Soils Glossary for the NM Envirothon

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This document was created to supplement other materials posted in New Mexico's Envirothon website. It is written at a high school level, and is not intended to replace other, more scholarly works. Students are not expected to memorize all of the terms below; many appear simply to help them understand other documents. Underlined terms are essential to a basic understanding of soil science, and are fair game on the soils exam.

Addition: the soil-forming process by which substances are added to a soil profile.

Adiabatic lapse rate (ALR): The trend in which the atmosphere becomes cooler at higher elevations. The ALR is related to the orographic and rainshadow effects.

Aerobic: occurring in the presence of 0_2. Aerobic organisms (aerobes) require oxygen in order to metabolize food, and will either die or go dormant in *anaerobic* conditions. Aerobic conditions occur in soils that are not saturated, and that have enough continuous pores to allow gases to freely travel between the soil and the atmosphere. Aerobic metabolism is much more energy-efficient than aerobic metabolism, so organic matter generally breaks down much faster in aerobic conditions. See *respiration*.

Alluvial Fan: a fan-shaped depositional landform that occurs where a steep canyon or arroyo spills out onto a valley bottom.

Alluvium: *parent material* which was deposited by moving water. Examples of alluvial deposits are floodplains, stream terraces, alluvial fans, and marine terraces. Rounded rocks are a good sign that you may be looking at an alluvial deposit.

Anaerobic: occurring in the absence of 0_2. Anaerobic organisms (anaerobes) can metabolize food without 0_2, using other chemicals instead. *Denitrification* is one example of anaerobic metabolism. Organisms which can perform anaerobic metabolism as well as *respiration* are referred to as facultative anaerobes, while those that cannot perform respiration are referred to as obligate anaerobes. Soils can become anaerobic if they are saturated, or if they are severely compacted. Aerobic metabolism is much more energy-efficient than aerobic metabolism, so organic matter generally breaks down much faster in aerobic conditions. See *reduction*, *reducing conditions,* and *organic soil.*

Anion: a negatively-charged ion. Examples are: Nitrate (NO_3^-) and Phosphate (PO_4^{3-}).

Arthropods: invertebrates with jointed legs. Soil arthropods perform a number of important activities. Refer to the Soil Biology Primer for more information.

Bacteria: a class of microorganisms that lack cellular nuclei. In soils, bacteria usually consume the simplest forms of organic matter, such as sugars and fats. Bacteria tend to do better than *fungi* in soils with high *pH*. Because bacteria are one-celled organisms, they are not directly harmed by *tillage*. In addition to releasing nutrients by decomposing organic matter, bacteria perform a number of important functions in soil, such as *denitrification* and *nitrogen fixation*.

Bulk Density: the ratio of the mass of a soil to its volume. Bulk density is often measured for dry samples as g/cm^3 (grams per cubic centimeter). Sandy soils naturally have high bulk densities, and clayey soils naturally have low bulk densities. As soils are *compacted* and pores collapse, bulk density increases.

Carbonates: salts which contain the carbonate ion (CO_3^{2-}). Common examples are calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$). Carbonates often appear as white masses in the soil. Carbonates have profound effects on soil chemistry. They raise soil pH which, in turn, makes many nutrients, such as Fe and P, unavailable to plants. For this reason, many plants do not do well in soils high in carbonates. Carbonates are easily leached in wet climates, but are very common in New Mexico's arid soils. Soil scientists test for carbonates in the field by squirting dilute HCl on soil; the following reaction releases CO2 gas, causing the soil to fizz:

$$CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$$

Cation: a positively-charged ion. Most essential plant nutrients are cations. Examples are: Ca^{2+}, K^+, and Ammonium (NH_4^+).

Cation exchange capacity (CEC): a soil's ability to hold onto and release positively-charged ions (*cations*). Particles of clay and humus have lots of negatively-charged sites on their surfaces. These negative charges attract positively-charged ions much like opposite poles of magnets attract each other. These sites constantly exchange cations with the *soil solution*, swapping one cation for another in a very complex process. In simple terms, a soil with a high CEC can generally retain and provide more cations to plants than a soil with a low CEC.

Colluvium: *parent material* which was deposited by gravity. Colluvial deposits are common at the bases of steep slopes and cliffs. Colluvial soils often contain rocks of many sizes that have relatively sharp edges.

