MDEQ Water Resources Division

Soil Management to Encourage Vegetation Growth

Definition

Soil management involves all practices, treatments, and operations used to protect soil and enhance its performance to grow profitable crops and preserve environmental quality. This includes soil conservation, soil amendment, and optimal soil health. Proper soil management practices can reduce the amount of greenhouse gases released into the atmosphere, as well as reduce the amount of harmful substances contaminating water in runoff.

Description

Soil management is done to provide the best growing conditions for turf and other vegetation. It can include adding lime, fertilizer, topsoil, or other constituents to the existing soil, to address low fertility, abnormal moisture content, or inappropriate pH. Soil management also includes cultivation and drainage techniques. Base any soil amendments on the results of soil testing.

Pollutants Controlled and Impacts

Proper soil treatment applied in conjunction with proper vegetative establishment will help prevent erosion and promote the filtering of runoff water. Soil treatment reduces the potential of groundwater contamination by providing a better environment for vegetative growth. The use of proper soil management practices also reduces the amount of carbon dioxide and other greenhouse gases released into the atmosphere.

Treatment Mechanisms, Pollutant Removal, & Efficiency

Soil testing can determine what needs to be amended in the soil. From these results, fertilizers or other additives such as lime can be properly applied to improve nutrient availability or pH levels. The presence of natural organisms can also help remove unwanted nutrients or chemicals in the soil. If proper amendments are made based on the results of soil testing, fertility and growing conditions typically quickly improve.

Companion & Alternative Practices

This BMP is used in conjunction with all vegetative BMPs, such as Seeding, Sodding, and Lawn Maintenance, as well as Pesticide Management and Fertilizer Management. Regarding the establishment of a site, please also see Grading Management, Soil Piles, and Diversions.

Advantages & Disadvantages

Benefits of proper soil management include restored and maintained soil fertility, an increase in crop yield, positive economic impact, and reduced pollutants released into the atmosphere and water.

Location

These practices are applicable to all land uses where soils will be used for vegetative establishment, and can be applied to all types of soil. Soil management varies based on soil classification and the use of that soil.

General Characteristics

Naturally existing soils are divided into layers called horizons, which are depicted in Figure 1 below. These horizons might differ visibly in color, structure, texture, and thickness. They can also differ in less evident ways such as by chemical and mineral content, moisture, consistency, and pH. For the purposes of providing good soils for vegetation, only the top two soil layers are of concern.

The **'O' Horizon** is the organic layer located at the surface and is typically two inches thick. This layer contains detritus, leaf litter, and other material on the soil surface and is usually dark in color.

The **'A' Horizon** is topsoil, and is usually located two (2) to ten (10) inches below the ground surface. This layer is loose and crumbly, with varying amounts of organic matter. This is the most productive soil layer, and is often darker in color than lower layers. As water moves down through the topsoil, many soluble minerals and nutrients dissolve and are leached form the topsoil.

The **'B' Horizon** is the subsoil, and is normally located ten (10) to 30 inches below the ground surface. This layer is usually low in organic matter, and is therefore lighter in color. This soil is dense and contains an accumulation of minerals leached from the topsoil.

The **'C' Horizon** is the substratum, and is typically located below a depth of 30 inches, and can reach depths of up to 48 or 60 inches. This layer is lighter in color than the subsoil. It is made from non-weathered rock or minerals from which the soil formed (parent material). This layer usually changes very little over time.

Changes to the characteristics of the soil might be needed if the soil is not suitable for its intended use (e.g. if the soil is to support a building, its composition will be completely different than if its purpose is to grow grass). Therefore, first determine the intended use of the soil.

Since many land uses involve the establishment of grass and other vegetation, the remaining text of this BMP is devoted to soil amendments for improving vegetative growing conditions. Refer to the USDA soil texture classification triangle in Figure 2 to determine soil texture based on the percentage of clay, silt or sand. This chart helps clarify what soils such as "loam" and "clay loam" are comprised of.

