Soil Assessment for Urban Trees

Bryant Scharenbroch
U. of Wisconsin – Stevens Point
The Morton Arboretum
TREE Fund Webinar
January 14, 2020
Learning objectives

• To understand how soil quality is determined
• To discuss how soil quality can be utilized for urban tree care
Scharenbroch et al., 2014
Available at International Society of Arboriculture

Revised edition coming soon

Soil Management for Urban Trees

Best Management Practices

Aim

Analyze

Act

Assess

(Scharenbroch et al., 2014)
Assess

Sample

Physical

Chemical

Biological

(Scharenbroch et al., 2014)
Why assess urban soils?
Why?

• Soils are important for urban tree health
• Soil information is not available for urban trees
Why?

• Urban forest diversity
• Urban tree management
How to assess urban soils?
Physical

Chemical

Biological

Support human health

Protect the environment

Maintain productivity
Soil quality assessment

1. Define soil function(s)
2. Select indicators
3. Measure indicators
4. Compute soil quality score
5. Utilize soil quality score
Define soil function(s)
Support human health

Protect the environment

Maintain productivity
UWSP campus garden in Stevens Point, WI
Post Office Square Park in Boston, MA
Trees

Healthy

Urban

Trees
Select indicators
Select indicators

• What to measure?
Soil quality indicators

• Integrates soil PCB properties
• Functionally related
• Management sensitive
• Accessible to users
• Database components
Physical

Biological

Chemical
USQI = f(texture, Db, WAS, pH, EC, SOM and POM)

tree size = -1.73e^{-10} + 0.773*(USQI)

R^2 = 0.53; P < 0.0001

(Scharenbroch & Catania 2012)
\[ \text{RUSI} = \left( \frac{\sum s}{3n} \right) \times 100 \]

(Scharenbroch et al., 2017)
(Scharenbroch et al., 2017)
Soil quality indicators

Physical
- Texture
- Structure

Chemical
- pH
- Salts

Biological
- Organic matter

(Scharenbroch & Catania 2012; Scharenbroch et al., 2017)
Measure indicators
Measure indicators

• Where, when, and how should we measure them?
Where?

• Consider $x$ and $y$ (dripline+)

• Consider $z$ (depth)
Michelle and Marlene performing a site assessment in Lisle, IL
Site A

Site B

Site C
Multiple fills, contaminants, and artifacts in urban soil in Kursk, RUS
When?
• Consider $t$ (time)
Time A
Time B
How?

• Expertise
• Tools
Soil sampling tools
High pressure air tool
Soil field day at LBGIII in Lisle, IL
Soil quality indicators

- Physical
  - Texture
  - Structure

- Chemical
  - pH
  - Salts

- Biological
  - Organic matter
Texture

• The relative proportions of the individual particle separates
Ball, ribbon, and dimple test for soil texture
Start by placing two teaspoons in your palm. Add a few drops of water (more if needed) and knead to break aggregates. Soil is at the proper consistency when it feels plastic and moldable, like moist putty.

Does the soil remain in a ball? 
N → Is it too dry? 
N → Is it too wet? 
N → SAND

Gently squeeze the ball of soil with thumb and forefinger upward into a ribbon of uniform width and thickness. Allow the ribbon to emerge and extend over forefinger, and break from its own weight. Does it form a ribbon?

Y → Does the soil feel very gritty?
N → LOAMY SAND

Does the soil make a weak ribbon < 1" long before it breaks?
N → Does the soil make a medium ribbon 1-2" long before it breaks?
N → SILT

Y → Does the soil make a strong ribbon >2" long before it breaks?

Make a ball, push a dimple, and wet soil. Rub the dimple with your forefinger:

<1"
Y → SANDY LOAM
N → LOAM

1-2"
Y → SANDY CLAY
N → CLAY

>2"
Y → SILTY CLAY

Does the soil feel very gritty?
Y → Gritty
N → Sticky

Neither gritty nor smooth?
Y → Smooth
N → Smooth

Does the soil feel very smooth?
Structure

• Shape and arrangement of soil aggregates and pore spaces
Platy
Single-grained
Bulk density sampler and core
Cone penetrometer
pH

• -log of H+ in soil solution
Soil pH Hellige-Truog kit
Electrical conductivity

• The ability of soil to transmit an electrical current
Soil EC probe
Organic matter

