BASIC SOIL CONCEPTS
FOR NURSERY AND LANDSCAPE MANAGEMENT

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What is Soil?

There are many answers to this question. Soil is a mixture of mineral grains, air, water, organic matter, and living organisms. It can be thought of as a living medium. A healthy soil will be teaming with life. Soil may be the least understood yet most important component of any horticultural system. It provides the interface between living plant and animal communities at the earth's surface and largely inert geologic substrates below.

Functions of Soil

Perhaps the most important functions of soils are to supply water and nutrients to plant roots. As we will learn in this chapter, different types of soil have very different capacities in this regard. Soils also act to physically support and anchor root systems. They provide a home to countless animals including millions of microorganisms. Soils provide air to roots. When it rains, soils act like a sponge, taking in water which would otherwise run over the ground in floods, and then supply water to plants between rain and irrigation events. Finally, microorganisms within the soil break down waste products and other environmental contaminants converting many of them to plant nutrients. In all these functions, soil potential varies substantially from one location to another across the land.

Soil Formation

The wide range of soils that exist in Montana and Idaho have formed over *time* in response to differences in *geologic parent material, climate, topography* (the shape of the land), and *vegetation/biota*. These five factors are called the soil forming factors (Fig. 1-1). Each plays a distinct role influencing specific soil properties. Given the wide range of parent material types, local climates, landforms, and plant communities found in Montana and Idaho, it's no wonder we have such a diverse range of soil types across this region.

How long does it take for a soil to form? This depends in part on how you define soil. Soil organic matter begins to accumulate at the soil surface as soon as vegetation colonizes fresh sediment that may have been deposited by a river or blown in on the wind. In some sense, a soil has formed. Soils as old as tens of thousand years, formed in locations of the most recent widespread glaciation in north America can be considered young compared to the highly weathered soils of the south that have experienced hundreds of millions of years of weathering .

Soils in Horticulture

Soils are important to the horticulturist for a number of reasons. The first relates to matching plant requirements to site conditions. Why does one species planted at a site thrive while another barely survives? Did we fail to consider microclimate in our plant selection? Was our planting technique flawed? Maybe we failed to water enough after planting? Or perhaps, we failed to consider the soil requirements to which the second species is adapted. Soil factors such as texture, drainage, pH, depth, salinity, calcium carbonate, soil organic matter, and the amount of rock fragments all play a role in influencing the adaptability of selected horticultural species to a site.

Horticulturists often have to manage soils through irrigation, fertilization, or even bringing in new soil, in order to obtain desired plant performance. Understanding soils becomes an essential part of this management whether you are working in an established landscape or installing a new landscape. For example, water management is often a prime concern. The timing of watering, how much water to add, and the depth to which water is being applied all depend upon properties of the soil. The effective design of irrigation systems cannot be accomplished without knowledge of soil properties as well as characteristics of plants. The effective use of fertilizers, other amendments like gypsum, and some herbicides, depends on knowledge of soils.