Soil Testing

Base all soil additions on the results of soil testing. Below is a step-by-step procedure for collecting soil samples. The Michigan State University Soil and Plant Nutrient Lab (SPNL) can analyze the samples, and staff can offer suggestions on the appropriate amount of fertilizer and other additives that are needed. Soil testing kits are also available through their website. Please see *(The link provided was broken and has been removed)* for current fees and instructions.

Soil samples are generally collected and analyzed for nitrate-nitrogen, phosphorus, and pH. As discussed in the Lawn Maintenance and other BMPs mentioned above, nitrogen and phosphorus are two of the three primary nutrients which make up commercial fertilizers. Fertilizers put on the soil in excess of that which is needed by the plant can run off the soil into lakes, rivers, and streams, causing algae blooms, or it can leach through the soil and impair groundwater supplies.

Generally, take representative samples. This could mean only a few samples in the case of an average, one-acre yard, or a dozen or more samples in the case of a larger field. The more variety of soil textures in the area to be vegetated, the more samples that will be required. Individually analyze any turf areas that differ significantly in grass type, use, or growing conditions.

Remember that there are three primary types of soil textures are sands, silts and clays. Soil which is comprised of a mixture of sand, silt and clay is called loam. The soil texture classification triangle is depicted in Figure 2.

Testing Areas Less than One Acre in Size

1. With a spade or trowel, collect soil at a depth below any plant roots, about three (3) inches for turf, or about seven (7) inches for other plants. Place this in a clean bucket, plastic container or paper bag. Do not contaminate samples by mixing them in a metal container. Do not include roots, thatch, or any other plant material.

2. Take about 10 random samples from the lawn or garden area as needed to represent different textures of soils, and for the different ways the turf might differ—such as by grass type, use, or growing conditions. Add the soil to the bucket or container and mix thoroughly.

3. Air dry the sample by spreading the soil out in the bottom of the bucket/container, or, if a lot of soil is collected, spread out on paper. Do not use artificial heat (i.e., radiator, oven, microwave, hair dryer, etc.) to dry the samples.

4. When the soil is dry, mix it thoroughly. Then take out about one cup, and put it in a jar, or plastic bag provided by the soil kit mentioned above for testing.

5. Take the soil sample to the county Soil and Plant Nutrient Lab (SPNL) office or a private lab experienced in soil analysis. Be prepared to answer questions about the amount of fertilizer used in the past, the spreading/spraying technique used, and the type of grass, sod, or plants to which the fertilizer will be applied. Also indicate to the SPNL staff any problems which have been encountered on the lawn, such as thin spots, brown spots, etc.

6. The SPNL staff will analyze the soil sample and provide the results, along with a recommendation for the amount of fertilizer needed, the application rate, the optimal application time, and the frequency of applications. Tailoring fertilizer applications to only what is needed saves money and protects surface and ground waters.

7. It is recommended that homeowners test their soil once every three or four years, unless additional problems arise.

<u>Testing Areas Greater than One Acre in Size</u>

1. Get a copy of a soils map from the Natural Resource Conservation Service (NRCS) or the Soil and Plant Nutrient Lab to identify the number and types of soils on the property.

2. Collect soil samples to a depth of four (4) to five (5) inches and one-half inch thick using a spade, soil auger or soil sampling tube. Place the samples in a clean bucket.

3. Take samples as needed to represent each of the different soil types identified on the soil map. In the absence of a soil map, take random samples to attempt to capture each soil texture present. Add the soil samples to the bucket.

4. Follow steps 3 through 6 in the previous section above.

5. It is recommended that soil samples be collected annually from large turf areas.

The discussion below includes possible treatments which might be needed based on the results of soil testing. Customized fertilizer recommendations based on soil test results are available from Michigan State University's soil test web page.

