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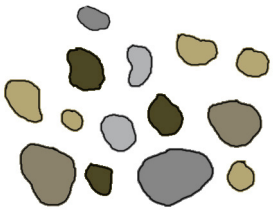
***Sustainable Landscapes Series***

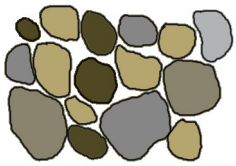
# Combating Soil Compaction

## What is soil compaction?

Half of a healthy soil's makeup is pore space, with the other half composed of organic matter and mineral particles (sand, silt and clay). Pore space provides room for air and water to circulate around the mineral particles, providing a healthy environment for plant roots and beneficial microorganisms. In compacted soils, the particles are pressed together so tightly that the space for air and water is greatly reduced.



**Healthy soil with pore space between particles**



**Compacted soil with greatly reduced pore space**

## Why is soil compaction a problem?

- Very dense soil makes it difficult for plants to grow properly. Roots cannot penetrate the soil to obtain the nutrients, water, and structural support they require for survival.
- Lack of pore space translates into lack of drainage. When the soil is filled with water, there is no room for oxygen, inhibiting plant growth. The lack of oxygen also inhibits organisms that decompose organic matter, an essential process for recycling nutrients and aerating the soil.
- Compaction prevents water from percolating properly through the soil, forcing it to run off the surface and cause erosion.

## Common causes of soil compaction

- **Vehicle and foot traffic**. In many home landscapes, soil is compacted during building construction, from repeated use of riding lawn mowers, or from off-road parking of automobiles and recreational vehicles. Pedestrian pathways across garden beds and turf areas are also significant contributors to compaction.

- **Rain on bare soils.** Drops of rain cause splash erosion, which disturbs the top layer of soil particles and causes formation of a thin surface crust that blocks water from reaching plant roots. (For information more information about erosion, consult the fact sheet "Preventing Erosion," available at http://www.ag.udel.edu/udbg/sl/hydrology.html)

- **Excessive tillage**. Tilling the soil accelerates breakdown of organic materials that inhibit compaction. It can also damage soil structure, the arrangement of mineral particles in relation to pore space, especially if soil is tilled when it is wet. Over the years, repeated tillage orients all of the soil particles in the same direction, causing a layer of compacted soil (a plow pan) to form directly beneath the area being tilled. Plow pans are mainly a problem on farm fields where the soil is consistently tilled at the same depth.

- **Natural processes.** Soils with high clay content—typical of wetlands and river bottoms—can become compacted due to natural processes. Because individual clay particles are so small, they are more susceptible to being pressed together tightly.

## What does soil compaction look like?

Recent construction sites, farm fields, and soils with high clay content are most commonly affected by compaction. Unfortunately, soil compaction can be difficult to detect in the landscape because its symptoms can be caused by other site problems. Some indicators include:

- **Badly formed plant roots** (enlarged, stubby or twisted roots, or taproots that grow horizontally)

- **Standing water** that implies a drainage problem

- **Physically dense soil** that is hard to dig whether wet or dry

- **Plants with nutrient deficiencies**, manifested by stunted growth, discolored leaves and drought stress.

Soil scientists measure compaction with a device called a soil penetrometer. The easiest way for a homeowner to test for soil compaction is to plunge a soil probe (or hollow metal pipe) into the soil. If the probe barely enters, the soil is compacted.