Compaction: the process by which heavy objects compress soils. As soils compact, pores collapse, porosity decreases, bulk density increases, and *infiltration* rates decrease. Compaction can lead to a number of ecological problems, such as erosion, flooding, drought, and *anaerobic* conditions. Soils are easiest to compact when they are wet but not saturated, so land managers should try to keep animals and equipment off of wet soils. Conversely, construction crews intentionally compact soils to provide better support for roads and structures, and wet them to make this process easier.

Component: a part of a *map unit*. If a component is a soil, then it is usually given a soil *series* name. A component can also be a miscellaneous land type, such as Rock outcrop or Urban land. Soil components have a lot of information attached to them, including climate and vegetative data, as well as the physical and chemical properties of each horizon.

Denitrification: an anaerobic metabolic process in which *denitrifying bacteria* convert nitrate (NO_3^-) to gaseous compounds such as N_2O, NO, NO_2, and N_2. The first three gases are pollutants which contribute to the greenhouse effect. Denitrification usually occurs in saturated soils.

Denitrifying bacteria: anaerobic bacteria which perform *denitrification*

<u>Depositional</u>: deposited by moving water

Detritus: the debris of dead plant parts from above and below the soil surface (roots, leaves, etc.)

Detrivore: an organism which feeds directly on *detritus*. This term usually applies to larger organisms such as *arthropods*, but can also apply to *saprophytic microbes*.

<u>Electrical conductivity (EC)</u>: a practical way to measure the *salinity* of soils. In liquids, current is carried by the movement of ions. Because salts dissociate into ions when they dissolve, soils containing lots of soluble salts produce very conductive soil solutions. Electrical conductivity can be measured in the field by mixing equal volumes of soil and water, stirring, and placing an EC meter into the suspension.

Enzymes: proteins that allow specific chemical reactions to occur. All living organisms produce enzymes which participate in all physiological processes, from metabolism to reproduction. Because *bacteria* and *fungi* lack mouths, they secrete digestive enzymes, which break down complex chemicals into simple chemicals. These organisms can then absorb the simple chemicals into their bodies though their cellular membranes.

<u>Eolian deposits</u>: *parent materials* which were deposited by wind. Sand dunes are familiar examples. Many of New Mexico's soils formed out of eolian deposits laid down on top of other materials. Because wind can rarely carry particles larger than sands (0.05-2.0 mm), the presence of larger rock fragments in a layer is a good sign that it is <u>not</u> an eolian deposit.

<u>Erosion</u>: the process by which soil is removed from an area by water or by wind. Water erosion occurs when rains cannot *infiltrate* quickly enough (often due to *compaction*) and begin to flow across the soil surface in a process called *runoff*. As this water collects and accelerates, it begins to pull soil particles off of *aggregates* and carry them away. Wind erosion occurs when a soil surface is exposed (often due to tillage) and high-velocity wind is able to detach and carry off soil particles. Severe erosion can destroy productive ecosystems by removing the fertile topsoil. *Silts* and very fine *sands* are most easily eroded because they are not "sticky" like clay particles, and because they are small enough to be easily carried off. Plant cover and crop residues prevent erosion by slowing the movement of water and wind across the soil surface, and by promoting *infiltration*. Soil *organic matter* acts like a glue which helps to prevent soil particles from being detached. Rows of trees known as windbreaks can drastically reduce wind speeds and further prevent wind erosion.

Erosional: a term for landforms which got their shapes by being carved away by erosion.

Floodplain: a relatively new alluvial landform which lies along the channel of a stream, river, or arroyo.

Frost action: the process by which freeze/thaw dynamics move soils. When water freezes, it expands. When water fills a pore and then freezes, it exerts pressure on all sides of the pore. Over time, ice can ratchet particles or *aggregates* apart. This can be problematic, such as when the expansion of a soil causes a road or foundation to crack. It can also be beneficial, as when frost action breaks up a *compacted* layer, thereby reducing *bulk density* and increasing *porosity*.

Fungi: a class of soil organisms that have cellular nuclei and do cannot move like animals. Fungi often grow in long filaments known as hyphae, which are damaged by *tillage*. Many fungal species are capable of breaking down complex chemicals like lignin, an important component of wood. Fungi tend to be dominant in low-pH soils. *Mycorrhizal fungi* help plants in a number of ways.