Soil pH

Although most turf grass grown in Michigan will grow well under a wide range of soil pH conditions, the optimum pH range for turf grass is 5.0 to 7.5, depending on the turf species selected. Some acid-loving plants such as blueberries and rhododendrons prefer pHs between 4.0 and 7.0. Again, the type of plant to be grown in the soil will determine the pH requirements. Determine the pH with soil testing. Tables 1, 2, and 3 below lists some typical plants and their optimal growing pH ranges. For a more comprehensive list, see Midwest Laboratories (2015).

<u>Low pH</u>

Treat soils that are too acidic for the plant type with lime to raise the pH. This is particularly important because as the soil becomes more acidic, metals become more soluble. As metals become soluble they can be more easily transported to surface and ground waters. Mix lime into the soil to a depth of at least three (3) inches before seeding or sodding. Because it takes time for lime to raise the soil pH, apply it in the late summer or early fall.

Table 1. Desirable Soil pH Ranges for Field Crops and Forages

Plant Type	Soil pH Range
Alfalfa	6.5 – 7.5
Barley	6.0 – 7.0
Clover (Alsike)	6.0 – 7.5
Clover (Arrowleaf)	5.5 – 7.0
Clover (Crimson)	5.5 – 7.0
Clover (Red)	6.0 – 7.0
Clover (Sweet)	6.5 – 7.5
Clover (White)	6.0 – 7.0
Coastal Bermuda	5.5 – 7.0
Corn	6.0 – 7.0
Cotton	5.5 – 7.0
Fescue	6.0 – 7.5
Grass (Orchard)	6.0 – 7.0
Grass (Sudan)	5.5 – 6.5
Lespedeza	6.0 – 7.0
Millet	5.5 – 6.5
Milo	5.5 – 7.0
Oats	5.5 – 7.5
Peanuts	5.5 – 7.0
Rice	5.5 – 6.5
Rye	5.5 – 6.5
Sorghum	6.0 – 7.5
Soybeans	6.0 – 7.5
Sugarcane	5.5 – 7.0
Sunflower	6.0 – 7.5
Tobacco	5.5 – 7.5
Vetch (Hairy)	5.5 – 7.0
Velvet Beans	5.5 – 6.5
Wheat	6.0 – 7.0

Source: Midwest Laboratories, 2015.

<u>High pH</u>

Alkaline soil conditions can result in chlorosis, or yellowing, of trees and scrubs. pH levels higher than the optimum range (to 7.5) are not typical in Michigan, but where necessary, sulfur or sulfur compounds can be added to lower the pH to the optimum range. It is difficult to lower soil pH levels, and is often not economically feasible for large areas used for crop production. Drastically lowering pH even in small areas is challenging since it is difficult to apply sulfur or other acidifying substances at a high enough rate to lower the pH without damaging grass and plants. The amount of sulfur to apply will depend on soil texture, or the proportion of sand, silt, and clay. Once sulfur is applied, changes in pH levels will occur gradually over several months (A & L Great Lakes Laboratories, 2002)

Table 2. Desirable Soil pH Ranges for Vegetables

Plant Type	Soil pH Range
Asparagus	6.5 – 7.5
Beans (Field)	6.0 – 7.5
Beans (Kidney)	6.0 – 7.5
Beans (Snap)	6.0 – 7.5
Beets (Sugar)	5.5 – 6.5
Brussel Sprout	6.0 – 7.5
Cabbage	6.0 – 7.5
Cantaloupe	6.0 – 7.0
Carrot	6.0 – 7.5
Cauliflower	6.0 – 7.0
Celery	5.5 – 7.0
Collard	5.5 – 6.5
Corn (Sweet)	5.5 – 7.5
Cowpea	5.5 – 7.0
Cucumber	5.5 – 7.0
Eggplant	5.5 – 6.0
Endive	5.5 – 7.0
Kale	5.5 – 7.0
Lettuce	6.0 – 7.0
Mustard	5.5 – 6.5
Okra	6.0 – 6.5
Onion	5.5 – 7.0
Parsley	5.5 – 7.0
Parsnip	5.5 – 7.0
Pea	6.0 – 7.0
Pepper	5.5 – 7.0
Potato (Sweet)	5.5 – 6.0
Potato (White)	5.0 – 6.0
Pumpkin	5.5 – 7.5
Radish	6.0 – 7.0
Spinach	6.0 – 7.0
Squash	6.0 – 7.5
Tomato	6.0 – 7.0
Turnip	5.5 – 7.0

Source: Midwest Laboratories, 2015.