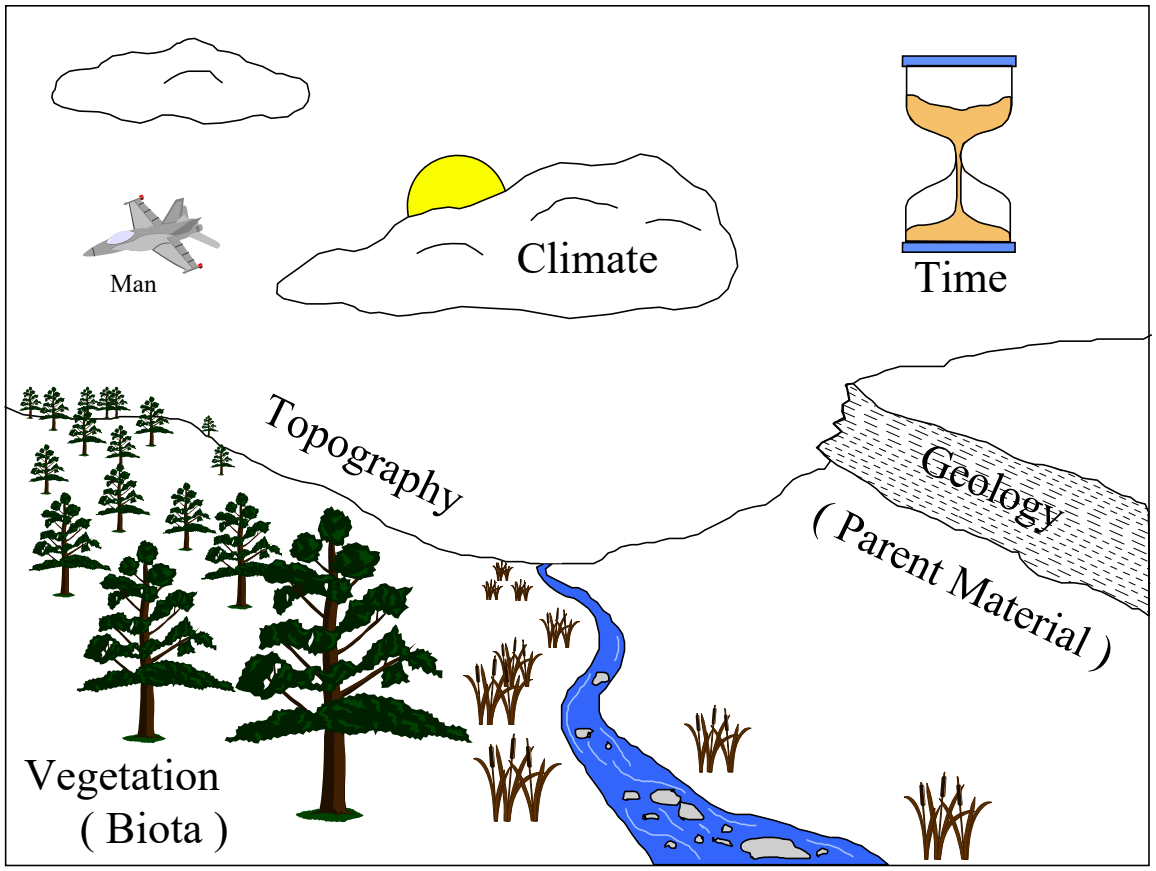

Figure 1-1. Schematic diagram of the five soil forming factors: parent material, climate, living organisms including man, topography, and time.

Particle Sizes

Soils are primarily composed of mineral grains, tiny pieces of rock that are packed together to form the soil matrix. All mineral grains less than 2 mm in diameter are considered fine-earth. Particles larger than 2 mm are rock fragments.

The fine-earth portion of soil can be further divided into clay, silt, and sand sized particles. Clay particles are those less than 0.002 mm in diameter, Silt particles are between 0.002 and 0.05 mm in size, and sand particles are between 0.05 and 2.0 mm. Figure 1-2 shows the relative size of each, magnified approximately 30 times. Exact class breaks between the different particle sizes are of little concern to us here. The net effect different size classes have on soil behavior is of prime importance.

Coarse - Medium Sand 2.0-0.25 mm | **Fine Sand 0.25-0.05 mm** | **Silt 0.05-0.002 mm** | **Clay less than 0.002 mm**

Figure 1-2. Relative sizes of sand, silt, and clay particles (enlarged about 30 times).

Soil Texture

For most soils, if you could know only one thing about the soil, you would probably want to know its texture. Soil texture refers to the relative proportion (or percent) of sand, silt, and clay in the fine-earth (<2 mm) fraction of the soil. As a start, soils that are predominantly clay size particles are called clays. Soils that are primarily sand size particles are called sands and soils that are mainly silt size particles are called silts. A fairly even mixture of sand, silt, and clay sized particles is called a loam. In an ideal world, we would probably like all the soils we work with to be rich, fertile, loams.

