TREATING SOIL COMPACTION NEAR TREES

E. Thomas Smiley

Grounds Maintenance, Jul 1, 1997

Soil compaction is a problem in many landscapes. A recent survey of arborists estimated that 40 percent of commercial and residential properties had an area of significant soil compaction near trees. Historically, grounds managers have had few options for correcting this problem. Fortunately, recent advances have made it easier to effectively treat compaction problems around established trees.

In the landscape, soil compaction occurs from a high volume of foot or vehicular traffic, or construction machinery. When soils are moist, compaction occurs more readily due to the lubricating effects of water and the flow of fine clay particles between the coarser sand particles. Soil at field capacity holds its maximum amount of water. This is the condition that exists following heavy rain or irrigation and during which soils are most susceptible to compaction.

It is easier to avoid compaction with thoughtful design and construction of the landscape than to correct it after it occurs. Design considerations include separating traffic from plantings, selecting compaction-tolerant tree species and routing traffic around susceptible plantings via shrub borders and mulch beds. During construction, you should fence planting areas with no grade change to exclude machinery. If you must operate machinery over an area, cover it with 6 to 10 inches of wood-chip mulch to distribute the compactive forces over a larger area. In planting areas that already are compacted, cultivate the soil with a subsoil plow or excavate the soil and set it back into place, retaining the original soil profile. Perform the final grading by hand or using small machinery with low-pressure tires to minimize additional compaction. If soil is low in organic matter or fertility, this is the time to incorporate supplementary materials. Unfortunately, most projects do not involve consultation with a landscape manager about compaction avoidance. Instead, managers usually inherit a landscape with severe compaction problems--a much more difficult situation with which to deal.

Correcting compaction near trees requires treating a large soil volume using equipment and techniques that will not cause damage to the root system. Several research projects around the country are searching for practical solutions to this problem. Not all of these projects are complete, but the preliminary information they have developed may be useful in starting compaction-correction programs.

Soil problems Before discussing treatments let's consider exactly what is happening in the soil. First, applying forces to the soil surface eliminates the relatively large voids in the soil, called macropores. They are squeezed into smaller micropores or lost entirely, which increases the density of the soil. When density reaches a certain point, roots are unable to penetrate the soil. The point at which density inhibits root growth is dependent on the tree species and soil texture.

Second, compacted soils are typically prone to drought. Macropores hold air or, after heavy rain or irrigation, they fill with water. When compaction reduces these voids, less oxygen is available, carbon dioxide does not readily move away from the roots and water-holding capacity is reduced. Further, compaction reduces quality and density of ground-cover vegetation, such as turf. This can lead to crusting of the soil surface and development of a water-repellent, or hydrophobic, layer that further inhibits water penetration.

Third, compacted soils often have lower nutrient and organic matter levels. With less ground cover vegetation, there is less accumulation of plant litter and fewer roots beneath the soil surface. This leads to slower buildup, or even a net loss, of organic matter in the soil. Organic matter is part of the natural "glue" that holds soil particles together in granules, called peds, which are beneficial in resisting compaction. Organic matter also provides a long-term source of nutrients. In forests, for example, many nutrients derive from the natural mulch of fallen leaves, which also aids in capturing the nutrients present in precipitation. Subsoils epitomize soils that are low in organic matter and nutrients. Too often contractors use subsoils as "topsoil" around construction sites before laying sod.

These factors are all interrelated. Therefore, we typically are dealing not only with dense, hard-to-penetrate soil but with droughty and nutrient-poor soil as well. For treatments to be effective, you must address all of these factors.

Treatments * Drill-hole soil replacement. The traditional method of reducing soil compaction around trees consists of drilling holes. These are usually 2 to 4 inches in diameter and 8 to 10 inches deep, in 1.5- by 1.5-foot spacing around the tree. Depending on soil analysis, fill the holes with a combination of fertilizer or organic matter such as compost or peat moss. Roots that are near the drilled holes will prosper in this rich rooting environment. During the growing season, many fine roots may grow into the drill holes within weeks of treatment. Unfortunately, this treatment affects a relatively small area of soil. Using 2-inch-diameter holes, you would replace only about 5 cubic feet per 1,000 square feet (to a depth of 6 inches). Using a 4-inch-diameter hole increases this volume to about 20 cubic feet. This is better but still improves only a small portion of the area. Therefore, this technique will rarely be effective. Indeed, that is what research shows¾drill hole treatments seldom provide much improvement in tree vigor.

* Compressed-air treatments. Several machines on the market inject air into the soil at 100 to 300 psi. This high-pressure influx of air can lift the soil surface--and anyone standing on it--by up to a foot, making it a very dramatic treatment. Workers then inject fill material to keep some of the cracks open. Technicians use materials such as peat, Styrofoam or porous ceramic, in addition to fertilizers formulated for this purpose. This treatment improves a very large area: up to 50 square feet per injection. Using 10- by 10-foot spacing improves 500 of every 1,000 square feet. However, aeration machines provide only a single saucer-shaped fracture in fine-textured soils. Fill material is barely capable of keeping open even a small fracture near the injection site. Because this affects only about 0.5 inch around the fracture line, treating 1,000 square feet of surface only improves about 20 cubic feet. You might think treating 50 percent of the area would mean dramatic improvement, but this is not the case when it is only 4 percent of the volume. Again, research shows that this is an ineffective treatment. When positive results do occur with air injection, it is usually due to fertilizer injection, not the aeration treatment.

