Up By Roots
Healthy Soils and Trees in the Built Environment

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Urban Soil and Site Assessment
Trees in urban soils often fail, or are irregular in their growth from tree to tree.
Urban soils

- Compaction
- Water / Drainage
- Too much / too little
- Grading
- Fertilizer
- Salts
- Soil mixing
- Texture
  - sand / silt
  - clay
- Structure
  - Clumps / clods
  - peds
- Density
  - weight / volume
  - pore space
- Reduced Soil Biology
  - Organic matter
  - Carbon
- Nutrients
  - N P K +
- Salts
- Fertilizer
- pH
  - Acidity
  - Higher pH
- Loss of structure
- Compaction
- Profile soil interface
- Limited air and water movement
- Urban soils
  - Limited air and water movement
  - Higher pH
  - Lower organic matter
  - Loss of structure

Page dimensions: 720.0x540.0
Rapid and large scale soil movement and compaction
Soil Compaction is critical to engineers building cities. Their compaction goals are in direct conflict with tree root requirements.
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.
Maximum soil density and root limiting density changes with soil texture.
Compaction results in massive structure and horizontal peds
Urban soils are highly disturbed with altered drainage and destroyed soil structure. Soil damage is greater if the soil is worked while wet.
Urban soil profiles - many different soil conditions in small areas.
Dramatic changes over small distances, Do not make assumptions!
Utilities - Part of the urban soil profile that severely limit options to improve the soil.
Remnant Soils – Buried layers of original soil that can support tree rooting.
Reduction in soil volume

Roots follow soil weak points
Human induced chemical changes

pH rise
Over fertilization
Salt
Soil chemical toxicity

Elevated pH
Salt damage

Air born salt

Soil water born salt
Urban soil conditions result in a significant reduction in plant usable soil volume.

How Much Soil

20” (500 mm) Trunk Diameter

Ratio of tree size to soil volume

More Soil

1200 CF (34 M3) Soil Volume

20” (500mm) Trunk Diameter
Traditional Soil Surveys
Read the soil series descriptions for soil nearest the site with similar topography such as ridges or valleys. Look for reference soils at or near site.

1600 soil types!
# Urban’s Real Soil Classifications

3 soil types!

<table>
<thead>
<tr>
<th></th>
<th>Sort of Bad</th>
<th>Good</th>
<th>Real bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage</td>
<td>Excessive</td>
<td>Moist but well drained</td>
<td>Excessively Wet</td>
</tr>
<tr>
<td></td>
<td>Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compaction</td>
<td>Very Loose</td>
<td>Consolidated or Aggregated</td>
<td>Very Compacted</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic Content</td>
<td>Greater than 10%</td>
<td>2-3%</td>
<td>0.5 - 0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td>High sand</td>
<td>Loam</td>
<td>High Clay or Silt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertility Indicators</td>
<td>high or Low</td>
<td>Just Right</td>
<td>Very high or low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>Below 5.5</td>
<td>6.0 to 7.5</td>
<td>Above 8.5 or Below 5</td>
</tr>
</tbody>
</table>
Non traditional ways to survey urban soil

<table>
<thead>
<tr>
<th>Boring No.:</th>
<th>Type of Boring</th>
<th>Description of Materials (Classification)</th>
<th>Sample Depth (in)</th>
<th>Sample Depth (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-15</td>
<td>HSA</td>
<td>TOPSOIL - Residual (Possible Alluvial) - Soft, Brown, Sandy Elastic SILT (MH) - moist to wet.</td>
<td>2-2-2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very Stiff, Brown and Tan, Clayey Sandy SILT (ML) - moist to wet.</td>
<td>5-7-9</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loose, Tan and Gray, Clayey Silty Fine SAND (SM) - moist to wet.</td>
<td>3-4-6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stiff, Gray and Tan, Sandy Lean CLAY (CL) with trace rootlets - moist to wet.</td>
<td>4-4-5</td>
<td>8-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dense, Tan, Silty Fine SAND (SM) - moist to wet.</td>
<td>12-17-15</td>
<td>13.5</td>
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<tr>
<td></td>
<td></td>
<td>Very Stiff, Tan and Gray, Sandy SILT (ML) - moist.</td>
<td>7-9-12</td>
<td>18.5</td>
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<tr>
<td></td>
<td></td>
<td>Dense, Brown, Silty SAND (SM) - moist to wet.</td>
<td>11-19-22</td>
<td>23.5</td>
</tr>
</tbody>
</table>

Boring Terminated at 25 feet.