Within the above framework, there are a number of subdivisions resulting in a total of 12 soil texture classes determined by the relative proportions of sand, silt, and clay. Each of these classes is displayed on the texture triangle (Fig. 1-3). To interpret the triangle, first note that along each edge there is a 0 to 100% scale. The axis on the left side of the triangle is percent clay from 0 in the lower left corner to 100% at the top. The scale for percent silt runs along the axis on the right side from 0 at the top to 100% silt in the lower right corner. The scale for percent sand starts at 0% in the lower right corner and increases to the left up to 100% sand in the lower left corner. Any point within this triangle represent a unique combination of percent sand, silt, and clay that totals 100%. Superimposed on the triangle are the twelve soil texture classes. Soil texture class can be read directly off the triangle once the location on the triangle is found for the percent sand, silt, and clay in the soil. For example: a soil with 20% clay, 25% sand, and 55% silt falls within the silt loam class.

It will help if you think of the soil texture names in terms of adjectives and nouns. The adjective precedes the noun and modifies it. Thus, a silt loam is a loam with a relatively high amount of silt. It has less silt size particles than a silt but more than a standard loam. A clay loam is a loam with a relatively high amount of clay size particles yet less than a true clay. The same holds true for a sandy loam, etc. Some classes have two adjectives, such as a sandy clay loam. A loamy sand is a sand with a small amount of clay or silt. Thus, the loamy sand is coarser (more sandy) since it is a sand than a sandy loam which is a loam, although the loamy sand is not quite as sandy as a pure sand. Often the term coarse is used to describe sandy soils by laypeople. Fine textured or heavy textured are terms used to describe clayey soils.

Why is Texture Important?

The ability of a soil to hold water and supply that water to plant roots depends directly on soil texture. The same can be said about a soil's ability to store and supply plant nutrients. Other properties related to soil texture include: water infiltration, soil erodibility, organic matter accumulation, soil porosity, root penetrability, and the populations of microbes in the soil (Table 1-1). All of the above affect the ability of plants to survive and flourish within a landscape. By knowing something about soil texture, we know a lot about overall conditions in the soil and how to manage it .

Soil Texture	Water Holding Capacity	Nutrient Holding Capacity	Water Infiltration Rate	Soil Drainage Rate
Sands	Low	Low	Very Rapid	Very Rapid
Sandy Loams	Moderate	Moderately Low	Rapid	Rapid
Loams or Silt Loams	High	Moderate	Moderate	Moderate
Clays or Clay Loams	High	High	Slow	Slow

Table 1-1. Selected soil properties by soil texture classes.

