas of the habitat. This simply means identifying the bracken as a different unit within the habitat and then sampling it separately from the main part of the habitat.

While the bracken area clearly needs to be taken into account, it is nevertheless important to avoid overemphasising its significance within the habitat as a whole. Its importance is kept in context by locating a proportional number of samples directly within the bracken unit. The proportion of samples taken within the unit is determined by the area of the unit in relation to the overall area of the habitat.

For example, say the grassland area is 200 m2 overall, with the bracken patch occupying 50 m2 of this total area. The bracken therefore accounts for 25% of the total grassland area. Say it has been decided that a total of 12 samples need to be taken in order to accurately reflect the composition of the whole habitat. Then 3 of those samples (one quarter, or 25%) would be located within the bracken unit and 9 (three quarters, or 75%) in the general grassland area.

There is a standard formula for calculating the number of samples to be placed in each unit. This is:

$$\text{The number of quadrats sampled in the unit} = \frac{\text{the area of the unit x the total number of quadrats to be sampled}}{\text{total area of the habitat}}$$

For example, in the illustration given above this would be:

$$3 = \frac{50 \times 12}{200}$$

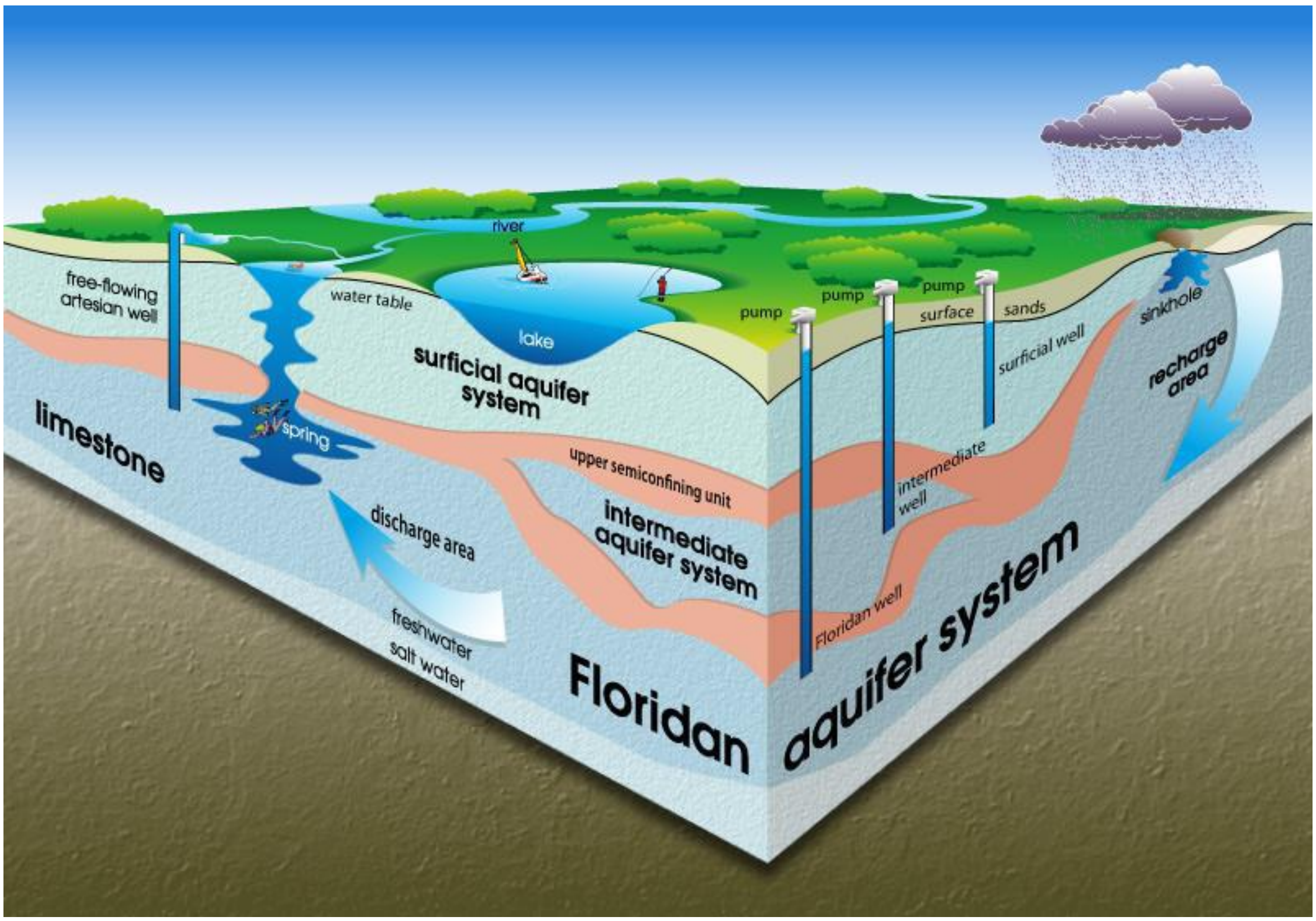
("How to Carry out Ecological Sampling.")