## How can you combat soil compaction?

- **Avoid walking in planting beds.** For areas where traffic is temporary and unavoidable, you can lay a protective pathway with wooden planks, permeable fabric covered with gravel, or a thick layer of mulch (6+ inches).
- **Avoid working soils when they are too moist.** Digging or tilling is not recommended in soil that holds its shape when pressed into a ball, as very moist soils are the easiest to compact. (Dry soil has too much friction between particles to be easily compressed. Extremely wet soils are also difficult to compact because the condensable air space is replaced by water that resists pressure—evidenced by muddy tires moving the soil into ruts instead of just pressing it down.)
- **Use the lightest, smallest construction equipment possible on the smallest area possible.** When building, choose the smallest piece of equipment that can accomplish the task at hand over an acceptable time period, and restrict the use of that equipment to the footprint of the building area. The heavier the equipment, the more serious the resulting compaction; the wider the equipment, the greater the area that is affected.
- **Let winter do the work**. Freeze-thaw cycles can help alleviate shallowly compacted soils, though these natural processes are generally not adequate where compaction was caused by heavy equipment.
- **Choose adapted plants.** Mildly compacted soils can be overcome by proper plant choice, especially in wet areas. Plants adapted to wetlands have special enzymes that allow them to survive in saturated soils (where non-adapted plants would manufacture ethanol alcohol, a toxic by-product).
- **Cover soils with mulch or groundcovers.** Bare soils form a thin surface crust that prevents water from penetrating the soil. A layer of plants or 2-3 inches of mulch will help prevent this type of compaction from occurring.
- **Aerate the soil.** A garden tool called a core aerator can be used to remove small plugs of soil in turf grass, alleviating compaction and preventing the accumulation of thatch.

- **Amend the soil.** Adding compost to your soil is one of the best ways to combat compaction. As organic materials decompose, they attract soil organisms that naturally aerate the soil through creation of pore space.

  When amending with compost, spread it evenly over the site and till to a depth of 18 inches. In severely compacted soils, large amounts of compost will be needed to make a difference—25% of the existing soil by weight for sandy loam soil types, and as much as 50% for clay soils.

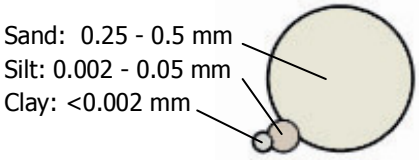
  Adding inorganic materials to amend soils is inefficient and expensive compared to adding organic matter. At minimum, it requires an addition of 75% more material by weight to positively affect the level of compaction. Adding less can very well make the problem worse (sand plus clay makes concrete!). If you do choose to add inorganic materials in the proper amount, use consistently coarse-grained materials. Particles that are too small will inhibit drainage in the amended soil.

- **Dig a radial trench around established trees**. When soil is compacted around an established tree, dig trenches 4-6" wide and 12" deep from the trunk to the drip line at about three-foot intervals. The pattern will look like the spokes of a bicycle wheel. Backfill the trenches with coarse gravel and top with soil. This process allows you to loosen soil without damaging more than one-third of the tree's root system. High pressure air wands (Air Spade®) are also available for removing soil from trenches with even less damage to tree roots.

- **Replace or bury the soil.** Over large areas, replacing the soil entirely is

### *What is your soil texture?*

Soil texture refers to the size of soil particles, with clayey soils having the smallest particles, sandy the largest, and silty, medium. Loamy soils posses a relatively even concentration of the three particle sizes.




*Relative size of soil particles*

A rough test for determining your soil makeup is to take a small lump of moist soil in your hand and squeeze it out between your thumb and forefinger to make a soil "ribbon." Generally speaking, the most clayey soils will create a ribbon longer than 2 inches, silty/loamy soils will create ribbons between 1–2 inches, and the sandiest soils won't make a ribbon at all.

*For more information about determining the makeup of your soil, consult NASA's Soil Science Education page "Step-by-Step Guide: Texture," available at http://soil.gsfc.nasa.gov/pvg/texture1.htm*

impractical and expensive. However, in smaller areas this method may be useful for dealing with severely compacted soils. To accommodate shrubs and trees, the new topsoil soil must have a depth of 1-½ to 3 feet.

- **Employ sub-surface soil sculpting or deep plowing**. Grading or deep tilling of sub-surface compacted soils can be utilized to break up the plow pan or to direct water drainage away from the plant root zone.

## Additional Resources

Aerating Your Lawn
http://www.ext.vt.edu/pubs/turf/430-002/430-002.html

Basics of Soil and Plant Fertility
http://extension.umd.edu/publications/PDFs/FS782.pdf

Estimating Soil Texture: Sandy, Loamy, or Clayey?
http://www.cmg.colostate.edu/gardennotes/214.pdf

NASA's Soil Science Education
http://soil.gsfc.nasa.gov/index.html

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