

ALS 3133

INTRODUCTION TO SOILS

Overview

Information about soils is necessary to understand how we can use our land resources in a productive and environmentally-sound manner. Information on soils is important for:

- Nutrient management: inorganic fertilizers
- Nutrient management: organic fertilizers (manure, composts, biosolids)
- Pesticide management: potential for contamination of groundwater
- Land-use planning: potential and limitations for various uses
- Wetland delineation: soil characteristics aid in wetland delineation

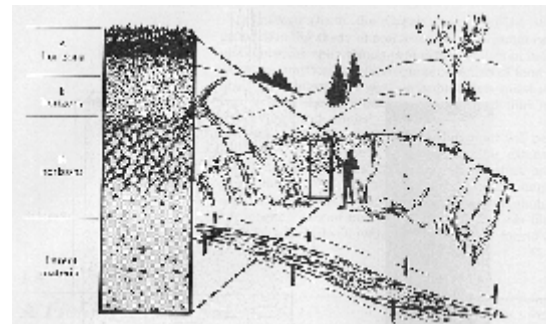
The following was a statement in the Gainesville Sun that was meant to be a joke: “*Despite all our accomplishments, man owes his existence to a 6-inch layer of topsoil and the fact that it rains*”. However, with the world’s growing population and the continued degradation of our soil resources on a world-wide basis, this is not a joking matter. In order to have a sustainable agricultural system, we must protect our soil resource.

What is Soil?

The soil is **not** an inert medium that simply provides a place for plants to establish a root system. The soil **is** a natural, living resource. There are several ways to define soil. For the purposes of this class, soil is a natural body on the surface of the earth consisting of inorganic and organic (living and non-living) material whose characteristics depend on five soil forming factors.

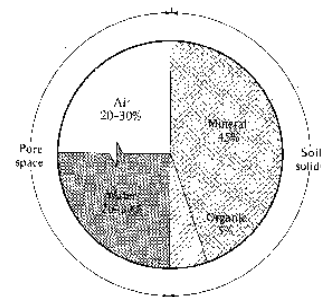
- Parent material
- Topography
- Climate
- Vegetation
- Time

Because of variations in the five soil forming factors, there is much variation in soil characteristics. All soils are not identical. A soil as it exists in the landscape is generally made-up of layers. These individual layers are known as horizons. Collectively, these horizons make-up a soil profile. Each kind of soil has its own distinctive soil profile as determined by the number of horizons and the characteristics of the horizons. The three basic horizons, sequentially, are the A, E, and B horizons, as illustrated in the adjacent figure. This information is used to classify soils by a system called Soil Taxonomy that is similar to the system used to classify plants. For classification purposes, soil characteristics are determined to a depth of two meters. Several soil profiles will be shown in class to illustrate some differences between soils as they exist in the landscape.



What Will You Find in a Handful of Soil?

A handful of soil consists of four interacting components, i.e., minerals (inorganic), organic matter (living and dead), water, and air. A typical soil will consist of 50% solid material and 50% pore space. The organic component in a typical mineral soil generally ranges from 1 to 5%. The pore space will be filled with water and air.



Soil Texture

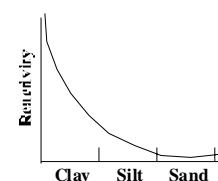
The inorganic component of soil consists of minerals such as quartz, feldspars, micas, kaolinite, vermiculate, and montmorillonite. These minerals exist as varying sizes of particles. The three basic particle-size designations used to characterize a soil are termed sand (2.0 - 0.05 mm), silt (0.05 - 0.002 mm) and clay (<0.002 mm).

Soils are grouped into TEXTURAL CLASSES determined by the relative portion of sand, silt, and clay size particles in the soil. The six basic textural classes and typical amounts of sand, silt and clay sized particles are illustrated below.

Textural Class	Texture	% sand	% silt	% clay
Sand	Coarse	90	8	2
Sandy loam	Moderately coarse	75	20	5
Loam	Medium	45	45	10
Silt loam	Medium	30	55	15
Clay loam	Moderately fine	25	35	40
Clay	Fine	10	20	70

Soil Reactivity

Soils range widely in chemical and physical characteristics. Sand, silt, and clay content (texture) exert major influence on the behavior of chemicals (nutrients, pesticides, toxic metals) and water in the soil. The finer the texture of a soil, the more reactive the soil is with respect to interactions with chemicals and water. This can be illustrated by several physical and chemical parameters, for example, surface area and cation-exchange capacity of the soil particles. The surface area per unit mass is an important property of a soil because surface area affects many soil characteristics such as adsorption of water, nutrients, and from an environmental standpoint, the fate and transport of various soil contaminants such as pesticides, other toxic organic materials and toxic metals.



Soil particles exhibit a negative charge and thus tend to attract cations as illustrated in the drawing below. Many of the plant nutrients such potassium, calcium, magnesium and ammonium nitrogen are cations and are held by the soil in a way which they can be used by plants but at the same time, are resistant to leaching. The cation-exchange capacity of a soil, often abbreviated as CEC, is defined as the soil's ability to retain adsorbed cations which are subject to exchange with other cations held in the soil solution.

Particle-size Designation	Surface Area cm ² /gram	Cation-Exchange Capacity cmol/kilogram
Sand	23	1
Silt	450	5-10
Clay	8,000,000	100+

Soil Organic Matter

Soil organic matter can be living or dead. The living part of the soil organic matter consists of many types of microflora and microfauna. Typical numbers of soil organisms in one gram of soil and the weight of the microorganisms in one hectare of soil to a depth of 15 cm (6 inches) are shown in the following table.