Horizon: a layer in a soil profile which is different in one or more ways from another layer in the same profile.

Humus: highly-decomposed organic matter. Humus plays a very important role in providing nutrients and moisture to plants. It acts like a sponge, and can hold many times its weight in water. It also improves soil structure and slows rates of erosion. Humus is what gives A-horizons their dark colors. Humus decomposes very slowly, but it also usually takes a long time to accumulate.

Hydric Soils: soils which are saturated long enough during typical years to become *anaerobic* near the surface. These soils have special characteristics, and require special management practices.

Hyphae: filaments of connected fungal cells.

Infiltration: the process by which water flows through the surface of the soil. Infiltration is faster in sandy soils, and in soils with good structure. Soils without adequate cover by plants and litter are exposed to the direct impact of raindrops. Raindrops detach soil particles which, in turn, end up clogging soil pores, thereby slowing infiltration rates. Soils with slow infiltration rates experience *runoff* and *erosion* during rain events. Soils with fast infiltration rates collect rainwater and deliver it very gradually to streams and rivers, thereby preventing flooding and drought. Once a soil is saturated (all of its large pores are filled with water), infiltration cannot go faster than *percolation*.

Leaching: the process by which *percolating* water removes soluble substances from the soil. Whenever water enters the soil, it dissolves certain compounds. As it percolates through the soil, it carries these compounds with it. If a soil receives enough moisture, soluble compounds can be leached below the root zone. Examples of easily-leached compounds are NaCl (sodium chloride) and $CaCO_3$ (calcium carbonate). In wetter climates like the East Coast, older soils are highly leached, and lack these more soluble compounds. In many of the soils of the arid Southwest, rainfall has only been able to leach salts for short distances, so we find concentrations of these compounds in lower soil horizons. Refer to Section 3 of From the Surface Down for more information on these processes.

Map Unit: a concept for a particular land type in a soil survey. A map unit is composed of one or more *components*. Map units are depicted on soil maps using *map unit symbols*. Each map unit has a name which contains the names of its major *components* and the slope range. An example of a map unit name would be **Mirada-Bosquecito complex, 0 to 2 percent slopes**. If there is only one major component, the surface texture of this component is noted: **Altazano loamy sand, 0 to 2 percent slopes**.

Map Unit Symbol: combination of characters that is used to denote a particular *map unit* on a soil map. Examples of map unit symbols are 523 and Cb.

Mesa: a flat-topped erosional landform, capped by an erosion-resistant layer. Mesas often have steep side-slopes.

Mineralization: the process by which nutrients are converted from large organic molecules to small inorganic molecules during digestion. These smaller inorganic molecules are available to plants. An example of mineralization is the conversion of proteins (which are too large to be absorbed into plant roots) to ammonium (which roots can readily absorb).

Mycorrhizal Fungi (or mycorrhizae): a group of fungi that form symbiotic relationships with plants. These fungi invade plant roots and extend out like a vast network of fungal roots. Because fungal *hyphae* are much smaller in diameter than plant roots, they can access spaces in soil that plants cannot. Mycorrhizae play key roles in providing water and nutrients to plants, and also protect roots from parasites and diseases. In exchange, the fungi get sugars from plants. Because Mycorrhizal fungi rely on plants, they are often lost when fields are kept fallow. Like other fungi, mycorrhizae can be harmed by *tillage*.

Nematodes: a group of tiny, simple worms. Nematodes feed on nearly every class of organism in the soil, but different nematode species have different dietary needs. Nematodes can be beneficial, harmful, or even parasitic to plants. Like *protozoa*, nematodes play key roles in mineralization.

Nitrogen fixation: Our atmosphere is 78% elemental nitrogen (N_2), but plants cannot use N in this form. The process by which elemental nitrogen from the atmosphere (N_2) is converted to other forms which plants can use is called nitrogen fixation. In *biological nitrogen fixation*, certain bacteria convert N_2 to NH_3 (ammonia) and NH_4^+ (ammonium). When ammonium is released by these microbes, it becomes available for plants. Many plants, such as legumes, form symbiotic relationships with nitrogen-fixing bacteria: bacteria live in nodules in the roots and get food and shelter in exchange for NH_4^+. Nitrogen is also fixed by free-living bacteria, by lightning, and by certain industrial processes.