Droughty Soils

Droughty soils might be caused by a lack of irrigation, or because of a lack of organic material. Soils that are too sandy or silty are very porous and therefore can't hold water for long. Saline soils have a high salt content due to the buildup of soluble salts, and as a result dry out quickly. Determine the cause of the droughty condition, then adjust the irrigation schedule, or add organic matter such as loamy material, topsoil, or compost to increase the moisture holding capacity of the soil.

Table 3. Desirable Soil pH Ranges for Fruits and Nuts

Plant Type	Soil pH Range
Almond	6.0 – 7.0
Apple	5.5 – 7.0
Apricot	6.0 – 7.0
Blueberry	4.5 – 6.0
Cherry (Sour)	6.0 – 7.0
Cherry (Sweet)	6.0 – 7.5
Citrus	6.0 – 7.0
Grape	5.5 – 7.0
Peach	6.0 – 7.5
Pear	6.0 – 7.5
Pecan	6.0 – 8.0
Plum	6.0 – 7.0
Strawberry	5.0 – 6.5
Tung	5.0 – 6.0
Walnut	6.0 – 8.0
Watermelon	5.5 – 6.5

Source: Midwest Laboratories, 2015.

Saturated Soils

Soils that contain too much moisture for extended periods of time can be just as harmful for plant growth as droughty soils. Saturated soils mean there is less oxygen present for root respiration, which can cause the roots can die. The presence of a black layer of soil with a sulfuric odor indicates that soils might be saturated. Soil saturation can be cause by excessive irrigation for the type of soil; peaty soils and soils that contain high amounts of clay tend to hold more water than other soil types. Saturation can also be cause by a lack of proper drainage. Processes such as aerification—which is the mechanical process of creating air space in the soil—can help avoid saturation in soils (Thomas Turf Services, 2003).

Nutrients

Nutrients in a soil are in constant flux, with availability depending on soil conditions. Fertilizers sold commercially contain varying amount of the 16 mineral elements essential for turf growth and development, with nitrogen, phosphorus, and potassium being the three most common elements. Have soil samples analyzed to determine how much of each nutrient is available.

<u>Nitrogen</u>

Nitrogen is an essential element for plant growth. Because nitrogen makes grass "green," it is often used in excess of what the plant needs. Nitrogen which is not absorbed by vegetation can leach through the soil and into the groundwater. During this leaching process, nitrogen is converted into nitrate, which can contaminate drinking water supplies and cause health problems. The U.S. Environmental Protection Agency limits the acceptable level of nitrate in drinking water to 10 ppm (parts per million).

Nitrogen is often unavailable to turf roots because it leaches through the soil rapidly. Turf deficient in nitrogen might have poor color, decreased elasticity, and less ability to compete with weeds. Apply nitrogen based on any need identified through soil testing. Do not apply any more than one pound of actual nitrogen per 1,000 square feet during a single application (Frank et al., 2015).

Phosphorus

Phosphorus is important for root development, maturation, and seed production. This element is found chemically bound to oxygen; two particles of phosphorus are bonded to five oxygen particles ($P2O5$). Since this molecule is practically immobile in soil, few soils are deficient in phosphorus. Soils that are deficient show purpling of grass blades. Note that this symptom can be confused with the color change induced by cold weather.