Aquifers

Clean, fresh water is our most precious natural resource. In Florida, fresh water comes from subsurface aquifers that are composed of multiple layers of water-bearing limestone. Groundwater released from the aquifers sustains thousands of ecosystems, and is an essential resource for human health, outdoor recreation, industry and agriculture. Supplying nearly 100% of the state's drinking water, Florida's aquifers discharge over 8 billion gallons of water each day; they are among the most productive in the world.

Groundwater comes to the surface through more than 600 natural springs found throughout the state. Groundwater is also pumped to the surface by artificial wells, bringing millions of gallons of drinking water into residential homes and into bottling plants that ship Florida's groundwater all over the planet.

FLORIDA HAS MORE THAN ONE AQUIFER Florida's aquifers vary in depth, composition, and location, and are divided into two general categories: **Surficial and Floridan**.



13 Photo Credit - St. Johns River Water Management Distric

Surficial aquifers are shallow beds of shells and sand that lie less than 100 feet underground. They are separated from the Floridan aquifer from a confining bed of soil. Some have been contaminated by saltwater, yet they provide most of the public freshwater supply southwest of Lake Okeechobee and along the Atlantic coast north of Palm Beach.

In surficial aquifers, the groundwater continuously moves along the hydraulic gradient from areas of recharge to places of discharge. Surficial aquifers are recharged locally as the water-table fluctuates in response to drought or rainfall. Therefore, the temperature and flow from water-table springs varies.

Important surficial aquifers include:

The **Biscayne aquifer** is a surficial aquifer located in southeast Florida. It covers over 3,000 square miles, and is the most intensely used water source in Florida, supplying water to Dade, Broward, Palm Beach, and Monroe counties. The aquifer lies close to the surface and is extremely vulnerable to pollutants that leach through the shallow limestone bedrock. In some areas, it has been contaminated by fuel spills, industrial discharge, landfills, and saltwater.

The **sand and gravel aquifer** stretches 2,400 square miles across the Panhandle. Although this surficial aquifer is replenished with rainfall, water levels have dropped due to water-well use (pumping), and it has been contaminated by industrial waste and saltwater instrusion.

The **Chokoloskee aquifer** is another surficial aquifer in the state; it covers 3,000 square miles in southwest Florida. It is recharged by rainfall. It is believed that artificial drainage canals have lowered water levels and increased saltwater intrusion.