Nutrient Cycling: the process by which nutrients are transferred between different organisms. These exchanges of nutrients between plants, soil organisms, and the surfaces of soil particles keep nutrients from being lost into the atmosphere or *leaching* out of the rooting zone. Nutrient cycling is a function of the *soil food web*.

Organic Soil: a soil which is composed mostly of organic matter, rather than mineral materials. These soils mostly occur in very wet environments like bogs and swamps, where *anaerobic* conditions slow the breakdown of accumulating organic matter.

Orographic effect: The phenomenon where an airmass cools as it is pushed over mountains, thereby increasing its relative humidity. This explains why our mountains get so much more precipitation. See adiabatic lapse rate.

Parent Material: the material which a soil develops out of. Examples of mineral parent materials are *alluvium*, *residuum*, *eolian deposits*, and *colluvium*. Organic matter is another important parent material. Most soils have more than one parent material. For example, many soils of the Eastern New Mexico Plains formed out of *eolian deposits* on top of *residuum*, and have received organic matter inputs from dying roots.

Particle size analysis: the process of estimating the percentages of different particle size classes in a soil sample (e.g. 35% sand, 41% silt, 24% clay). Particle size analyses can be performed using hydrometers, pipettes, sieves, or a combination of these.

Percolation: the process by which water travels downwards through soil pores because of gravitational forces. Percolation follows *infiltration*. Percolation is essential for *leaching*, and for recharging streams and aquifers. Once a soil is saturated, percolation is controlled by a soil's *saturated hydraulic conductivity*.

Plasticity: a measure of how well a wet soil sample holds together when deformed. Soils with high clay tend to be more plastic. In fact, plasticity is a property which we use to estimate clay when hand-texturing. Push a wet soil sample between your thumb and forefinger into a thick ribbon. The longer the ribbon gets before breaking, the higher the plasticity. Organic matter reduces the plasticity of clayey soils.

pH: in general terms, pH refers to a solution's relative acidity or alkalinity. Solutions with low pH contain ions, while solutions with high pH contain more OH^- ions. The pH of the soil solution profoundly influences nutrient availability. The composition of a soil solution is controlled by the chemistry of soil particles, as there is a constant exchange of ions between these two *phases* of matter.

Phase: soils are composed of three phases of matter: solid, liquid, and gas. That's right, the air and water in soil pores are considered to be parts of the soil.

Phosphorus Fixation: a complicated chemical process in which phosphate ions form strong chemical bonds with clay particles in the soil. This has the effect of making P much less available to plants. P-fixation is common in older soils in warmer, wetter climates. Although P-fixation is not a major issue in the Southwest, P-availability is often low here because of high pH (see *Carbonates*).

Plow Pan: a compacted layer, usually a foot or two below the soil surface, which is caused by plowing or tillage. This layer can inhibit percolation, gas-exchange, and root-growth. For these reasons, soils with plow pans are often less productive and more susceptible to *erosion* than soils without plow pans. See *compaction*.

Porosity: the amount of space between solid soil particles, which is filled by liquids and gases. Soils with lots of large, continuous pores allow water to *infiltrate* rapidly, and can "breathe" efficiently (see *aerobic*). Thus, such soils are typically *aerobic*, and resist water *erosion*. These large pores are often the result of good soil *structure*. As a soil is *compacted*, solid particles are forced closer together, and pores collapse. *Compacted* soils have higher *bulk density* and lower porosity than non-compacted soils.

Precipitation: This is a tricky one because has two meanings that are important to soil science. It can refer to the

Protozoa: a group of single-celled organisms that have cellular nuclei and can move through the soil. These organisms feed on bacteria and other soil organisms, and are essential in the *mineralization* of nutrients.

Reaction: in soil science terminology, this is a fancy term for soil *pH*.

Reducing conditions: When soils become *anaerobic* due to saturation and/or *compaction*, *aerobic* metabolism is no longer possible. *Anaerobic* processes take over. These processes lead to the *reduction* of chemicals in the soil.

Reduction: in chemical terms, reduction refers to a chemical reaction which transfers electrons to an ion or compound. Examples of reduction in soils are the conversion of Fe_3^+ to Fe_2^+, the conversion of NO_3^- to NO_2, and the conversion of organic molecules to methane (CH_4).

Relative humidity: The ratio of an air mass's water vapor concentration to its total potential water vapor concentration. Since a warmer air mass can hold more water vapor than a cooler air mass, relative humidity increases as a given air mass cools. See orographic effect.

