Up by Roots: Healthy Soils and Trees in the Urban Environment

Soil science and tree biology:
Physical Soil Properties

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Urban Tree + Soils
Natural soils vs. Disturbed urban soils

- Natural soils:
  - Uniform across site
  - Natural horizons
  - Adequate OM, nutrients, structure for native plants

- Disturbed urban soils:
  - Vary across site
  - Topsoil layer removed
  - Compaction, low OM
  - Subsoil (or worse) fill layers
  - Debris, toxins?
Water (& Air) Movement through the Soil
Most fine roots of trees are located close to surface where many of the nutrients that limit tree growth are found.
Critical Aspects of Soil

- Texture: sand / silt / clay
- Structure: Clumps / clods / peds
- Nutrients: N P K +
- Soil Biology: Organic matter (Carbon)
- Density: weight / volume (pore space)
- pH: Acidity

Air and water movement / soil profile
Physical properties of soil

- Texture: sand / silt / clay
- Structure: Clumps / clods / peds
- Density: weight / volume / pore space
- Nutrients: N P K +
- Soil Biology: Organic matter / Carbon / pH / Acidity
- Air and water movement / Soil Profile
Soil science and tree biology:

**Physical Properties**
- Parent soil
- Texture
- Structure
- Profile
- Compaction
- Water / soil relationships
Soil Parent – natural processes of soil formation

- Igneous
- Wind deposited
- Sedimentary
- Glacial
- Alluvial
Sub-Soils in the Puget Sound Basin: Leftovers from glaciers & volcanoes

**glacial till**: unsorted, unstratified mixtures of clay, silt, sand, gravel, and boulders; deposited under ice, or in moraines

**hardpan**: till compacted under glacier

**outwash & alluvial soils**: layers sorted by particle size by water - sand / gravel / rocks

**lake/marine bed soils**: clay or silt that settled out in lakes & estuaries

**volcanic ash**: light, fertile, holds moisture - mostly blown east of Cascades

**mudflows**: mixed size, compact - like till
Glacial till

- May be piled, uncompressed and unsorted, in *moraines* at edge or terminus of glacier

- *Basal till* from under the glacier (1/2 mile of ice over Seattle!) has been compressed into hardpan

- Good for foundations, but low permeability and hard for roots to penetrate
Glacial outwash

- May be sorted boulders, gravel
- ...sand and fines.....
- Or a mix!
Lake beds, lenses, and layers

- Silts and clays settle out…
- And then may be overlain in lenses with sand or gravel from succeeding outwash
- Grey-yellow color when saturated and anaerobic
- Great for farming, (best nutrient capacity) but unstable in slopes or foundations!
Volcanic ash or mudflows

- *Tephra* (ash) – light, fertile, holds moisture, erodable

- Mudflow – compact, mixed fines and boulders, low permeability, looks and acts like basal till, but more fertile
Alluvial soils

• Flat, loamy deposits in river floodplains (or ancient rivers)

• Best for farming, often wasted on development because they’re flat
Layers *upon* layers…
*ignore them at your peril*!!

- Sandy outwash over compacted basal till hardpan
- Thin soil over bedrock
- Clay lenses over hardpan, or inter-layered with sand (unstable!)
Soil formation - Human forces
Disturbed soils in urban areas

- Topsoil layer removed
- Compaction
- Subsoil (or worse) fill layers.
- Debris or toxins?
Texture
Soil Texture (= mineral particle size)
Proportion of sands, silts & clays
<table>
<thead>
<tr>
<th>Soil Material</th>
<th>Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Silt</td>
<td>0.002 - 0.05</td>
</tr>
<tr>
<td>Silt, fine</td>
<td>0.002 - 0.02</td>
</tr>
<tr>
<td>Silt, coarse</td>
<td>0.02 - 0.05</td>
</tr>
<tr>
<td>Sand</td>
<td>0.05 - 2.00</td>
</tr>
<tr>
<td>Very fine sand</td>
<td>0.05 - 0.10</td>
</tr>
<tr>
<td>Fine sand</td>
<td>0.10 - 0.25</td>
</tr>
<tr>
<td>Medium sand</td>
<td>0.25 - 0.50</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>0.50 - 1.00</td>
</tr>
<tr>
<td>Very coarse sand</td>
<td>1.00 - 2.00</td>
</tr>
<tr>
<td>Gravel</td>
<td>2.0 - 75.0</td>
</tr>
<tr>
<td>Cobbles</td>
<td>75.0 - 250.0</td>
</tr>
<tr>
<td>Stones</td>
<td>250 - 600</td>
</tr>
<tr>
<td>Boulders</td>
<td>&gt; 600</td>
</tr>
</tbody>
</table>
Ideal range for imported landscape soils.
Importance of knowing your **soil texture**: Pore Spaces affected by particle sizes and arrangement

- Well sorted, loose packing
- Well graded, loose packing
- Well sorted, tight packing
Soil Texture Test