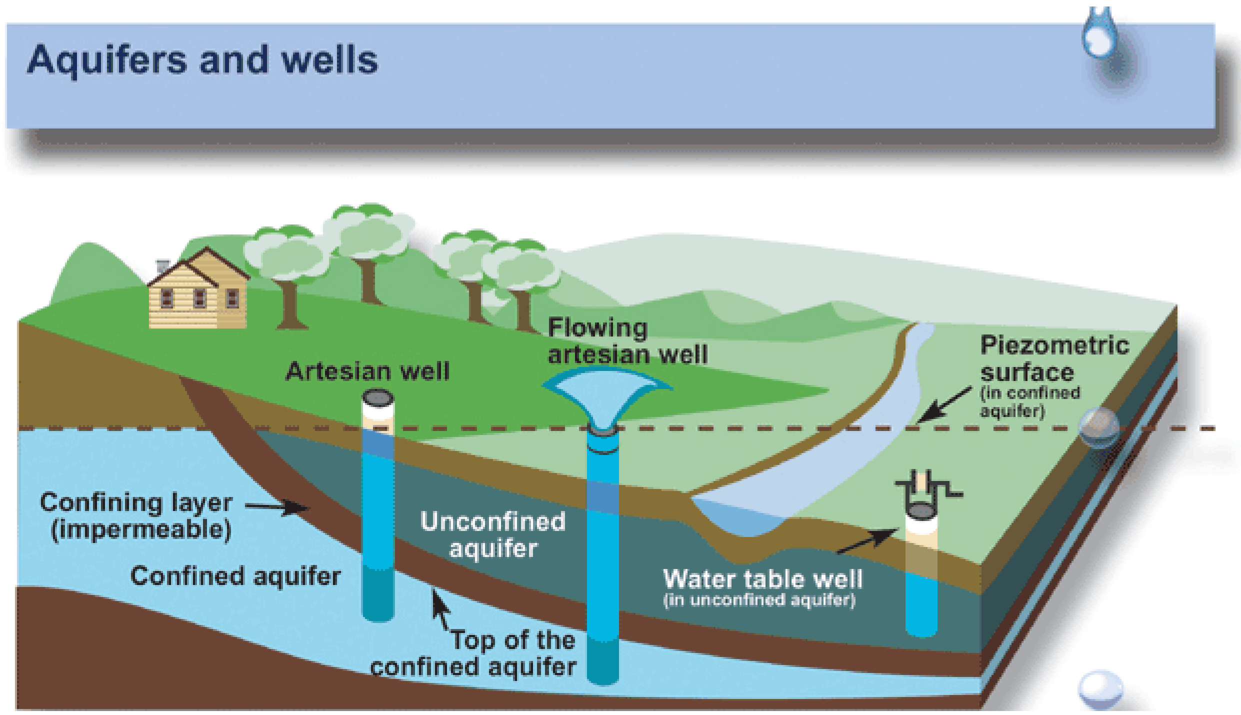
The **Floridan aquifer**, in contrast to surficial aquifers, is the portion of the **principal artesian aquifer** that extends into Florida. The principal artesian aquifer is the largest, oldest, and deepest aquifer in the southeastern U.S. Ranging over 100,000 square miles, it underlies all of Florida and parts of southern Alabama, southeastern Georgia, and southern South Carolina. The Floridan portion developed millions of years ago during the late Paleocene to early Miocene periods, when Florida was underwater.

Unlike water in surficial aquifers, groundwater in the Floridan aquifer *is contained under pressure* by a confining bed of impermeable sediments. When the water pressure is great enough, the groundwater breaks to the surface and a spring flows. Water temperature and flow from a Floridan spring is relatively constant.

The Floridan aquifer supplies fresh water to many cities such as Daytona, Gainesville, Jacksonville, Ocala, St. Petersburg, Tallahasse, and numerous rural communities. In areas where the Floridan contains saltwater, due to saltwater intrusion along the southwest Florida coast, it is injected with sewage and industrial waste.

In addition to the surficial and Floridan aquifers, several **intermediate aquifers** comprised of limestone beds lie between the surficial and Floridan aquifers, and a variety of **undifferentiated aquifers** store approximately ten percent of Florida's groundwater.