* Radial-trench soil replacement. In Europe, arborists have tried vacuuming compacted soil from around trees and replacing it with a soil mix. Results from this treatment have been good, but the cost is very high. A more conservative approach is to replace soil from selected areas, such as trenches radiating out from near the trunk. For large trees, this means starting a trench at or beyond the dripline of the tree and trenching toward the trunk to no closer than 6 inches for each inch of trunk diameter. For example, you should stay 10 feet away from the trunk of a 20-inch-diameter tree. With newly planted trees, you can dig the trenches right up to the root ball if roots have not yet grown outward. If you encounter roots greater than one inch in diameter, do not cut

them. Researchers have not yet determined the ideal trench width: Experiments have used widths from 4 to 24 inches and depths of 12 to 18 inches. Backfill the trenches with native soil mixed with organic matter such as composted yard waste or wood chips, and amend with fertilizer if soil tests show low nutrient levels. Root growth in trenches can be four times greater than in surrounding soil within two growing seasons. Trees may benefit from radial trenching for 2 or 3 consecutive years, but you must avoid trenching the same line twice.

* Soil cultivation. Recently transplanted trees that are failing to establish a root system in compacted soil can benefit from even more dramatic treatment: soil cultivation. Before considering this treatment, dig sample holes both inside and outside the root ball. Ensure that there are live roots in the root ball or backfill and that few have grown into the native soil. In highly compacted sites, the difference in root density inside and outside the planting hole is easy to see. Soil cultivation is fast and simple but is appropriate only if there are few tree roots extending into the native soil. This treatment can be detrimental to large, established trees.

Start by spreading organic matter, such as composted yard waste or wood chips, to a depth of 2 inches in a circle around the root ball. The radius of the circle depends on how long you intend for the treatment to benefit root growth. Healthy root growth averages about 18 inches per year in temperate climates. Thus, for the treatment to be effective for 2 to 3 years, the width of the circle should be about 3 to 4.5 feet. Add granular slow-release fertilizer on top of the mulch if soil tests show it is necessary. Then, till the fertilizer/mulch mix into the soil to a depth of 4 to 6 inches. If organic matter levels in the soil are low--below 3percent--perform this two or three times to work sufficient levels into the soil. Last, mulch the area with 2 to 4 inches of wood chips. Because this treatment affects 100 percent of the soil volume, there is a high probability of success. Unlike other treatments, however, you cannot repeat the cultivation treatment because roots will soon inhabit the treated area.

* Mulching. Even without other treatments, applying a mulch layer can be beneficial to trees on compacted sites. This is the least costly treatment available because of the low cost of composted yard waste and wood chips. Simply apply the mulch in a layer 2 to 4 inches thick from near the trunk and extend it out as far as possible, preferably to the drip line. Never put mulch directly against the trunk. In the short term, this treatment conserves soil moisture. Annually reapply mulch as necessary to ensure an adequate thickness. In the long term, the mulch will protect against additional compaction and provide organic matter to aid in soil-structure development. Even though you can use mulch over a large surface area, do not expect rapid results. Interestingly, however, the most dramatic results I have ever seen in a soil compaction experiment came from using mulch alone. During this particular study, a severe drought occurred. Unmulched treatments suffered greatly in the drought, but the mulched area retained an extra 2 percent soil moisture. In this case, it was the difference between brown trees and green trees.

* Irrigation. Proper soil-moisture levels are critical for root growth. Because the moisture level is difficult to determine in compacted soils, the use of a moisture-sensing device and an irrigation system is important in overcoming the effects of compaction on established, high-value trees. Sophisticated irrigation systems connected to moisture sensors can provide optimum moisture without the risk of excessive irrigation. A simpler method is the use of tensiometers to time manual applications of water. Both over- and under-irrigating are concerns. If a hydrophobic layer is causing water to puddle or run off rather than infiltrate, consider using a wetting agent.

One final note: Trees subject to compaction are susceptible to many pests that would not ordinarily affect healthy plants. Frequent monitoring and treatment of pest problems before they build up to damaging levels is important while the plants are responding to treatment. Further, soil compaction around established trees already may have damaged roots irreparably, so it is best to inspect the tree before starting treatment. There is no use investing in a tree that is already doomed.

After starting any of these treatments, it is best to keep traffic off the treated area. Don't counteract your good efforts by failing to prevent further compaction.

Dr. E. Thomas Smiley is a plant pathologist with Bartlett Tree Research Laboratories, Charlotte, N.C.