Many Michigan soils have been historically over-applied with phosphorus. Since phosphorus binds readily with soil, excessive applications of phosphorus which are carried off in eroded soil can result in algae blooms and nuisance aquatic plant growth. This results in eutrophication, or an enrichment of a water body with excess nutrients causing overgrowth of plant life, and consequently a lack of oxygen in that body of water. This lack of oxygen can result in the death of other organisms living in the water.

Phosphorus fertilizer must be delivered directly to turf roots. This can be done by fertilizing after aeration or by liquid fertilizer injection. Be aware that the Michigan Fertilizer Act PA 299 of 2010 prohibits the use of fertilizer containing phosphorous for home, commercial, or municipal use, except in the following situations:

- A soil test conducted in the last three years that confirms phosphorous is needed;
- The fertilizer is needed for the establishment of a lawn; or
- The fertilizer is a finished sewage sludge product, or an organic or manipulated manure.

Apply all phosphorus amendments based on soil test results, and according to Michigan law for application rates (Gibb & Bhakta, 2012).

Potassium

Turf uses potassium in quantities second only to nitrogen. This element is important for rooting, and wear and climatic stress tolerance. While rarely visually evident, turf deficient in potassium has yellowing and dead blade tips. Potassium generally does not cause water quality problems, nor is it over-applied in the same manner as phosphorus and nitrogen. Apply potassium amendments based on soil test results.

Nutrient Deficiencies

If soils are nutrient-deficient, follow specifications in the Fertilizer Management BMP.

Micro-Nutrients

Micronutrients are elements used by plants in relatively small amounts. They include boron. copper, iron, manganese, molybdenum, and zinc. Typically, micronutrients required by turf are naturally present in Michigan soils in adequate amounts, but high soil pH can render these elements insoluble, making them unavailable to turf roots. Iron is an example of a micronutrient that is commonly deficient in alkaline soils, or soils with a pH greater than 7. Iron is required for chlorophyll production, and therefore the green coloring of plants. It is also important for root and shoot development and drought resistance. Iron-deficient turf usually has blotchy yellow patches. Severe iron deficiencies might result in white grass blades or the death of plants. Application of iron fertilizer will provide temporary green-up of turf. Since the deficiency is due to soil alkalinity, long-term treatment requires modifying the soil pH (Vitosh et al., 1994).

Soil Organisms

Living and decaying soil organisms contribute greatly to a soil's organic matter and fertility, and play an important role in nutrient cycling. As they burrow, organisms break down organic matter, making nutrients available for absorption by turf roots.

Earthworms are the best known of soil organisms, but a great number of microorganisms also occupy the soil. One teaspoon of soil can contain a billion bacteria, a million fungi, and several thousand algae. Most of these organisms improve soil conditions for plants.

Turf managers who appreciate the benefits of soil life are careful not to destroy it with unnecessary soil amendments. Again, make amendments to the soil based on the result of soil testing.

Managing Compacted Soils

Compacted and heavy clay soils contain less pore space, and therefore less air, and have a hard surface that drains poorly. Pore space is essential for a healthy plant environment because that space is needed for air and water movement though the soil, and for microorganisms to break down plant residue into organic matter. Root development and turf quality declines when soil is compacted.

Compaction is more likely to occur in heavy soils like clay and loam, but any type of soil can become compacted. Soils can become compacted from over-tilling, working up the soils when it is too wet, mixing sand rather than organic matter into clay soils to loosen soil, and from compression due to weight, such as with the use of heavy equipment or with heavy foot traffic (Voyle & Hudson, 2014).

Mechanical aerators help by creating holes in compacted and heavy soils. This practice increases the movement of air in the soil and improves drainage. Machines that remove cores from the soil are generally more efficient aerators than those that spike or slit the soil. Coring machines remove a quarter to one-inch diameter cores and deposit them on the surface of the turf.

When practical, break up deposited cores by dragging chain-link fence or similar material over them. Discard cores of poor quality soil. Holes will more rapidly be covered by turf if the area is top dressed, seeded and fertilizer is applied directly after aeration. Follow this with a light watering. Fall is the best time to aerate turf, when weed seed germination is at a minimum.