WELLS



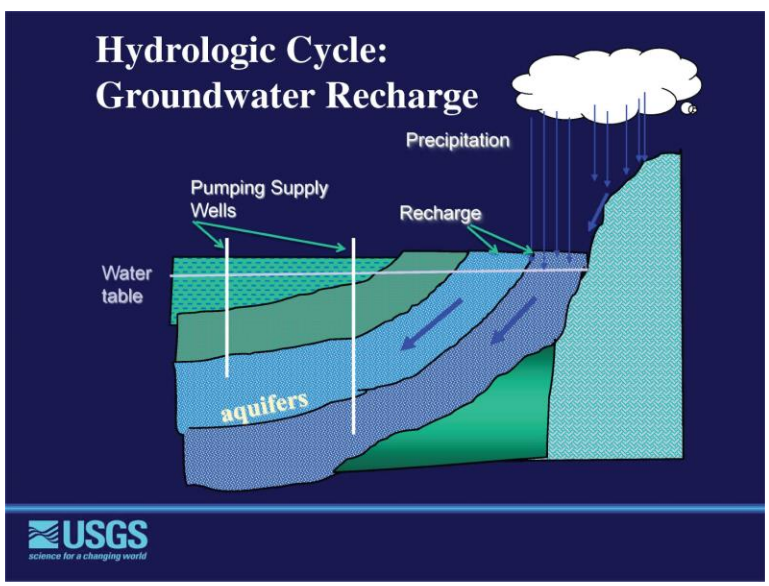
14 Photo Credit - United States Geological Survey; USGS Water Science School

In order to extract water, a well must penetrate the water-table. The amount of water released from a well depends on the **permeability** of the bedrock. Wells drilled into confined aquifers must pierce the confining bed. When the well penetrates the aquifer, the hydrostatic pressure pushes the water above the confining bed where it can be pumped to the surface.

The demand for well-pumping increases as Florida's population continues to rise. Over-pumping can lower the water-table, and as a result, accelerate **sinkhole formation** and decrease **springflow**.

AQUIFERS and the HYDROLOGIC CYCLE

Groundwater in the aquifer is replenished by surfacewater that leaches into the water-bearing limestone bedrock. Rainfall accumulates on the surface and seeps into the soil. Water that is not absorbed by plants percolates deep underground into the porous limestone bedrock until it reaches the **water-table**, the level where the limestone is saturated with water.



15 Photo Credit - United State Geological Survey

The quantity of water stored in the bedrock depends on the **porosity** of the limestone. Very porous limestone will hold more water. When the aquifer is full and unable to accept additional water, surface water drains into nearby lakes, rivers, and oceans where it evaporates back into the atmosphere and eventually precipitates to the surface again.

GROUNDWATER MOVEMENT

Beneath the surface, groundwater moves from areas of **recharge** and replenishment, such as **sinkholes**, to areas of **discharge**, such as **springs**.

Groundwater travels along a **hydraulic gradient**, the downward horizontal slope of the subsurface bedding plane. As water accumulates underground, water pressure, or the **hydrostatic head**, increases. Groundwater movement is directed by a combination of the hydraulic gradient, the hydrostatic head, and **confining beds** of impermeable materials such as clay.

Moving groundwater chemically **erodes** joints and fractures in the limestone bedding plane creating subsurface cavities, **caves**, drainage basins, sinkholes and other geologic features that characterize Florida's **karst** topography.

DRINKING WATER

Underground aquifers are the reservoirs for Florida's natural water filtration systems. Aquifers provide nearly 100% of the state's drinking water and more than 60% of the state's freshwater usage in agriculture and industry. Beneath the surface, organic matter and impurties are removed from groundwater as it filters through the porous limestone bedrock. Water that has not spent enough time filtering through the aquifer can emerge turbid or smelly when it is extracted. Clean groundwater can become polluted by certain contaminants in the surfacewater that replenishes the aquifer, or by subsurface septic tanks and fuel receptacles.