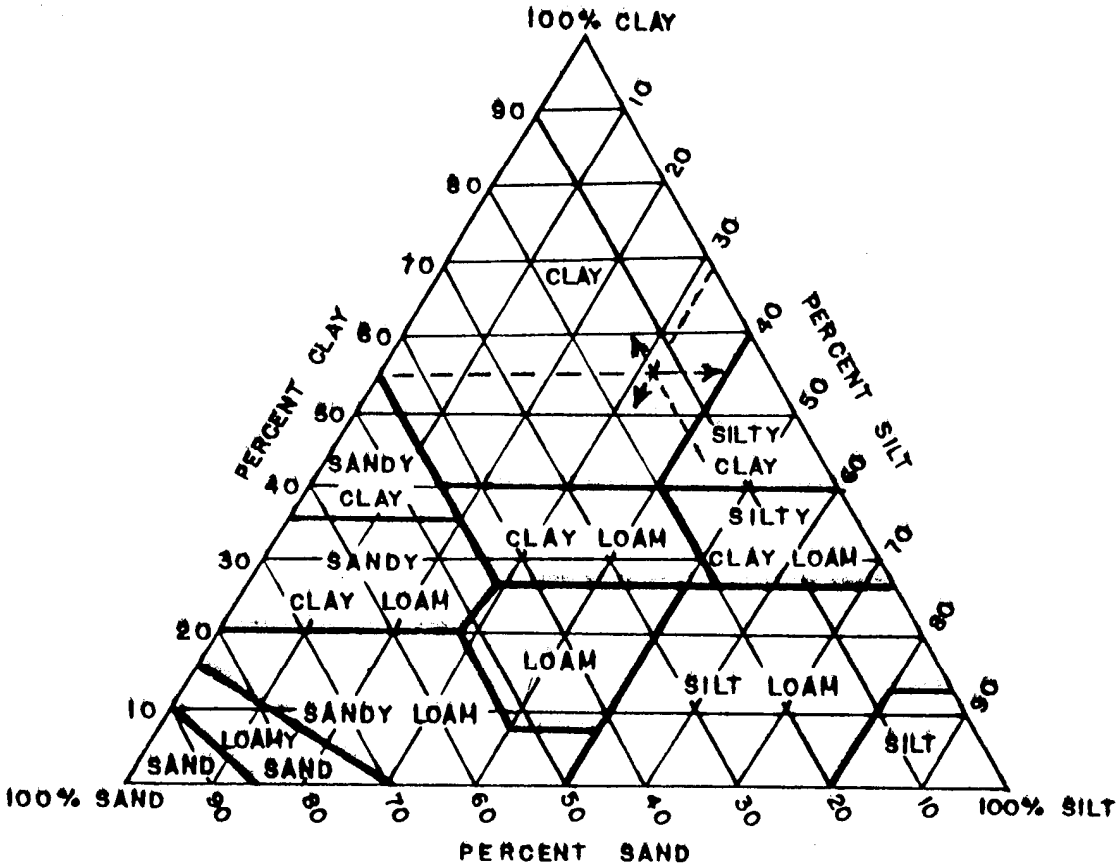

Figure 1-3. USDA soil texture triangle for determination of soil texture classes. Follow the diagonal lines on the triangle that correspond to the percent sand, percent silt, and percent clay of your sample to the point where they intersect. Texture class can then be read directly from the triangle.

Soil Texture Determination

Soil texture can most accurately be determined by submitting a sample to a soil testing lab. Lab analysis will determine the exact percentages of sand, silt, and clay in your sample. Often this approach is not feasible or needed in horticulture. Rough estimates of soil texture, appropriate for most situations, can be made by hand texturing, a skill best developed by guided practice. In general, if a small amount of soil is wetted in your hand, sand will feel gritty, silt will feel smooth, and clay will make the soil sticky.

Porosity - The Space Between Soil Particles

Soil pores or the spaces between mineral grains make up approximately one half the volume of most soils. The pores provide a reservoir of both water and oxygen for plant roots. For soil water, the larger pores or macropores function primarily to transmit water. Smaller micropores function primarily to store water. As the soil drains, after a rain or following irrigation, the larger pores drain first while water remains in smaller pores. The soil, in this manner, provides both water and oxygen to plant roots. Further drying requires that water be removed from smaller and smaller pores.

A direct relationship exists between grain size of the fine-earth fraction and the distribution of pore sizes in the soil. Sandy soils have a high proportion of large pores that readily transmit water but retain very little water for plant uptake. Clay soils contain mainly micropores which can store an abundance of water for plant uptake but transmit water very slowly. Thus, a clayey site may remain too wet for working long after a sandy soil has dried out. Loams provide a happy medium as they are capable of storing abundant soil moisture for plant uptake, yet water will be readily transmitted through the soil.

Table 1-2 provides some approximate guidelines for the amount of plant available water that can be stored in soils of different texture classes. Units are in inches of plant available water per inch of soil. These values can be readily converted to an equivalent depth of plant available water if multiplied by the soil or rooting zone depth. For example: You are working in a sandy loam soil that can store approximately 0.15 inches of plant available water per inch of soil depth. The plants you are putting in have an effective rooting depth of two feet. Approximately how much plant available water can this soil store within the desired rooting zone?

0.15 inches of water/inch of soil x 24 inches of soil = 3.6 inches of plant available water

This amount of water is important for several reasons. For plant species sensitive to water stress, it is wise not to let the plant deplete more than half of the plant available water, or 1.8 inches. During the height of the growing season, actively growing plants will use 1-2 inches of water per week, depending on the weather and the plant species. During cooler weather less than 1 inch of water per week. Thus, it is rarely necessary to irrigate more often than once per week, and irrigation amounts should be calculated so as not to exceed the available water holding capacity of the soil.

