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Soil Profile Rebuilding:
An Alternative to Soil Replacement

Urban foresters know poor soils can lead to an endless cycle of dieback and tree replacement.

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Even if trees do establish, growth can be underwhelming and tree health disappointing. Increasingly, project managers have been turning to soil replacement, where existing soils are excavated and removed and replaced with "recycled" or blended soils. These soils present their own challenges, however. For example, many imported blends rely on high sand contents to improve drainage, resulting in low water-holding capacity and drought stress for unirrigated plantings. Resulting sharp transitions in soil texture introduce the possibility of creating a "bath tub" effect in situations where it is impossible to replace all the soil and new soils are confined to the immediate vicinity of individual trees.

This site is a good candidate for SPR because soil is compacted and has an impermeable layer that can likely be broken up by the backhoe subsoiling process. Note limestone gravel mixed in soil indicates pH will be high, which will not be altered by the rehabilitation process. Surface gravel should be removed if possible and underground infrastructure clearly marked. *Photo by Susan D. Day.*

There is an alternative to soil replacement that is especially appropriate where there are extended open soil (unpaved) areas such as in street medians - soil rehabilitation. Soil rehabilitation can help restore important ecosystem functions such as stormwater transmission and vegetation support to existing native soils.

In soil management, urban foresters and designers need confidence that they will get the results they desire and that soil improvements will persist for the long term. Researchers at Virginia Tech developed specifications for **Soil Profile Rebuilding (SPR)**, a soil rehabilitation technique, and have been evaluating performance for nearly a decade. This process can improve tree establishment, increase growth rates, improve soil permeability for stormwater management, increase soil carbon stores, and help meet soil restoration requirements for projects seeking SITES certification (Sustainable Sites Initiative, sustainablesites.org). Urban foresters can use SPR to rehabilitate soils damaged by construction and development and set them on the path to long-term recovery. The procedure is relatively simple—deep mixing of high quality compost with existing soil followed by planting trees or shrubs.

Documented Benefits of SPR

Virginia Tech research has documented that in controlled studies, SPR can dramatically increase canopy growth of shade trees (by as much as 84% after 7 years), reduce soil bulk density (by anywhere from 0.19 to 0.57 g/cm cubed), increase

With backhoe subsoiling, the operator scoops a bucket of soil with compost on the top, lifts it several feet in the air, and drops it. This technique allows work in tight spaces such as street medians, breaks up compacted soil into large clods, and makes it possible to create veins of compost down 24 inches (61 cm). *Photo by Rachel M. Layman.*

soil permeability by as much as 6-11 times, increase stable soil carbon stores, and possibly result in deeper rooting. The end result is, of course, dependent upon all aspects of the plant × environment interaction including species, soil fertility, climate, and rainfall. Furthermore, the magnitude of improvements over untreated soil will strongly depend upon just how bad conditions were to start with - the worse the starting soil conditions are, the greater effect you can expect. Links to peer-reviewed research are available at urbanforestry.frec.vt.edu/SRES that can give insight into the conditions and outcomes of these trials as well as help make informed estimates of outcomes that can reasonably be expected in a given situation.

Compost is spread 4 inches (10 cm) deep over the surface of the existing soil. *Photo by Rachel M. Layman*

Stormwater management is a driving force in tree planting and green infrastructure management. In many areas, compost incorporation such as SPR can be used as a best management practice (BMP) or qualify projects for some type of stormwater credit. However, the approach to stormwater management is somewhat different than that used in bioinfiltration cells. First, SPR is best used where there is sufficient space—broad medians, roadside plantings, landscapes, lawns, or parks. Rather than collecting stormwater from a large area in a confined location, SPR improves the performance of existing soil to receive rainfall, thus reducing runoff from the entire area. Second, water movement through the soil is dependent upon the *least* permeable layer. If the surface seals, it won't matter how permeable lower regions are. Consequently, surface permeability must be maintained by restricting pedestrian traffic and using mulches or groundcovers. The good news is that woody plant roots will help maintain paths for water to move through the soil profile and into deep horizons below the root zone.