**Ribbon+feel test:**
Moisten soil, roll between hands, then squeeze out with thumb:
- Sand: no ribbon, grainy
- Sandy loam: ½ inch ribbon
- Loam: thick 1 inch ribbon
- Silt: makes flakes rather than ribbon
- Silty clay loam: thin, breaks easily, has floury feel
- Sandy clay loam: stronger, has grainy feel
- Clay: long (3 inch) ribbon, has smooth feel
SOIL STRUCTURE

The arrangement of soil particles into various aggregates (or peds)

Don’t grind up your soil! Mix loosely to preserve the peds.
Some Types of Soil Structure

Granular

Blocky

Columnar & Prismatic

Platy
Why is Structure Good??

• Large pores **fill** readily BUT also **drain** easily,

• Small pores **retain** water against quickly draining BUT also **slowly fill** up
Structure

Before wetting

High O.M.  Low O.M.

After wetting

High O.M.  Low O.M.
Good Soil Structure!!
Organic amendments (compost) improve structure in all soil types, through biological activity and bio-chemical modifications.
Compaction or Density
Bulk Density
(dry soil mass per field volume)

higher BD = greater compaction

• Affects root penetration
• Affects pore volume - water, air, ???
• Land Use & Management affects BD?
  – negative, positive??

Fine textured soils
(pores already small so compaction will decrease even smaller)

Coarse textured soils
(pores large so increasing BD will decrease some pores)
Bulk Density of Different Soils

- Forest and grass land
- Cultivated clay and silt loam soil
- Cultivated sandy loam soil and sands
- Clay soil
- Silt Loam
- Sandy loam
- Sandy soil
- Wood
- Beginning penetration limitation in most soil

Bulk density (Mg/m³):
- 0.5 - 0.6
- 0.7 - 0.8
- 0.9 - 1.0
- 1.1 - 1.2
- 1.3 - 1.4
- 1.5 - 1.6
- 1.7 - 1.8
- 1.9 - 2.0
- 2.1 - 2.2
- 2.3 - 2.4
- 2.5 - 2.6
- 2.7 -

- Concrete
- Quartz
Bulk densities of soil mixes are different for similar natural soil textures.

Compost is very light, while sand and lost structure tends to make soil test heavier.

You have to test bulk density at a stated Proctor percentage.
As compaction increases, pore space for water and air decreases.
There is a decrease in compaction with depth as the compaction force spread out into the soil in a cone shaped wave.

Increasing soil structure increases soil strength and force-spreading, so decreases net soil compaction.
Densitometer
- Moderately slow 10 minutes
- Accurate
- Expensive
- Must calibrate to soil
- Readings impacted by OM
- Soil service only

Penetrometer
- Fast less than one minute
- Not very accurate
- Soil moisture limited
- Inexpensive
- Anyone can operate

Bulk density cores
- Slow one day
- Accurate
- Somewhat expensive
- LA or soil service

Rod penetrometer
- Inexpensive 3/8” bar with T-handle, driven by inspector's weight
- Inaccurate, but gives comparative feel for compacted or uncompacted conditions

Soil Compaction Testing
Soil Profile

Soil Horizons

O

Organic matter
Surface or top-soil

E

Eluvium (leached)

A

Sub-soil

EB

Parent material
(substratum created & deposited by geologic processes, un-weathered)

C

Bedrock
Different Soil Profiles
Remnant Soils – Buried layers of original soil that can support tree rooting.
Examining a soil profile with a Dutch soil auger
Examining a soil profile with a soil probe / core sampler

*Only works 6-12” deep, so better for lawns than trees.*

**Compacted vs. Amended**

Examining soil profile with shovel

*To verify scarification of subsoil and amendment of upper 8” with compost.*

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**Diagram:**

- **Mulch**
- **Loose soil** with visible dark organic matter
- **Loose or fractured subsoil**

Test holes should be one foot deep — after first scraping away any mulch, and about one foot square.
Gravitational water flow examples through soils containing different soil structure.
Gravity & Capillary Actions in Soil

- Capillary - the movement of a liquid along the surface of a solid caused by the attraction of molecules of the liquid to the molecules of the solid.
Water and Soil Texture

Sand

Silt

Clay

Loam

Modified from http://scvh2oprograms.com/soil-types-santa-clarita-valley-0
In a layered soil, water will not move into a **different textured soil** until saturation takes place and gravity affects water movement.

(Walter Gardner - WSU, 1988)
Effect of water percolation related to placement of mulch in the soil

(Walter Gardner - WSU, 1988)
Effect of water percolation related to placement of gravel in the soil

(Walter Gardner - WSU, 1988)
A well Managed Soil is a Live Soil

To manage the soil well you need to be aware of the Physical Soil Properties

- Parent soil
- Texture
- Structure
- Profile
- Compaction
- Water / soil relationships