Table 1-2. Approximate plant available water holding capacities of soils in inches of water per inch of soil for various soil texture classes.

Texture Class	Est. Plant Available Water Holding Capacity
Sand	0.03 in./in.
Loamy sand	0.08 in./in.
Sandy loam	0.14 in./in.
Loam	0.20 in./in.
Silt loam	0.20 in./in.
Clay loam	0.22 in./in.
Clay	0.18 in./in.

* Adapted from 1984 USDA-NRCS technical guide of Plant Available Water Holding Capacities for Soil Textural Classes in Montana.

Rock Fragments and Bedrock

Rock fragments in the soil include all mineral grains larger than 2 mm in diameter up to largest boulders. In general, rock fragments can be thought of as diluting the volume of soil available to supply water or nutrients. Our water holding example above assumed there were no rock fragments in the top two feet of soil. The same soil with 50 percent rock fragments would have a proportionately lower plant available water holding capacity of 1.8 inches of water in the top two feet. Many of our native plants, especially trees and shrubs, are adapted to having relatively high amounts of rock fragments in the soil. Rock fragments may help keep the soil loose for root growth and provides anchors in the soil that help roots support the plant. Of course, a soil that is nearly all rock fragments severely limits planting options.

Shallow soils also limit the volume of soil available for water and nutrient storage, especially when the depth to bedrock or gravel is less than 20 inches. Planting recommendations in shallow soils will need to be adjusted accordingly, using shallow rooted species and/or species that are adapted to more droughty conditions than warranted by the local climate. Water and fertilizer application frequency and amounts need to be adjusted as well.

Soil Organic Matter

An important component of soils that we have not mentioned yet is soil organic matter. Soil organic matter naturally accumulates in surface layers of soils, especially under grassland vegetation or in forests with lush grass understories. How much organic matter depends largely on local conditions. In general, the colder and wetter conditions are, the greater the accumulation of soil organic matter under grassland vegetation. Soils in semiarid portions of Montana and Idaho may have only one to two percent soil organic matter in surface layers. Grasslands in moist, high elevation, mountain meadows can have as much as 10 percent soil organic matter in surface layers. Wetlands in some of our mountain valleys have organic soil surfaces that are primarily (50%+) composed of accumulated organic material. The varied climates and landforms throughout Montana and Idaho result in a wide range of soil organic matter levels. A range of 1 to 5 percent soil organic matter in surface layers probably covers the majority of horticultural settings in our region. In general, high soil organic matter levels result in dark soil surface colors. Many landscaping soils have organic matter added in the form of compost.

Benefits of Soil Organic Matter

Increasing the soil organic matter content is nearly always good for plant and soil health. High organic matter levels in surface soil layers promote granular structure where individual soil particles become attached together into "granular" aggregates. This granular structure enhances water infiltration, soil aeration, root penetration, and microbial populations in the soil. In a word, high organic matter levels promote good soil tilth. Soil organic matter can improve the water holding capacity and fertility of sandy soils as well as water infiltration and aeration in clayey soils. Organic matter also provides a slow release of nutrients for plant use.

A word or two of qualification needs to be added here with regard to soil organic matter. While organic matter can improve many properties of the soil, soil texture will still dictate a soil's inherent capability. You can improve some of the basic qualities of a soil with soil organic matter but a loamy sand with high amounts of soil organic matter is still a loamy sand. Similarly, a clay with plenty of soil organic matter is still a clay. Some plant species are better off growing in soils with low levels of soil organic matter. Potatoes, for example, are more prone to disease problems if grown in soils high in organic matter.

Litter, Mulch, and Soil Organic Matter

A distinction needs to be made between organic litter on the soil surface or even mixed in the soil and soil organic matter. Soil organic matter refers to resistant organic compounds that remain in the soil after initial organic substrates have been partially decomposed by micro-organisms. Maintaining healthy microbial populations in the soil is essential for the accumulation of soil organic matter. Mulching and increasing soil organic matter are really two different tools of soil management. Plant litter left at the soil surface will break down only slowly to soil organic matter especially if allowed to dry out.

