Soils – A Few Basic Notes

What are soils?

The 'ideal' soil consists of 3 main components – the mineral part, the organic part, and pore space. The usual ratio given for the 'ideal' soil is 50% mineral component, 5% organic component, and 45% pore space. Depending upon environmental factors (e.g. are we talking right after a rainstorm?), the pore space may be nearly all water or all air – although, almost always, some mixture of both is better.

What about the mineral component?

Speaking in broad terms, almost all soils start as bedrock. This bedrock then gets weathered – broken down. How it gets broken down is a whole story in itself. The original rock then ends up as being one of 3 types of mineral components, based on particle size – sand, silt and clay. Any piece of rock larger than a grain of sand (for example, a pebble) is considered too big to be a part of soil. Sands are the largest particles – one description of sand is that it settles out within the first 45 minutes after you shake up a mixture of soil and water and then let it sit. Silts will settle out over the course of up to the next two days. Clay particles may settle out with the silts or they may never settle out. Fine silts can be very fine but they are not as small as most clays. Clay particles can be very small.

But that is not the big difference between silts and clays. Clays tend to be chemically interactive in ways that sands and silts are not. More on this later.

What is soil texture?

Soil texture is a way to classify soils based on its mineral components – basically, what percentage of the soil is sand, what is silt and what is clay. A balanced mixture of the three is called a loam. Loams are often considered to be the preferred soils, although, for individual species of trees, that may not be the case. Individual soils are often labeled based on how they compare to a loam. For example, a soil might be considered a sandy loam or a silty loam. Texture is often brought up in connection with drainage. Sands will drain much more rapidly than silts, and silts much more rapidly than clays. Of course, underlying conditions – e.g., a hardpan, slope, shallow bedrock – will also influence drainage.

OK – what is this about mineral chemistry?

Big lumps of solid rock of a specific type are often called minerals. In terms of plant nutrition, however, we are not talking about these big lumps of rock but the individual chemical components that these rocks can get broken down into – especially, those components that can then become dissolved in water. These individual chemical components include those chemicals that we call the mineral nutrients that plants, including trees, need. Examples of such nutrients are phosphorous, potassium and calcium.

A quick chemistry lesson – a lot of what happens in soils happens because a lot of chemicals occur in the form of salts. The salt we know best is table salt – sodium chloride. Being a salt means that the chemical consists of two electrically charged ions – a negatively charged anion and a positively charged cation. Opposites attract, and so a chemical like table salt, when dry, forms together into a solid crystal.

However, when mixed into water, the two ions separate – the cations and the anions get some space from each other. When this happens, the salt is said to go into solution (side note – a chemical does not have to be a salt to go into solution – sugar is a good example). Many of the chemical nutrients that plant needs are cations when in solution – such as the three mentioned earlier. Their being in solution is important to keep note of, as that is how the plants are able to take them up. They are drawn in with the water from soil and move with the water through the plant. These nutrients get carried to where they are needed. For instance, a complex molecule such as chlorophyll includes both nitrogen and magnesium. The tree has to get these nutrients to the leaves and other places where chlorophyll is made.

Back to the soil – both clays and humates (a part of the organic component or humus in the soil) are covered in negative electrical charges (think of a balloon charged with static electricity). This means cations, such as most of the nutrients we are talking about, are attracted to and held by these particles. Plants, however, are able to draw these nutrient cations away from these clays and humates and draw them into their roots. Until the roots take them up, though, it is important that the clays and the humates be able to hold onto these nutrient cations, so that these nutrients don't just get flushed out of the soil. Clays and humates are storage sites. The ability to hold onto cations is one of the features that differentiates a fertile soil from an infertile one. (To learn more about this, look up Cation Exchange Capacity or CEC).

What about the organic components in the soil?

We mentioned that a good soil will be about 5% organic material. This organic material comes from several sources – decaying leaves and wood, dead animals, what soil living animals process through their bodies and exudates from tree roots (the cakes and cookies mentioned by Mike). One end product of the decay process are the humates I just mentioned. In addition, as leaves and other organic materials break down, they release the nutrients they contain back into the soil.

Does the pore space in the soil make a difference?

Pore space in soils is critical. For one thing, if the soil particles are packed too tightly together, there is no place for the roots to grow. Also, the pore space holds water in storage for the tree roots to use and allows for gas exchange to occur. The tree roots along with all of the other soil organisms need to breathe oxygen and get rid of carbon dioxide. If there is not adequate pore space, this gas exchange cannot occur and the roots will suffocate. This can turn the soil sour (anaerobic). The same sort of thing can happen if the soil stays wet for too long. This can also suffocate roots.

