Improving Soil Conditions in Urban Sites

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DIFFERENT SITE GOALS DETERMINE APPROPRIATE MANAGEMENT

Before we can begin making decisions about how to manage urban soils, we need to be aware of what our goals are for the landscape in question. The goal in managing an agricultural production field, for instance, is quite different from that for an ornamental landscape (Table 1). The goals will determine the management methods, and we don't want to be applying management methods that achieve the wrong goals. Applying incorrect management methods, such as incorporating amendments into landscape soils, can create problems that affect tree and soil health.

Once site goals are determined, consider the soil conditions in the landscape. Soil maps are not useful in determining management strategies for urban soils, because soil maps reflect native soils. Differences between urban and native soils are significant and need to be considered (Table 2). The characteristics associated with urban soils are instrumental in diagnosing problems as well as guiding management.

Table 1. Plant-soil systems, goals, and appropriate management (from Chalker-Scott and Downer, 2020).

Comparative criteria	Intensive annual agriculture	Home vegetable garden	Ornamental landscape
System goal	Maximize yield	Crops for personal use	Sustainability
Plant life cycle	Annuals	Annuals/perennials	Woody plants/perennials
Planting scheme	Monoculture	Polyculture	Permanent landscape
Soil disturbance	High	Moderate	Low
Nutrient inputs	High	Moderate	Low

Table 2. Comparisons between native and unmulched urban soils.

Soil characteristics	Soils in natural environments	Unamended urban soils[1]	Amended urban soils[2]
Horizon transitions	Gradual	Abrupt	Abrupt
Compaction	Low	High	High
Organic content	Sustained over time	Low	High
Nutrient levels	Sustained over time	Low	Variable
Biological activity	High	Low	Moderate
Water availability	Continuous thorough horizons	Upper horizon	Upper horizon
Sufficient oxygen	Found throughout horizons	Upper horizon	Upper horizon
Tree root depth	Found throughout horizons	Upper horizon	Upper horizon
Perched water tables	Wetland ecosystems only	Occasional	Common

[1]Little to no topsoil
[2]Commercial topsoil added

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IMPORTANCE OF BASELINE SOIL TESTS FOR MANAGING LANDSCAPES

Before making landscape management decisions, make some baseline soil measurements and send samples in for testing. This will inform you and your client on what the soil environment requires.

While a site sample will give you valuable information, the best way to make soil management decisions is to compare the site data to a soil test from a nearby natural area (e.g., an unmanaged portion of a park) that reflects the same type of landscape. This soil test is a standard against which you can compare your own site data and make informed decisions about what can and should be done to approach a natural soil system. Organic matter and nutrient levels are most important to compare.

You can do your own soil texture analysis through well-documented processes (Chalker-Scott and Downer, 2019; Figure 1). This will allow you to approximate the amount of sand, silt, and clay in your sample, which in turn will inform you about other soil characteristics:

- Sandy soils – little nutrient retention, high oxygen levels and rapid drainage
- Silty soils – little nutrient retention, lower oxygen levels and slower drainage
- Clay soils – high nutrient retention, lowest oxygen levels and slowest drainage

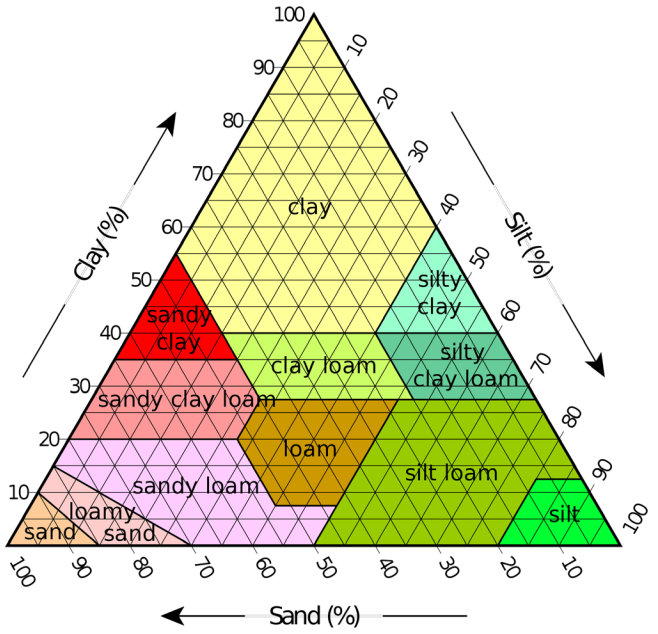

***Figure 1*. Soil triangle. Texture analysis can be easily done on site using the finger test, such as the one shown here: https://puyallup.wsu.edu/soils/video_soiltexture/. *Image courtesy of Charlotte Scott*.**

Soil samples should be submitted to a soil testing lab with a demonstrated ability to address landscape soils and not just agricultural soils. The goals for these two systems are different and the recommendations for nutrient inputs will be different as well (Table 1). The methodology for taking and sending soil samples is usually on the testing lab's website, but a few general points can be made:

- Collect several samples from each managed site, pool and mix, then take one sample to send in.
- Be sure to collect a sample from a natural area to use as a local standard.
- The frequency of testing depends on the results. A baseline reading is critical, and you may need future samples to monitor desired changes.