Care should be taken when mixing organic substrates into a planting bed. If the material added is high in nitrogen, such as fresh grass clippings, there will be sufficient nitrogen available for both the needs of the microbial population that decomposes this material and the growing plants. If, however, the organic substrates added are low in nitrogen, such as wood chips or straw, then the nitrogen that is available will likely be taken up by micro-organisms responsible for the decomposition. This may create a nitrogen deficit for the plants. A secondary source of nitrogen should be added when low-nitrogen organic materials are incorporated into planting beds, so there will be sufficient nitrogen for microbes and plants. Most woody plants, trees and shrubs, are adapted to relatively low fertility levels in the soil. Potential problems due to tying up nitrogen with the addition of organic substrates will be less of a problem for these plants than for other plants with high nitrogen demands such as corn or bluegrass lawns.

Cation Exchange Capacity

Clay sized particles (clay minerals) and soil organic matter make up the chemically reactive portion of the soil. Each have a net negative charge associated with their surface that acts to attract and hold positively charged ions, called *cations*. Cation exchange capacity (CEC) refers to the soil's ability to hold these positively charged cations. Plant nutrients such as calcium (Ca^+), magnesium ($Mg2^+$), potassium (K^+), ammonium (NH_4^+) and many of the micronutrients are cations. Knowing the relative (high, medium, low) cation exchange capacity of a soil is important to horticulturists because it provides an index of the nutrient supplying ability of a soil. It also provides the basis for understanding why

certain chemicals such as negatively charged nitrates (NO_3^-) and certain herbicides that lack a surface charge can be readily leached through the soil and potentially contaminate the groundwater below while others are immobile in the soil.

Higher clay contents and higher soil organic matter levels translate into higher the cation exchange capacities in the soil. You can substitute "higher inherent fertility" for "higher cation exchange capacity" in the statement above. A sandy soil with little soil organic matter, will have very little capacity to hold positively charged nutrients. A clayey soil, especially if it contains a lot of soil organic matter, has a high capacity to hold positively charged nutrients.

The misuse of chemicals in horticulture can pose a serious threat to local water quality. Horticulturists need to understand how the chemicals they are using will react in the soil. The alternative might be to face serious liability issues. If the chemical you are applying is mobile in the soil, such as nitrate fertilizer, you might consider using several light applications rather than a single large application. This gives the plants a chance to use up the fertilizer before it can be leached beyond the root zone. A single large application might overwhelm the plants ability to use the nitrate fast enough. Coarse, sandy soils or areas of shallow groundwater accentuate the problem to where in critical areas alternative chemicals or approaches might be needed.

Soil pH

Soil pH measures the relative concentration of hydrogen (H^+) ions in the soil on a 1 to 14 negative log scale. A pH of 7.0 indicates neutral conditions where the concentrations of H^+ and OH^- ions are equal. Above a pH of 7.0 the concentration of OH^- ions increases and the concentration of H^+ ions decreases creating increasingly basic conditions. Since pH is a negative log scale, each one unit increase in pH indicates a 10-fold drop in hydrogen ion concentration. For example, the soil at a pH of 7.0 has 100 times the amount of H^+ present than one at pH of 9.0. Below a pH of 7.0 the opposite effect occurs. As pH drops, the concentration OH^- ions decreases, the concentration of H^+ ions increases, and the soil becomes increasingly acidic. A one unit drop in pH reflects a ten-fold increase in the H^+ ion concentration. The range of pH found in soils is approximately 4.0 to 8.5, with most plants thriving in soils of neutral to slightly acidic pH and doing fine in slightly basic soils common in Idaho and Montana.

Why is pH Important?

Various chemical reactions in the soil dictate the availability of plant nutrients. Chemical reactions also determine the rate at which waste products and contaminants are decomposed in the soil as well as their toxicity. Soil pH is perhaps the major factor mediating chemical reactions in the soil. Other factors, like soil moisture, oxygen concentrations, microbial populations, and temperature play important roles, but in many instances soil pH is the most important.