Florida's Department of Environmental Protection requires drinking water suppliers to provide customers with **consumer confidence reports** that show where the water comes from, and if any contaminants are present. Home-owners can also purchase **water-testing kits** to investigate the purity of their well water.

HUMAN IMPACTS

Groundwater, our drinking water, stored in Florida's aquifers, is increasingly threatened by human activities. Drinking water in Florida is particularly susceptible to contamination because the water-table is close to the surface and the limestone bedrock is permeable. Human and animal bacteria, agriculture, pesticides and fertilizers, fuel spills, salt and methane gas are human impacts.

The long term health effects of many pollutants are still unknown.

PROTECTING OUR AQUIFERS

Proper management of chemicals and waste can help protect Florida's groundwater and help prevent the spread of pollutants throughout the aquifer, and into residential homes. Safeguarding primary recharge areas and responsible waste disposal can help preserve our most precious natural resource - fresh water.

(Sidibe)

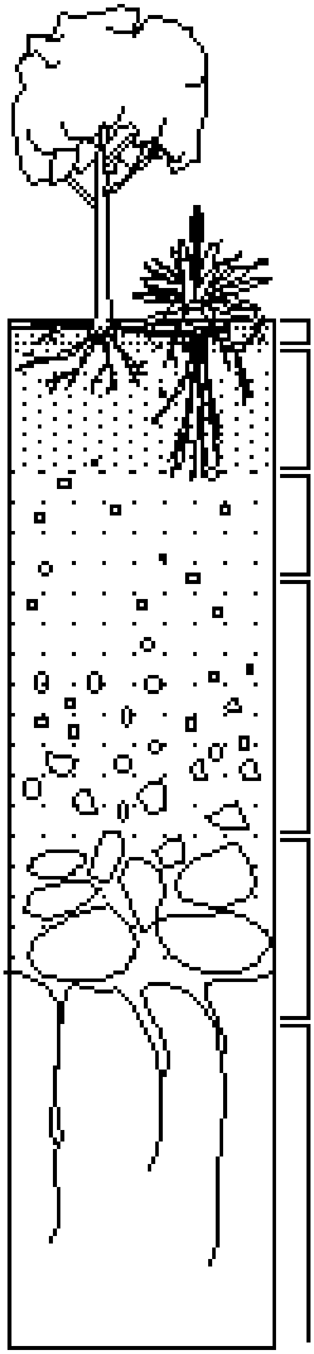
Activity 1: Identifying Soil Layers

Objectives:
- Learn the different soil layers

Materials:
- Soil layer worksheet
- Soil horizons answer key

Procedure:
1. Teach student about the different layers of soil
2. Ask them to fill out the worksheet to quiz their knowledge after the lesson

Soil Layers



Answer Key

O Horizon - The top, organic layer of soil, made up mostly of leaf litter and humus (decomposed organic matter).
A Horizon - The layer called topsoil; it is found below the O horizon and above the E horizon. Seeds germinate and plant roots grow in this dark-colored layer. It is made up of humus (decomposed organic matter) mixed with mineral particles.
E Horizon - This eluviation (leaching) layer is light in color; this layer is beneath the A Horizon and above the B Horizon. It is made up mostly of sand and silt, having lost most of its minerals and clay as water drips through the soil (in the process of eluviation).
B Horizon - Also called the subsoil - this layer is beneath the E Horizon and above the C Horizon. It contains clay and mineral deposits (like iron, aluminum oxides, and calcium carbonate) that it receives from layers above it when mineralized water drips from the soil above.
C Horizon - Also called regolith: the layer beneath the B Horizon and above the R Horizon. It consists of slightly broken-up bedrock. Plant roots do not penetrate into this layer; very little organic material is found in this layer.
R Horizon - The unweathered rock (bedrock) layer that is beneath all the other layers

