How Compaction Affects Tree Root Growth and Structure

Soil compaction is a common problem in urban and suburban landscapes occurring as a result of both equipment trafficking during construction and pedestrian trafficking during periods when soils are moist and most susceptible to damage. Non-compacted soils are actually about 50% pore space. These pores range in size from small micropores that hold and release water between rainfall events and large macropores from which water drains rapidly after a rainstorm. Soil macropores are important because they provide open passages for movement of oxygen and other gasses within the soil. When soils are compacted, the total pore space and, in particular, the amount of macropores is decreased (Fig. 1). This adversely affects the soil in several ways. It reduces the ability of water to move through the soil so that during wet periods there is inadequate movement of oxygen to roots. During dry periods, compacted soils can become so hard that root systems cannot grow through the soil. The end results of these two effects are trees with poor root systems.

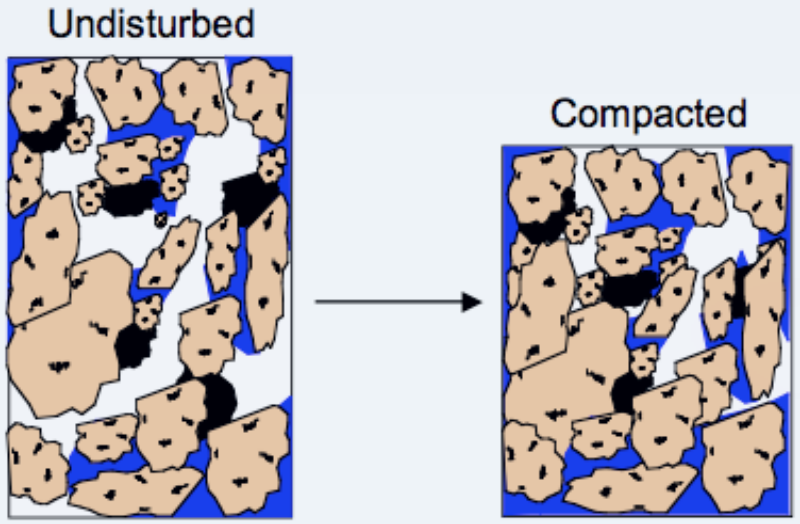

Fig. 1 Compaction occurs when soil pores (white space) are compressed by machinery, human use, or other environmental factors. Compacted soils are denser and have a lower ability to allow water to drain after a rainstorm.

To understand how compaction affects roots, it is important to understand the source of compaction and how soil moisture affects soil strength. When a weight is applied to the surface of a loose, non-compacted soil, the soil immediately beneath the weight compacts to the point that it can support the weight (force) being applied. The greater the force the greater the soil must compact to support it. Also, soil moisture affects how much a soil will compact under a given weight. Wet soils will compact to a greater degree than dry soils for the same weight because water tends to reduce the friction between individual soil particles as they move by one another – this movement is part of the compaction process. Finally, forces applied at the soil surface tend to dissipate with depth. The same force applied over a small area of the soil surface will not have as much of an effect on compaction deep within the soil as when that force is applied over a large area. Consequently, compaction associated with construction equipment with large tires or tracks tends to go deep within the soil, 12-20 inches, whereas compaction associated with the pedestrian traffic is often restricted to the surface 3 to 6 inches. Both types of compaction harm tree roots.

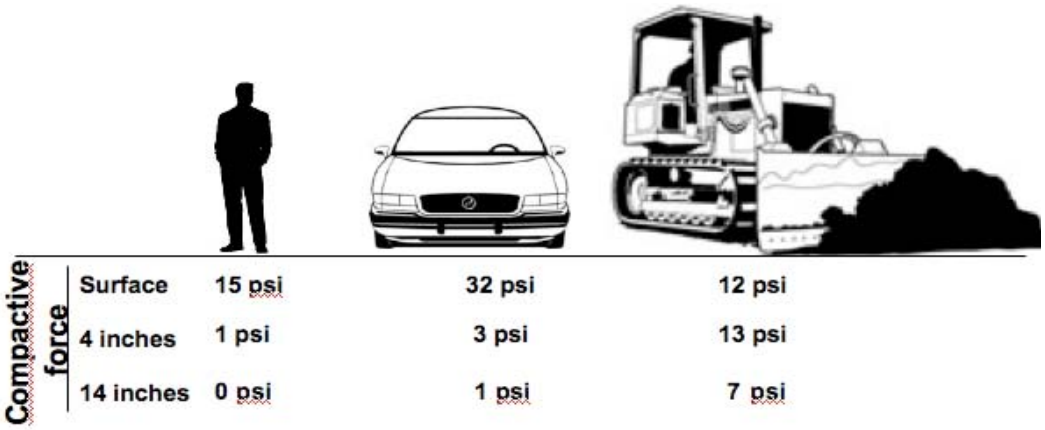

Fig 2. The nature of soil compaction differs depending on its source. Walking pedestrians and cars have ground pressures equal to or greater than construction equipment but construction equipment compacts soil to a deeper depth because of the large surface area of the load and the vibration associated with equipment trafficking.

Construction projects invariably require use of heavy equipment, and often operations continue during wet conditions when soils are most susceptible to compaction. This practice results in a much deeper type of soil compaction (Fig. 3). This type of deep compaction is not corrected by surface tillage associated with most landscape installation, so that trees planted on these sites will tend to have root systems with less developed tap roots and sinker roots and an overall shallower roots system. Additionally, because roots do not utilize as much soil depth, they will be more prone to stress during dry periods of the summer. In severe cases, roots systems will tend to develop along the contact between the non-compacted surface and compacted subsoil. When wind accompanies heavy rain, there is a greater tendency for tree throw to occur in these soils. This type of compaction should be corrected prior to planting trees by using a subsoiler or backhoe to break up and mix compacted soil.

Fig. 3 Movement of heavy equipment across soils during construction can compact the soils very deeply. This type of compaction must be corrected prior to planting or trees will have a tendency to develop surface roots and be more susceptible to moisture stress.

Fig. 4 Trees grown on compacted soils fail to develop tap root and sinker roots and many lateral roots occur at the surface.

Surface soil compaction associated with pedestrian traffic presents a different set of challenges for the tree root. Typically, most of the fine “feeder” roots of trees occur in the surface soil where organic matter, nutrient availability, and water and oxygen transfer is the greatest. When surface soils are compacted, the density of roots in this active surface zone is decreased. The result is a tree with more limited access to soil nutrients. It is easier to correct surface soil compaction than deep compaction. Radial trenching, vertical mulching, and regular mulching can all improve rooting. Air tillage using high velocity air streams can loosen compacted soils without destroying fine roots (Fig. 5).

Fig. 5 Loosening compacted soils by air tillage is especially effective at reducing surface soil compaction. This technique will leave many fine roots intact.

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