Groundwater:
0 Hour - 14.5 feet
1 Hour - 4.5 feet
Stabilized - 2 feet
Regional geology mapping can give clues to parent material.
**Geotechnical Test Borings**

Good information on deep soil texture, color, and drainage.

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<tr>
<th>Approx. Elevation**</th>
<th>Depth**</th>
<th>DESCRIPTION OF MATERIALS (Classification)</th>
<th>Sample Blows*</th>
<th>Sample Depth (Feet)</th>
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<tbody>
<tr>
<td>672.2</td>
<td>0.8</td>
<td>TOPSOIL</td>
<td></td>
<td></td>
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<td>670.0</td>
<td>8.0</td>
<td>RESIDUAL (Possible Alluvial) - Soft, Brown, Sandy Elastic SILT (MH) - moist to wet.</td>
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<td>25.0</td>
<td>Boring Terminated at 25 feet</td>
<td></td>
<td>10.0</td>
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Groundwater:
- 0 Hour - 14.5 feet
- 1 Hour - 4.5 feet
- Stabilized - 2 feet
Recent and older aerial photographs  Old historic mapping
Historic photographs and town histories
Topographic Indicators of Past Disturbance
Interviews: a good way to get urban soil information
Adjacent constructions can reveal soil types and issues
Plants as indicators of soil differences and problems
C. Stress responses

1. Leaf response
2. Node length and branch extensions
3. Decline and branch dieback
4. Wood growth reduction
5. Compartmentalization
6. Pruning response
   Branches
   Roots
Leaf area
root area
balance
Compare urban tree leaf growth with those from nearby native soils.
Decreasing internode distance causes angular branch growth as stress increases.
Outer branch loss and epicomic branching.

Too little water or root damage.

Lower or interior leaf loss.

Too much water.
Early Fall Color indicating soil stress
Soil stress - Lower yearly trunk diameter growth.

These trees are the same age from the same planting about 100 feet apart.
Soil Test will be required after the initial non traditional assessment, but the assessment limits the location for testing.
Soil probes and test pits

At some point you need to start digging, but the more research you do the less digging is required.

A Dutch auger is the best option for soil test pits.
Creating a soil profile with a Dutch auger
Soil interface in profile

Dutch auger Soil investigations
Learning to identify basic soil texture by feel is easy and critical to identifying problems and solutions.
Clayey or silty soils?

Shoe test

The harder to clean your shoes, tools, trucks; the greater the % clay
Find a reference soil in or near the site that might be undisturbed.

Under old trees, at property lines, cemeteries, parks etc.

Use this to find remnant soils.
Planter with and without a remnant soil
Constantly smell the soil! Sour odor indicates poor drainage

Grey color, poorly draining soil
Soil Compaction testing

Bulk Density kit

Core soil sampler and slide hammer
www.benmeadows.com

Tools - Core soil sampler and slide hammer plus other stuff
Soil Compaction testing

Densiometer
accurate but expensive

Penetrometer
inexpensive but not accurate
Make a soil survey map
Record all the information on a drawing to show the different soil types and soil issues

Pit 3 - Soil Zone C: Good quality lawn, no trees. Soil is poorly drained but not anaerobic.

A Horizon - Brown clay loam topsoil, moist, little humic odor.

B/C Horizon - Orange brown clay transition between A and C horizons, moist to wet, no humic odor

C Horizon - Orange clay, sharp change in firmness at 17” due to dryer soil condition.

Soil test results and evaluations:

Pit 3 - A horizon: Clay loam soil. Low pH (5.8)
This soil is similar to the topsoil found in zone D. These topsoils are usable as deep soils for trees and for lawns that are not expected to have significant compaction forces or as a base material for sand/soil mix for compaction resistant lawn

Pit 3 – B/C horizon: Clay.
This soil could be a useful base to mix with sand and compost in areas of trees, shrubs and or lawns.

Pit 3 - C horizon: Soil determined at field evaluation to have too much clay and too compacted to be useful.
Lunch break