Activity 2: An Investigation into the Properties of Soil

Objectives:
- Learn different components of soil
- Learn the various properties of soil

Materials:

- Large jar
- Samples of different types of soil
- Magnifying glasses
- Stop-watches or timers
- Coffee filters with baskets
- Photocopied charts
- Pencils
- Water
- Measuring jugs
- Jars which the coffee filters will fit

Procedure:

Preparation done by the Instructor
- Prepare different types of soils for students

1. Before you start this lesson it is important to have a discussion about the importance of always washing hands when handling the soil samples.
2. Prepare several samples of different types of soil and let the children examine them. They can feel the textures and look at them through the magnifying glasses to observe color and consistency.
3. Have a discussion with the children about what they think the soil is made from. Their ideas should be noted for future use.
4. Put a sample of soil into a large jar with some water. Screw the lid on firmly and shake the jar until the soil is fully suspended in the water. Now set the jar aside so the contents can separate and settle during the remainder of the lesson.
5. Divide the children into small working groups.
6. Show the children the various different soil types and get them to think about the differences between them. Each group can then choose one type of soil to investigate more closely.
7. Have each group measure the samples carefully so they are all equal and then place them into the coffee filters and their baskets. These will then be put onto glass jars and water added. The children will then predict which groups' water will filter through more quickly or more slowly.
8. Record these predictions in a simple table.

9. Each group then observes how long it takes for the water to filter through using the stop-watches and record the results. They can compare their results with their earlier predictions and discuss the possible causes of the different times.
10. It should now be time to go back to the first jar of soil and water that you set aside to see what has happened. Hopefully, the soil will have separated and the children can see the various components. They can then compare what they observe with what their predictions were at the beginning.
11. This can lead onto a discussion of the different soils' properties and how this could be caused by where they were obtained and how much plant matter each soil had been observed to contain.
12. Explain to the children that the water and nutrients contained in the soil provide growing plants with two of the components needed for growth - the third being light.

Activity 3: Field Sampling Techniques

Objectives:

- Perform the duties of an ecologist
- Learn the procedure for field sampling different plant species

Materials:

- Ruler
- String
- stakes, tent pegs or quadrats
- Sampling worksheet
- Pencils

Procedure:

1. Introduce students to the Deering Estate Tropical Hardwood Hammocks walking to the natural areas trail.
2. Point out some native plants found in this habitat and discuss their characteristics with the students.
3. Discuss with students the identifying characteristics of the "wild coffee" plant.
4. Discuss the quadrat sampling technique.
5. Provide students with a measuring tape, ruler, string, stakes, tent pegs or quadrats.
6. Each group of students will set up a transect line through hammocks the starting at 0 m at the natural areas trail. The transect will be 25 m long
7. Square 0.50-1.0 m2 quadrats will be used for this analysis
8. Quadrats are positioned along the transect.
9. Do not include a plant whose rooted base lies outside the quadrat.
10. Students will count the "Wild Coffee" plants found in the quadrats. To help you identify the plant, draw a picture of it and take a sample of the leaves and put it in a bag. The color and shape of the flowers and leaves will help you to identify what plants are growing in each quadrat.
11. Count the amount of plants found within the quadrat.
12. Use the Quadrat Sampling Datasheet to establish the population of "Wild Coffee" in the area where samplings were taken.

Determining % cover

A. Quadrat Method

1) For each quadrat determine the total number of species occurrences (e.g., 25 for wild coffee, 25 for other plants = 50 occurrences).

2) Determine the relative percent cover of the species by dividing the species occurrence by the total occurrence and multiplying by 100 (e.g., for species A: (16/50)*100= 32%).
3) Calculate average percent cover by species by averaging across transects for each quadrat location.