Plant nutrients phosphorus and iron become increasing unavailable to plants under alkaline conditions above a pH of about 7.5. The same is true for many micronutrients like zinc (Zn^{++}) and copper (Cu^{++}). Acidic conditions also limit the availability of phosphorus, and other nutrients such as calcium (Ca^{++}) and potassium (K^+) become limited while certain micronutrients become so available that they begin to have toxic effects. Soil pH in the range of about 6.0 to 7.5 is ideal for many horticultural plants. Given the wide range of soil pH in native plant communities, however, there are some species that are well adapted to acid or relatively high alkaline conditions in the soil. Species selection may be critical if you are working in an area where either acid or alkaline conditions prevail. Likewise, expensive manipulation of soil pH may be required to grow certain acid-loving plants like blueberries.

Measuring Soil pH

Many different soil pH field kits or field pH meters are available for sale at garden supply centers. Oftentimes, these methods can give questionable results. For the best results, have a sample of your soil tested at a soil testing laboratory. Be sure to follow the laboratory's instructions in collecting your sample(s).

Calcium Carbonate ($CaCO_3$)

Most soils in arid and semi-arid areas of Montana and Idaho have accumulations of calcium carbonate at relatively shallow depths (less that 2 feet) in the soil. These will often appear as a white chalky substance in the soil. When tested with diluted hydrochloric acid, or even household vinegar, the $CaCO_3$ will effervesce or bubble as CO_2 gas is given off. The depth to accumulated calcium carbonate in the soils will tend to be shallower in the driest regions and carbonates may even occur at the soil surface in some locations. Calcium carbonate, or secondary lime as these

accumulations are called, provides a very strong buffer to soil pH. Soil with accumulations of secondary lime or a strong effervescence will nearly always have a pH around 8.2. Since this pH will be highly buffered by the presence of $CaCO_3$, attempts to adjust the soil pH by standard methods will not be successful until the secondary lime has been decomposed, which is likely to be prohibitively expensive.

Adjusting Soil pH

Lime ($CaCO_3$) is commonly added to agricultural soils in the eastern United States to raise soil pH. If you have problems with acid soils, the same approach will work equally well here in Montana and Idaho. Our pH problems tend to be related more to soil pH that is too high. There are several amendments that can be added to soils to adjust soil pH downward. They may be of value in some instances provided the area to be treated is relatively small. Elemental sulfur or iron sulfate are two possibilities. Elemental sulfur reacts slowly in the soil and should be incorporated from 6 months to a year before planting. Iron sulfate acts more quickly and can lower the soil pH within 2 or 3 weeks if sufficient moisture is present and provided accumulated $CaCO_3$ is not present. Gypsum (calcium sulfate) is a neutral salt and will not alter soil pH, unless the soil is high in sodium (see details under sodic soils). Ammonium fertilizers have an acidifying effect and may be a good choice as a nitrogen fertilizer when soil pH is high. Elemental sulfur is by far the most effective product for reducing soil pH, but it does take some time to have an effect because it depends on microbial activity for the sulfur to be oxidized to sulfate.

The presence of secondary calcium carbonate in many of our soils, especially near the surface, complicates the issue of lowering soil pH. Any acidifying material added to these soils has to neutralize the $CaCO_3$ in the soil first before any substantial change is soil pH occurs. This requires substantially more amendment than for non-calcareous soils. In all but isolated instances, a much better approach would be to use plants adapted to local alkaline conditions so long as soil pH does not exceed about 8.2 to 8.4.

Soluble Salts and Soil Salinity

Selected soil properties are closely connected to climate. Soluble salts along with calcium carbonate are generally leached out of the soil in areas of Montana and Idaho that receive 20 inches or more of mean annual precipitation. Concentrations of soluble salts in soils remain low in these areas. Soil pH tends to be in the 5.5 to 7.0 range. In drier areas, calcium carbonate tends to remain in the soil causing the soil pH to fall more in the 7.0 to 8.5 range. Soluble salt concentrations may still be quite low. Under drier conditions yet, or restricted soil drainage, or saline parent materials, more soluble salts remain in the soil.