Where Can SPR Be Used?

SPR reduces soil compaction and thus associated challenges such as poor drainage. It was originally designed to treat that familiar archetype of degraded urban soil that is left behind after land development. This is soil that is stripped of surface horizons (O and A horizons) and graded to facilitate building, traffic movement, or surface drainage. These soils are typically extremely compacted and compaction can run deep. SPR is ideal for alleviating this compaction and creating conditions that can lead to long-term soil recovery. It is intended to apply to a large area, not just immediately around individual trees. For example, let's say an access road is being built for a commercial building and grading for the road has compacted the soil. Performance of roadside tree plantings could be enhanced by applying SPR the entire length of the road for the full width of the compacted area. For projects seeking SITES certification, SPR can be a useful restoration tool. The SITES voluntary certification program for land development requires that healthy soils be protected first and be restored if damage during construction is unavoidable.

What sites are good candidates for SPR?	What soil conditions does SPR NOT treat?
Sites with compacted soils	High or low soil pH
Sites that will be reasonably protected from further compaction by vehicles or heavy pedestrian traffic	Contamination by heavy metals or other pollutants
Soils where topsoil has been stripped	Poor drainage caused by impermeable layers below 24 inches
Sites not currently occupied by large trees	Undesirable soil texture

Implementing SPR

What's involved and what can you expect? The procedure is relatively simple, but a few procedural details will help contribute to a better outcome. First, conduct a site assessment that ascertains, at a minimum, the compaction level of soil, depth of compaction, underlying conditions, soil pH, and any soil contamination issues. For those unfamiliar with site assessment, Chapter 5, "Site Design: Soils," in the *Sustainable Sites Handbook* gives a good overview of the site assessment process (Bassuk & Day 2012). You need to verify that the compacted soils zones will be treated by SPR and that there are not underlying soil chemical problems (see *Things to Watch for When Using SPR*, below) that may swamp any benefits. Second, implement the SPR procedure: 1. Spread 4 inches (10 cm) of compost; 2. Incorporate it to 24 inches (61 cm) with a backhoe throughout the site working backwards to avoid recompaction (scoop, lift, and drop); 3. Spread 4-8 inches (10-20 cm) of topsoil on surface and rototill; 4. Plant trees or shrubs; 5. Mulch or plant groundcover as desired. For a detailed explanation of the process, see the specification that is available online for your free use or adaptation (Day et al. 2012).

Things to Watch for When Using SPR

Compost quality can make or break an SPR project. Researcher Peter Somerville at the University of Melbourne found trees planted in SPR-treated soil developed nitrogen deficiencies. The culprit was compost with a high carbon/nitrogen (C/N) ratio of 34 that immobilized soil nitrogen. Although the trees recovered within 6 months, using high-quality stable compost pays off (see *What to Look for in Compost for SPR*).

Pre-existing contamination can also be an issue. Soils with high salt content or heavy metal contamination can prevent or slow tree growth and SPR will have little or no effect on such pre-existing conditions.

Where there is significant **concrete or gravel mixed into soils**, soil pH can be high, limiting growth of many species. While SPR can be used in such soils to remediate compaction, it will not address underlying pH issues and may even raise pH slightly if compost pH is high. Any site with soil pH greater than 6.5 will limit growth of some tree species. While soils can be screened to remove limestone gravel or concrete rubble, this will damage soil structure and may not be cost effective.

The compost incorporation depth called for in SPR is far greater than most contractors and equipment operators are used to and clear communication is essential. Work closely with contractors and follow up with a quick soil push tube test to verify that compost veins reach down the full 24 inches (61 cm).

Summary

Under foot and underappreciated, soil is the support system for our urban forests. Developing effective strategies for dealing with soil pays off, however, and SPR may be a welcome option to include in your soils toolbox. For more on soil restoration, see the chapter, "Improving Soil Quality for Urban Forests," in the upcoming Routledge Handbook of Urban Forestry due to be released this winter.

Literature Cited

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