Site Preparation

Established Areas

1. Collect soil samples following the procedures discussed above.

2. Discuss the soil test results with the local NRCS office, or the MSU Soil and Plant Nutrient Lab staff, and buy the recommended amount of fertilizers, lime, or other needed amendments. Apply fertilizers following specifications in the Fertilizer Management BMP. Do not spread lime with a hydroseeder. It can be blown onto steep slopes in dry form. For the application of compost, see the Organic Debris Disposal BMP.

Typical Seeding or Sodding Operation as Part of Construction Projects

1. Collect soil samples following the procedures discussed above.

2. Discuss the soil test results with the local NRCS office, or the MSU Soil and Plant Nutrient Lab staff, and buy the recommended amount of fertilizers, lime, or other needed amendments.

3. In large areas, remove and store topsoil in storage piles according to specifications in the Spoil Piles BMP.

4. Where appropriate, grade following specifications in Grading Practices. Complete all cut and fill activities. Use Diversions to prevent soil erosion and sedimentation. Follow the site plan.

5. Grade the surface of the earth bed upon which the topsoil is placed for seedbed and sod bed preparation so that it's at the proper elevation.

6. Work lime, fertilizer and other additives into the topsoil, either before or during final seedbed preparation, or before sod is laid. Prior to any seeding or sodding, mix lime into the soil to a depth of at least three (3) inches. Do not spread lime with a hydroseeder. It can be blown onto steep slopes in dry form. For all seeding applications, follow specifications in the Seeding BMP.

   For all sodding applications, follow specifications in the Sodding BMP. For the application of compost, see the Organic Debris Disposal BMP.

7. Inoculate all legume seed in accordance with the manufacturer's recommendations.

Additional Considerations

Treating soils on-site is less expensive than importing soils from off-site. Existing soils are also usually compatible with the lower horizons.

Maintenance

Following establishment, irrigate turf sufficiently so that the soil remains moist without being excessively wet. Mow turf on a regular basis to reduce stress, and to minimize the amount of fertilizer required to sustain rapid growth. Avoid applying herbicides for four to six weeks after establishment as turf will be extremely sensitive. Keep all foot traffic and vehicles off turf until it is well rooted. These steps are extremely important in the first two to three months following establishment to ensure turf survival. If the vegetation doesn't grow according to its intended use, additional soil samples might need to be taken and analyzed for other parameters. Take additional soil samples as new areas are developed.

Once vegetation is established, base the use of any additional soil amendments on soil test results.

Literature Cited

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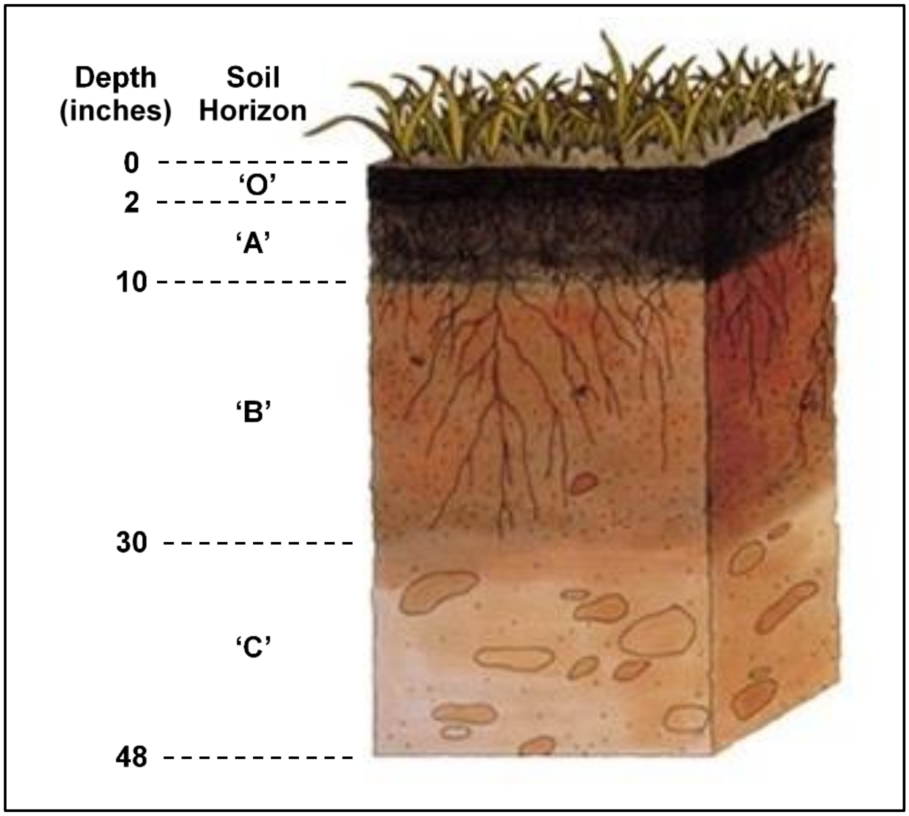