Name____

Quadrat Sampling

A complex system can be understood by looking at its components and their interrelationships. The environment is a complex system. A quadrat is a small square area of known dimensions that represents a small segment of the environment being studied. Sampling refers to studying a small fraction of the wholes as a basis for making inferences about the whole. Quadrat sampling involves identifying, counting and classifying all "individuals" of interest within the quadrat boundary. Sampling results lead to inferences about the environment.

Today we will be using quadrats to estimate the population of "wild coffee" in the Deering Estate's hardwood hammock. Using several randomly chosen sites, you will designate quadrats, identify wild coffee, and use mathematical equations to determine an estimated population.

Florida Forest Plants
Wild coffee (*Psychotria nervosa*)

Wild coffee is a native shrub distinguished by its beautiful evergreen foliage and bright red berries. Its conspicuous veins give the plant a textured look. It is found in shell ridge hammock under stories with filtered sunlight and beneath cabbage palms.

The plant is utilized by many butterfly and bird species, including cardinals, mockingbirds, catbirds and spicebush swallowtail butterflies.

Identifying Characteristics

Size/Form:	Wild coffee is a dense, round, evergreen shrub that reaches heights of 10' to 15'.
Leaves:	The leaves are simple, oppositely arranged, persistent, and 2" to 6" long by 2" wide. The elliptical-obovate leaves are dark, glossy green and usually have conspicuous (rugose) veins, giving them a wavy upper surface. The underside is a paler, dull green. The leaf base is wedged and the tip is acute. The margin is smooth, or irregularly wavy.
Fruit:	The fruit is a small, bright red, oval drupe that contains two seeds.
Stem:	The stem and twigs have noticeably raised nodes and are roughened between by irregular corkiness.
Habitat:	Wild coffee grows in a variety of soils types, from wet to dry. It is found in near-coastal hammocks, pinelands and shell ridges. Other associated species include cabbage palms.

Data Collected

Date	
Location	
Habitat type	

Quadrat 1	
# p.nervosa	
# total plants	
Quadrat 2	
# p.nervosa	
# total plants	
Quadrat 3	
# p.nervosa	
# total plants	
Quadrat 4	
# p.nervosa	
# total plants	
Quadrat 5	
# p.nervosa	
# total plants	
Quadrat 6	
# p.nervosa	
# total plants	
Quadrat 7	
# p.nervosa	
# total plants	
Quadrat 8	
# p.nervosa	

# total plants	
Quadrat 9	
# p.nervosa	
# total plants	
Quadrat 10	
# p.nervosa	
# total plants	

% of p.nervosa = ____

Activity 4: Aquifer Adventure

Objectives:

- Understanding of the dynamics of an aquifer
- Learn the impacts humans can have on an aquifer
- Learn how a well works

Materials:

A) Student Activity (one set-up per group)
  a. 1 Clear Containers (large specimen jars, beakers, etc.)
  b. 2 Cups, pea-sized gravel
  c. 1 Cups, dry sand
  d. 1 plastic cup with randomly punctured bottom (to simulate rain)
  e. 2 Cups, water
  f. Large cookie sheet (1 needed for entire class)
  g. Bucket (1 needed for entire class)

B) Teacher Example
  a. Small aquarium
  b. Enough pea-sized gravel to cover three inches of aquarium bottom
  c. Enough dry sand to provide an inch thick layer above the rocks
  d. Plastic cup with randomly punctured bottom (to simulate rain)
  e. Clean container (plastic cup, beaker, etc.)
  f. Fish tank siphon cleaner (to simulate well)
  g. Red food coloring

Procedure:

A) Student Activity (4 table, outdoor lab)
  1. Set up lab tables with all of the equipment before the children arrive
  2. Discuss with the children what they already know about aquifers.
    a. Formation
    b. Location
    c. Biscayne aquifer
    d. Wells & springs
    e. Water table
    f. Recharge & discharge
    g. Contamination
    h. Depletion/conservation
  3. Go over all the materials laid out for the children
  4. Explain to them that each group is going to be making a simple example of an aquifer

a. Have them place the gravel into the clear container. Make sure the gravel forms a flat layer.
b. Place the sand on top the gravel. Be sure to make the sand a flat layer.
c. Have a student hold the punctured cup: one hand grasping, and the other on the bottom blocking the holes. While another student pours the 2 Cups of water into the cup.
d. Hold the cup full of water over the sand and gravel, and allow water to flow. This simulates recharging the aquifer with rain.
e. Have the students observe the water flowing through the sand, and settling on the bottom.
f. Make sure they notice that the water level is in the middle of the gravel. This is an example of the water table.
g. Discuss their observations with them.
h. Clean up

1. Have them try to separate as much sand as possible from the rocks, and place it on the cookie sheet
2. Have them drain as much water as possible from the rocks
3. Have them place the rocks in the bucket
4. Rinse the rest of the equipment
    i. Have the children fill out the lab sheet

B) Teacher Example (1 table, outdoor lab)

1. Already have the aquarium setup with the gravel and sand.
2. Re-simulate for the children how the rain flows through the sand into the gravel. Be sure to point out the water table.
3. Take the fish tank cleaner, and force it to the bottom of the tank.
4. Start siphoning water, and explain how this is an example of a well.
5. In the clean container mix the red food coloring with 3-5 tablespoons of water.
6. Pour the red water over the top of the sand.
7. Again, simulate a “rain shower.”
8. Have the children observe how the red coloring flows into the aquifer.
    a. This is an example of how pesticides and fertilizers contaminate the aquifer.
9. Discuss contamination in more detail. Have them brainstorm on other forms of water contamination, and ways to prevent it.
10. Clean up

Assessments

- What are the different soil horizons?
- What are some characteristics of soil that you learned?
- What is the purpose of field sampling?
- Explain how an aquifer works.
- How can an aquifer be affected by pollution?

Accommodations

-

Accommodations: Notebook Quick List

A general list of accommodations designed for lesson plan books

Instructional methodology and materials

- ☐ Needs alternate format to obtain information—Braille, large print, oral, simplified text
- ☐ Needs assistance with note taking – copy of notes, outline, note taker
- ☐ Needs concrete objects, pictures, or graphics
- ☐ Needs appropriate assistive technology: _______________________
- ☐ Needs advanced organizers or study guides
- ☐ Needs adapted materials—uncluttered, fewer items, highlighted
- ☐ Other: ____

Assignments and assessments

- ☐ Needs to use alternate response mode—tell, draw, write, point
- ☐ Needs appropriate assistive technology: ______________________
- ☐ Needs guides or prompts for specified tasks: __________________
- ☐ Needs extended access to instructional resources and equipment
- ☐ Needs personal assistance – teacher, aide, peer, volunteer, interpreter
- ☐ Other: ____

Learning environment

- ☐ Needs adapted environment—acoustical treatment, lighting, barrier-free
- ☐ Needs preferential seating or study carrel
- ☐ Needs individual system for behavior management
- ☐ Needs to have instruction in small groups or one-to-one
- ☐ Needs individual planner or assistance with organization
- ☐ Other: ____

Time demands and schedules

- ☐ Needs additional time to complete course or grade
- ☐ Needs additional time to complete assignments and tests
- ☐ Needs to have independent or group work sessions in short time segments
- ☐ Needs reduction in number of required practice or assessment items
- ☐ Other: ____

Communication systems

- ☐ Uses Total Communication
- ☐ Uses American Sign Language, Finger spelling, or Signing Exact English
- ☐ Uses augmentative communication system: ____________________
- ☐ Needs instruction in home language other than English:
- ☐ Other: ____

Source: Beech, M., McKay, J. P., Frey, N., & Ward, T. (2000). Dealing with differences: Strategies that work! Trainer notebook, Tallahassee, FL: Florida Department of Education.

Resources

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