Standard table salt (NaCl) is one example of a soluble salt although many other types of soluble salts occur along with NaCl in saline soils. As total salt concentrations build up in the soil, it becomes increasingly difficult for plants to extract available water from the soils even though there may be plenty of waterpresent. This is due to the osmotic potential of the soluble salts that must be overcome by a plant before it can extract water from the soil. Soil salinity refers to the build-up of soluble salts in the soil and the difficulty plants have extracting that water.

Sodic Soils

Sodic soil conditions refers to the build-up of one particular type of salt in the soil; sodium. While related to other salinity problems, sodic soils present a unique challenge because the high sodium concentrations cause the soil at or near the surface to disperse all structure, resulting in sealing, crusting, and the restriction of the infiltration of water and air into the soil. The problem is not that plants have a hard time extracting water but that water cannot get into the soil. High pH's above 8.5 are most often associated with sodic conditions. In fact, soil pH above 8.5 should be considered diagnostic for potential sodic problems in the soil. Difficulties with sodic conditions and limited water infiltration primarily occur in fine textured, clayey soils but may occur in lighter textured soils as well.

Remediation

The first line of defense in dealing with moderate salinity or sodicity problems in the soil is to select adapted species for existing conditions. Gypsum ($CaSO_4$) can be incorporated into the surface of sodic soils. Calcium from the gypsum replaces sodium on the soil exchange sites, allowing the sodium to be leached away, improving the physical condition of the soil as well as lowering soil pH. Complete remediation of either sodic or saline soils requires the installation of a drainage system in the soil and flushing excess water (with or without gypsum) through the soil to leach salts below the root zone. Severe conditions may cause soils to be unsuited for horticultural use.

Soil Drainage

Soil drainage refers to the ability of water to leave the soil through internal drainage. Most soils are well drained. They store water for plant use but do not remain saturated for any appreciable period. Soils with restricted drainage generally have a groundwater table at shallow depths. Three classes of restricted soil drainage are as follows:

1. Very poorly drained: persistent high water table occurs within 12 inches of the soil surface.
2. Poorly drained: persistent high water table occurs 12 to 24 inches below the soil surface.
3. Somewhat poorly drained: persistent high water table occurs 24 to 42 inches below the soil surface.

Very poorly and poorly drained soils are most often associated with wetlands. Hopefully, there will be few instances where you will be landscaping in these areas. This may be the one case where soil texture has little significance. Plant species selections are limited to wetland species, especially on very poorly drained sites and draining wetland areas requires obtaining permits. Extreme care must be taken in using any type of fertilizers or herbicides due to the high likelihood of contaminating groundwater.

Somewhat poorly drained soils are restrictive for basements or septic systems but may offer excellent opportunities for landscaping due to the ready source of extra water in the soil. Certain horticultural plants will still be restricted by the shallow groundwater. There are many other species that can be used in these areas because of the extra water. Special care must still be taken to avoid contaminating groundwater with fertilizers or herbicides.

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Chapter Review

A. Name at least four functions the soil serves in landscapes.

1. _____ 2. _____

3. _____ 4. _____

B. Name five components that make up soil. 1. _____

2. _____ 3. _____

4. _____ 5. _____

C. Define soil texture? _____

D. Why is soil texture important?_____

_____

E. A soil has 30% clay, 40% sand, and 30% silt.

1. What texture class is it in? _____

F. Why is it important for horticulturists to understand significant differences between soils?

_____

_____

G. Soils form over time in response to differences in _____,

_____, _____, _____.

H. Describe the different roles of micropores and macropores in the soil with respect to water and oxygen.

_____

_____

I. List four benefits of soil organic matter in soils.

1. _____ 2. _____

3. _____ 4. _____

J. What is the difference between soil organic matter and surface litter? _____

_____

K. How is cation exchange capacity related the leaching of nutrients or horticultural chemicals in the soil?

_____

L. What role does soil pH play in nutrient availability? _____