Figure 1. Soil Horizons
Source: USDA NRCS (b).

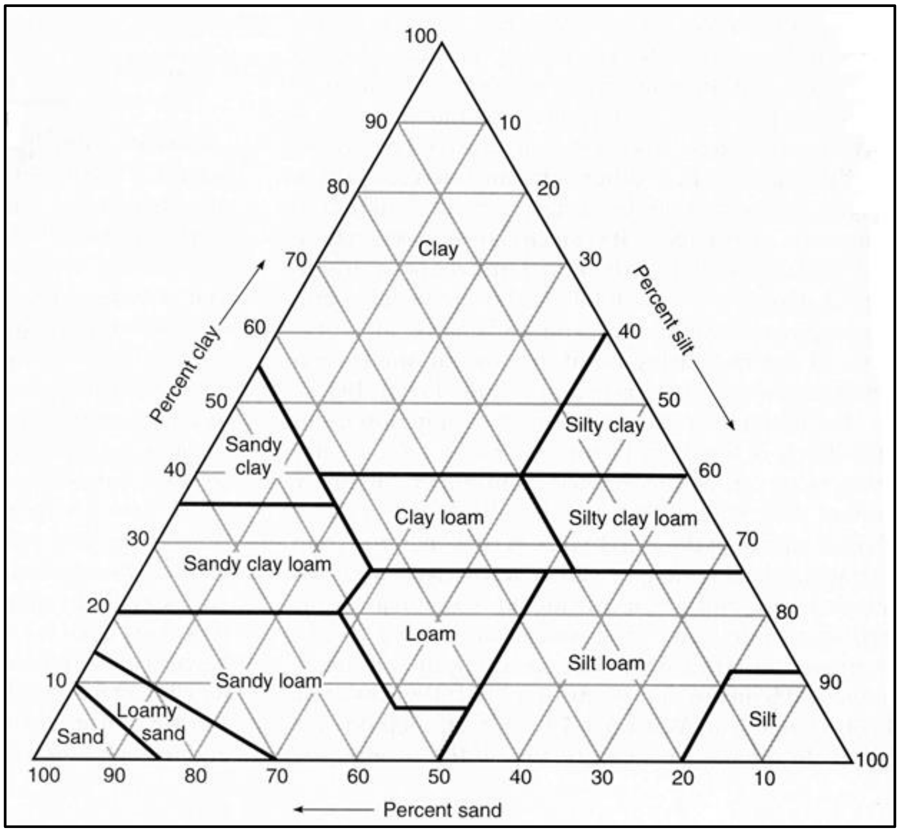

Figure 2. USDA Soil Texture Classification
Source: Adapted from USDA NRCS.