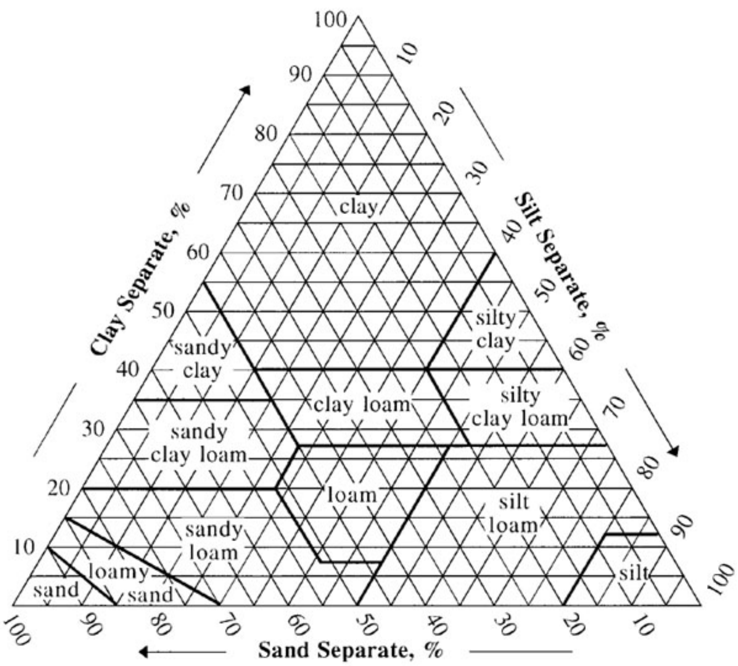
Where do the soils of Connecticut come from?

The glaciers from the last Ice Age are a big factor as to the kind of soils we have in Connecticut. The glaciers carried big jumbles of rocks and soil with them as they moved over Connecticut – and then deposited them when they melted and retreated. That means many of our soils were formed from a mix of transported pieces of bedrock. The way they were deposited is also is a big factor in the make-up of the soils – the internal layering of the soil.

Two main types of soil types we see a lot of in Connecticut are glacial till and stratified drifts. Till soils are soils that are basically all mixed up – the way a plow mixes up a soil in the process of tilling it. In glacial till soils, rocks of all different sizes are likely to be mixed in with a variety of soil particles. Stratified drift soils are usually the result of the way the melting waters of the glacier separated out the various particle sizes. You can see this as you dig through the soil. For instance, you might find a sandy layer on top of a layer rocks of roughly similar sizes, on top of a layer of finer sand.

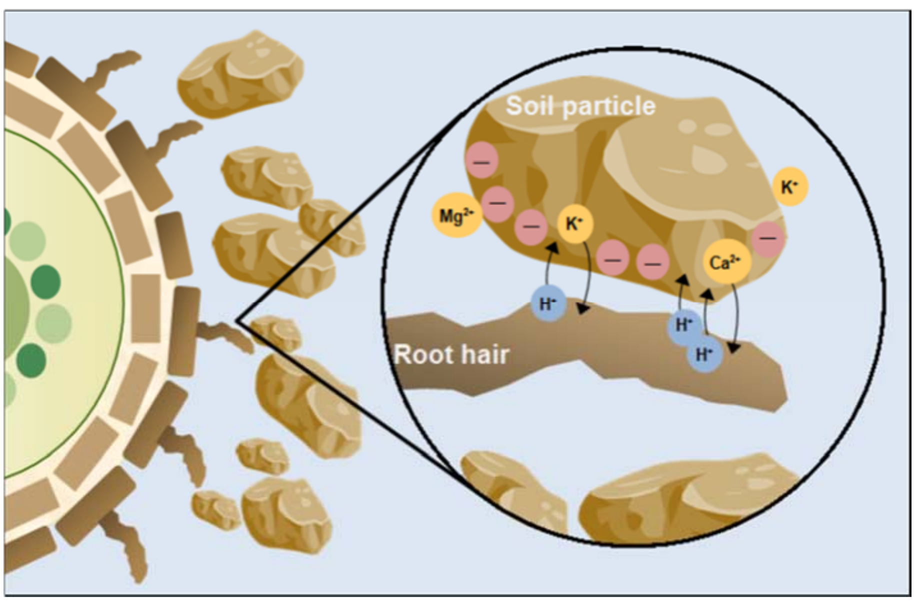
Events after the glacier also affect soils. Perhaps a soil has formed in what was once the beach of an old lake or the riverside deposit of an old, long gone river. This will all affect the soil composition.