Removal: the soil-forming process by which substances are removed from a soil profile.

Residuum: *parent material* which *weathered* in place from bedrock. In the Southwest, residual soils are often shallow or moderately deep to bedrock, and one can often see the structure of the parent material in lower horizons. See *weathering*.

Respiration: the *aerobic* breakdown of organic compounds. This process converts these compounds and O_2 to CO_2 and H_2O. Humans metabolize foods through respiration under most conditions.

Rhizosphere: the portion of the soil directly around roots. This area is very rich in soil organisms.

Rock Fragments: in soil science terms, rock fragments are mineral particles that are larger than 2 mm across. There are several sizes of rock fragments. Refer to page 16 of From the Surface Down and section 2-45 of the Field Book for Describing and Sampling Soils.

Salinity: the amount of highly-soluble salts in a soil horizon. High salinity makes it very hard for most plants to absorb water and many nutrients. Salinity is a problem in many Southwestern soils. It often results from improper irrigation practices, and can be remedied by applying enough extra irrigation water to *leach* salts below the rooting zone. *Electrical conductivity* is a common measure of salinity.

Saprophytic microbes (saprophytes): a class of organisms which feed on dead tissue (detritus). This term is reserved for microorganisms, as opposed to detrivore, which is usually reserved for larger organisms.

Saturated Hydraulic Conductivity (K_{sat}): the rate at which water will *percolate* through a saturated soil. In general, K_{sat} is higher in soils with lower clay, higher organic matter, higher porosity, and lower bulk density.

Series: a soil type that is defined by its range of characteristics. Soil series are usually given names of local places. An example is the Latierra series, which was named after Camino La Tierra in Santa Fe. This series forms in *alluvium* which washed out of the Sangre De Cristo Mountains long ago. Latierra has a surface *texture* of gravelly coarse sandy loam, has subsurface *horizons* with visible *carbonates*, and has an average soil temperature of 49° F.

Slope gradient: a fancy term for the steepness of a slope. Slope gradient is usually measured in percent or in degrees.

Soil Food Web: a complex system in which energy moves from one type of organism to another to another. In this process, organic matter is decomposed and nutrients are released and made available to plants. Organic matter fuels the soil food web. See *nutrient cycling* and *mineralization*.

Soil Solution: the liquid in soil. Water in soil pores is constantly exchanging ions and small molecules with soil particles. Soil solutions are extremely variable in their composition, depending on soil properties. See *cation exchange capacity*.

Stream Terrace: an alluvial landform deposited by a stream, river, or arroyo, which is older and more rarely-flooded than a floodplain.

Structure: the way in which soil particles are attached together into structural units known as aggregates or peds. These aggregates are formed by a number of processes, such as: the shrinking and swelling of clays as they wet and dry, the movement of soils by expanding and contracting ice lenses, and by the action of roots and soil organisms. Well-developed aggregates have spaces between them which allow water and gases to move quickly through the soil (see *infiltration*). A healthy soil community promotes good structure. You can learn to characterize a soil's structure in the field by referring to section 2-53 of the Field Book for Describing and Sampling Soils, and to the Soil Characterization guide on our website.

Texture: refers to the relative amounts of sand, silt and clay in a soil sample. A soil's texture affects nearly every aspect of its behavior. You will see references to texture in nearly all of the guides posted on our Soils page.

Tillage: mixing of soil, usually by heavy machinery. Tillage can have short-term benefits for crops, but can also harm soils in a number of ways.

Tillage pan: see *plow pan*

Tilth: the ease with which a soil can be tilled. Soils with good tilth are easy to dig in, and allow plant roots to grow quickly. Generally, soils that are lower in clay and higher in organic matter have better tilth.

Transformation: the soil-forming process by which substances in a soil change in their chemical composition. An example is the decomposition of plant tissues to humus.

Translocation: the soil-forming process by which substances move within a soil profile.

Weathering: the process by which parent materials are chemically and physically decomposed. Physical weathering processes break large particles into smaller ones; examples are the cracking of rocks by expanding ice and the chewing of leaves by arthropods. Chemical weathering involves chemical reactions which change compounds at the molecular level; examples are the dissolution of rocks, the conversion of fresh organic matter to *humus*, and the conversion of one clay mineral to another clay mineral.