Organism	Number per gram of soil	Weight (kg) per hectare of soil
Microflora		
Bacteria	One Billion	450 - 4,500
Actinomycetes	Ten Million	450 - 4,500
Fungi	One Million	1,000 - 10,000
Algae	100,000	50 - 500
Microfauna		
Protozoa	100,000	15 - 150
Nematoda	10 - 100	10 - 100
Earthworms		100 - 1,000

One of the most important roles of soil microorganisms is the decomposition (mineralization) of crop residues and other organic matter (animal manures, compost, biosolids) added to the soil. The decomposition of organic matter converts nutrients from an organic form to an inorganic

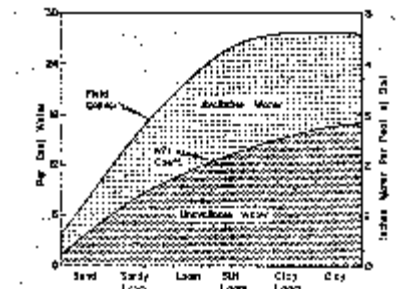
form that can then be used by plants. This a mechanism by which nutrients taken by plants can be returned to the soil for reutilization by plants, i.e., nutrient cycling.

Not all of the organic matter added to a soil is decomposed in the soil. When microorganisms decompose organic matter, they produce a complex, dark brown, colloidal organic material called HUMUS. Humus has chemical and physical properties which are of great significance to soils and plants. Some of the significant characteristics of humus are 1) a high surface area, generally exceeding that of clay-sized mineral particles, 2) the CEC generally exceeds that of clay-sized mineral particles, 3) the water-holding capacity of humus exceeds that of clay-sized mineral particles by 4-5 times, i.e., humus acts as a sponge in the soil, and 4) humus tends to cause soil aggregation and thereby improves the tilth of the soil.

Water Retention by Soil

How much water can a soil retain and why is the soil's "water-holding capacity" important? The "water-holding capacity of a soil is defined as "the percentage of water remaining in the soil after drainage is stopped". At this point, about half of the pore space will be filled with water and half with air. When more water is applied to the root zone than the soil can retain, either as rainfall or as irrigation, excess water moves below the root zone. This excess water carries soluble nutrients and pesticides beyond the depth of the root zone where they can ultimately contaminate either ground water or surface water, depending on the hydrologic characteristics of the area. This movement of soluble materials out of the root zone is called leaching.

The soil's water-holding capacity is determined by soil texture and organic matter content. The finer the texture and the greater the organic matter content, the greater is the water-holding capacity. This is illustrated in the adjacent figure. A 30 cm (12 inches) layer of a sandy soil will hold about 2.5 cm (1 inch) of water, a silt loam will hold about 7.5 cm (3 inches) and a clay soil will hold about 12 cm (4 inches) of water.



Soil Erosion

Another important concept with regard to water is infiltration rate or how fast the water enters the surface of the soil. Because of the large pores in a sandy soil, rainfall or irrigation infiltrates into the soil very rapidly. In contrast, because of small pores in a clay soil, water infiltrates slowly and tends to runoff the soil surface when rainfall or irrigation rates exceeds the infiltration rate.

This surface runoff can carry away soil particles, especially when the land is sloping, ultimately depositing them in rivers and lakes. This process is called erosion. Erosion tends to remove the fine particles of the soil first, i.e., clay, silt and organic matter, thus the best part of the soil is lost. Nutrients and other materials attached to the soil particles such as pesticides are also transported to rivers and lakes by erosion. Thus, erosion is a major contributor of pollutants to

rivers and lakes. Erosion is a major problem in many parts of the United States but not generally in Florida because of our sandy soils. The exception in Florida would be in the panhandle where rolling hills and fine-textured soils exist.

The United States Department of Agriculture (USDA) through the Natural Resource Conservation Service (NRCS) that was formerly called the Soil Conservation Service (SCS), has devoted much of its effort during the last 50+ years to developing methods to protect our soil resource. Examples of conservation practices the NRCS has developed to protect our soils include:

Contour farming: farming with row patterns nearly level around the hill - not up and down the hill. Ridges left by tillage and crop rows slow water flow and increase infiltration which reduces erosion.

Contour stripcropping: Crops are arranged so that a strip of grass or small grain is alternated with a strip of row crop.

Crop residue management: leave last year's crop residue on the soil surface rather than plowing it into the soil. This is commonly called no-till or conservation tillage. Crop residues shield the soil from impact of raindrops thereby reducing erosion.

Soil Survey

Where can you find information on the soils of a specific area? If you are familiar with the soils and vegetation of a locality, the vegetation may provide some clues as to soil characteristics. If you have some knowledge of soils, you could examine soil cores and develop basic soils information about the area. However, in nearly every county of the U.S., a detailed description of the soils has already been developed in the form of a "soil survey" which is published by the Natural Resources Conservation Service (NRCS) on a county-by-county basis. The soil survey is an acre-by-acre inventory of the soil resources of an area developed by soil scientists. These soil scientists converse an area, auger holes to identify the soil horizons, and record this information on aerial photographs. Based on this information, the various soil types are delineated on the aerial photographs and published as a soil survey. The reports and assistance in their use are available from local offices of the USDA Natural Resources Conservation Service, from local Soil and Water Conservation Districts, and from county Extension Service offices.



In addition to the soil maps on aerial photographs, a soil survey will contain detailed descriptions of the soil profiles for each soil type, physical and chemical characteristics of each soil horizon, and an evaluation of the suitability, limitations, and management of the soils for specific uses. It highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.



Following is the “FORWARD” to the Soil Survey of Alachua County, Florida. Use this as an overview of the type of information that can be found in a soil survey report and how that information might be used.

“This soil survey contains information that can be used in land-planning programs in Alachua County. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land used on the environment”.

“This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.”

“Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayed or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.”

“These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are show on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Natural Resource Conservation Service or the Cooperative Extension Service.”