The Soil Triangle



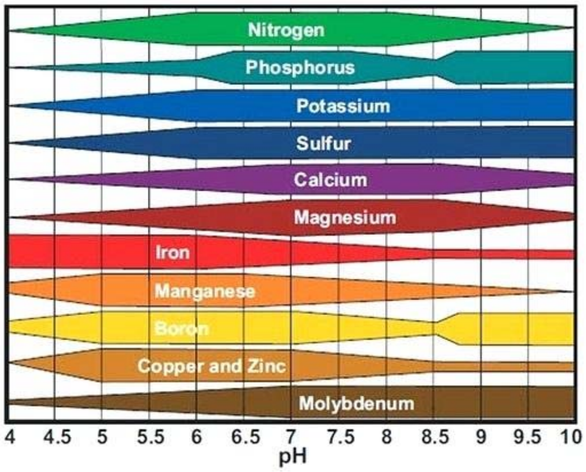
This shows where certain common types of soils, based on composition, lie on the chart. These terms relate to what is known as soil texture.

Cation Exchange



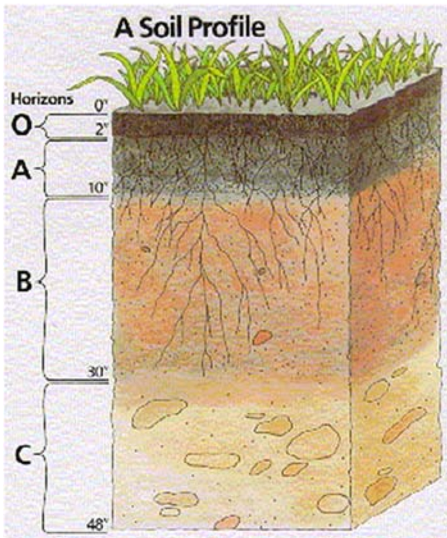
The soil particle (it could be either a clay particle or a piece of humus) is covered with negative charges – that is the chemical nature of the particle. These negative charges are holding the cations (here, the Mg+, the Ca+ and the K+) in place. The root hair then gives off H+ ions (hydrogen cations). These H+ are also attracted to the negative charges on the soil particle and can replace the mineral cations. The root hair can then absorb the released Magnesium (Mg+), Calcium (Ca+) and Potassium (K+) cations.

Nutrient Availability and pH



pH – how acid or alkaline a soil is, is also an important consideration with regards to soils. A low pH is more acid; a high pH is more alkaline, or basic. Soils in Connecticut tends towards being slightly acidic, except in the northeast corner, where the limestone bedrock tends to make them more basic. This is important, in part because certain nutrients become more or less available depending upon the pH of the soil. For example, iron is relatively less available at a higher pH. In these soils, trees such as pin oaks can show 'iron chlorosis' – a yellowing of the leaves due to lack of iron.

Soil Profiles



Soil scientists love to talk about the soil profile. The classic soil profile consists of 4 layers, called horizons. The top layer is the 'O' horizon, or the organic layer. This is all of those leaves, sticks, and other pieces of organic detritus that accumulate on the surface. It does not have a mineral component. Mulch around a tree is an effort to mimic the 'O' layer. The 'A' horizon is the top layer of the mineral soil. This is the layer where you would like to have that 50% mineral /5% organic /45% pore space composition. It is also where most of the roots will be. The 'B' horizon will have some roots as certain minerals will tend to be found in heavier concentrations here. In times of drought, there may be more water here than higher up in the profile. The 'C' horizon as shown here is mostly weathering bedrock and larger soil particles. This layer tends not to be as biological active. Not all soils are necessarily like this. The soil depths shown in this chart are just examples – actually thickness of layers will vary for many reasons.

A Description of a Soils Series – From an Actual Soil Survey

The Windsor series consists of very deep, excessively drained, rapidly permeable soils formed in glacial meltwater sediments. Some areas formed in sand dunes swept by winds from the Connecticut River Valley as ancient glacial Lake Hitchcock receded. The largest landscapes of Windsor soils are in the northern Connecticut River Valley, but the soils are mapped throughout the state. Slopes range from 0 to 15 percent. Windsor soils overlay sand and gravel groundwater aquifers. Droughtiness is the main limitation for crops, lawns, and landscaping. During dry months, irrigation is necessary for optimal production. There is a hazard of ground water pollution due to the rapid permeability of these soils.