While you wait for your soil testing results you can help your clients understand what soil characteristics can and can't be altered in a landscape system (Table 3). Help your client understand the differences in system goals (Table 1) and why landscape soils cannot be managed like agricultural soils (Chalker-Scott and Downer, 2019, 2020). It is also useful to consider the number of "soil improvement" products available to the public and why they are not appropriate for landscape soil management (Table 4).

Table 3. Ability to alter landscape soil characteristics sustainably.

Soil characteristics	Can be sustainably altered?	How?	Why not?
pH	No		Soil volume too vast
Texture	No		Soil volume too vast
Organic content	Yes	Topdressing with OM	
Nutrient levels	Yes	Surface application	
Biological activity	Yes	Proper mulching	
Drainage	Yes	Proper mulching	
Oxygenation	Yes	Proper mulching	
Bulk density	Yes	Proper mulching	

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INTERPRETATION OF SOIL TEST RESULTS

Soil tests provide a wealth of data, but some of these data can be considered merely informational and not directly applicable to making management decisions (Table 5). Of greatest importance are data reporting nutrient levels and organic matter content. Organic matter content is directly related to nutrient levels, and excessive nutrients are often caused by overamending with compost and other nutrient-rich organic products (Chalker-Scott and Downer, 2020; Figure 2). Reducing excessive levels of nutrients can be as easy as reducing the use of these products. Compare your results to those from the natural standard so that you can set goals to achieve more sustainable soil conditions.

Table 4. Products that will not improve landscape soils.

Products	Why?	Reference
Soil conditioners	Products are harmful to soil life and do not benefit soils	Chalker-Scott & Downer, 2019
Hydrogels	More expensive and less effective than wood chips	Chalker-Scott & Downer, 2019
Biodynamics	BD preparations have no significant effect	Chalker-Scott, 2013
Gypsum ($CaSO_4$)	Urban soils are rarely deficient in calcium	Chalker-Scott & Guggenheim, 2018b
Microbial inoculants	Treed landscape soils already contain microbes	Chalker-Scott, 2017
Epsom salt ($MgSO_4$)	Urban soils are rarely deficient in magnesium	Chalker-Scott & Guggenheim, 2018a
Sheet mulches	Restrict air and water movement	Shahzad et al., 2019
French drains	Does not remove water from saturated soils	Chalker-Scott & Downer, 2019
Soil amendment	Creates barriers between amended and unamended soil, interfering with water and oxygen movement	Chalker-Scott & Downer, 2019

Table 5. Soil test data and application.

Data	Can be adjusted/ managed	Can require action	Can be ignored
Organic matter	Yes	If nutrients are excessive	If nutrients are optimal
Nutrient levels	Yes	If excessive or deficient	If low to optimum
Non-essential heavy metals	Yes	If dangerous to people or the environment	If they are below threshold levels
CEC (Ca, Mg, K, Al)	Yes	If < 5 or > 15 meq/100 g; check for excessive Ca or Mg	If range is 5-15 meq/100 g
Soluble salts	Yes	In arid or marine environments	If below threshold levels
pH	No	May influence species selection	Landscape soil pH cannot be changed
Humic acids	N/A	No – they do not exist in nature	Humic acids are lab artifacts
Generic fertilizer recommendations	N/A	If nutrients are deficient – but ground-truth first	If specific nutrients are above deficient levels
Base saturation	N/A	No	Has little relevance

GROUND-TRUTHING SOIL TEST RESULTS

Before applying any source of nutrients, be sure to ground-truth the results. If your tests indicate a deficiency in some essential element, can you see widespread evidence of that deficiency throughout the landscape? Conversely, if you see apparent deficiency in tree foliage, is that deficiency reflected in the soil tests? There are common foliar deficiencies, such as iron and manganese, that are caused by excessive levels of soil phosphate (Chalker-Scott and Downer, 2020). Or there may be other confounding factors in the landscape that interfere with normal root function and restrict oxygen and water movement.

- Compaction reduces pore space in soils.
- Layered soils create perched water tables.
- Amended soils create textural barriers.
- Drainage “improvements” (e.g., French drains) create perched water table.
- Use of any sheet mulch (newspaper, cardboard, landscape fabric, plastic).

Poor root function will lead to foliar problems caused by restricted water and nutrient uptake, leading to a misdiagnosis of nutrient deficiency.

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LANDSCAPE MANAGEMENT DECISIONS TO DISCUSS WITH CLIENTS

- Data-based landscape management
  - Have at least one soil test to determine baseline nutrient levels and %OM.
  - Select plants that will tolerate site soil type and conditions.
  - Roots need nutrients, water, and oxygen. Avoid anything that reduces availability of these factors.
- Soil amendment
  - Amendments create textural discontinuities that reduce water, oxygen, and root movement.
  - Layered soils will create perched water tables.
  - Some soil characteristics can be changed through mulching with an arborist wood chip mulch.

***Figure 2*. Soil amendments can be high in organic matter and contain other materials not necessary for optimal soil nutrient content. *Photo courtesy of Linda Chalker-Scott*.**

- Nutrient sources
  - Do not add fertilizers or rich organic matter unless you have confirmed nutrient deficiencies.
  - If tests indicate nutrient toxicities, do not add compost or other rich organic matter.
  - If specific nutrients are needed, only add those nutrients to the soil surface and cover with arborist wood chips .
  - Mulch all treed landscape with arborist wood chips (Chalker-Scott, 2015).

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Second in a series of 10 Technical Information Sheets. Funded by The Britton Fund, Inc. and supported by the Western Chapter of the International Society of Arboriculture.