• Anything that is living or once was
Munsell color book
<table>
<thead>
<tr>
<th>ORGANIC MATTER</th>
<th>COLOR (moist soil)</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td></td>
<td>3½ to 7%</td>
</tr>
<tr>
<td>3½%</td>
<td></td>
<td>2½ to 4%</td>
</tr>
<tr>
<td>2½%</td>
<td></td>
<td>2 to 3%</td>
</tr>
<tr>
<td>2%</td>
<td></td>
<td>1½ to 2½%</td>
</tr>
<tr>
<td>1½%</td>
<td></td>
<td>1 to 2%</td>
</tr>
</tbody>
</table>

(Strong sunlight may eventually cause these colors to fade slightly.)
Color app, Nix pro color sensor, and Nikon chroma meter
Depletions and concentrations in a Btg horizon
Soil quality indicators

- **Physical**
  - Texture
  - Structure

- **Chemical**
  - pH
  - Salts

- **Biological**
  - Organic matter

(Scharenbroch & Catania 2012; Scharenbroch et al., 2017)
Compute soil quality score
Soil quality score

1. Determine the scores
2. Identify the weights
3. Compute the score
<table>
<thead>
<tr>
<th>Indicator</th>
<th>Ideal range</th>
<th>Limiting range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Residues and many organisms present</td>
<td>Evidence of compaction, crusting, erosion, or ponding</td>
</tr>
<tr>
<td>Color</td>
<td>Browns, reds, yellows</td>
<td>Grays</td>
</tr>
<tr>
<td>Smell</td>
<td>Earthy</td>
<td>Rotten</td>
</tr>
<tr>
<td>Texture type</td>
<td>Sandy loam, loam, or silt loam</td>
<td>Clay, sandy clay, silty clay, or sand</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>&lt;30</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>&lt;70%</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>Structure type</td>
<td>Granular or subangular blocky</td>
<td>Massive, cloddy, platy or single-grained</td>
</tr>
<tr>
<td>Aggregate stability</td>
<td>Most (&gt;50%) aggregates are stable in water</td>
<td>Most (&gt;50%) aggregates dissolve in water</td>
</tr>
<tr>
<td>Bulk density (Mg/m³)</td>
<td>&lt;1.4 (sandy types) &lt;1.3 (clay types)</td>
<td>&gt;1.7 (sandy types) &gt;1.6 (clay types)</td>
</tr>
<tr>
<td>Penetration resistance (MPa)</td>
<td>&lt;2</td>
<td>&gt;3</td>
</tr>
<tr>
<td>Volumetric water (%)</td>
<td>10-30</td>
<td>&lt;5 or &gt;40</td>
</tr>
<tr>
<td>Infiltration rate (mm/h)</td>
<td>&gt;25</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td>2-5</td>
<td>&lt;1 or &gt;10</td>
</tr>
<tr>
<td>Microbial respiration (mg/kg/d)</td>
<td>100-300</td>
<td>&lt;50 or &gt;500</td>
</tr>
<tr>
<td>pH (1:1)</td>
<td>6-7</td>
<td>&lt;5 or &gt;8</td>
</tr>
<tr>
<td>Electrical conductivity (dS/m)</td>
<td>1-2</td>
<td>&gt;4</td>
</tr>
</tbody>
</table>

(Scharenbroch et al., 2014)
Soil quality index (SQI)

- \( \text{SQI} = (S_1 W_1 + S_2 W_2 + S_1 W_3 + \ldots) \)

- \( S = \) scores (from values)
- \( W = \) weights (sum to 1)
Utilize soil quality score
Tree planting sites in Chicago and Glen Ellyn, IL
Scrape, compact, and fill in Moscow, ID
Organic mulches on a research plot in Lisle, IL
An example
Declining oak in Baker Hill, Glen Ellyn, IL
Soil A

Soil B
Soil quality index

• $\text{SQI} = (S_1W_1 + S_2W_2 + S_1W_3)$
Soil quality index

Scores
- $S_1 = OM$
- $S_2 = pH$
- $S_3 = compact$

Weights
- $W_1 = 0.3$
- $W_2 = 0.2$
- $W_3 = 0.5$
Scoring functions

- **OM (score)**: Soil color (value)
- **pH (score)**: pH (1:1)
- **Compaction (score)**: Pen. resistance (PSI)
$$SQI = (S_1W_1 + S_2W_2 + S_3W_3)$$

Scores
- $S_1 = \text{OM}$
- $S_2 = \text{pH}$
- $S_3 = \text{compact}$

Weights
- $W_1 = 0.3$
- $W_2 = 0.2$
- $W_3 = 0.5$
<table>
<thead>
<tr>
<th>Parameter</th>
<th>V</th>
<th>S</th>
<th>W</th>
<th>SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOM</td>
<td>3</td>
<td>0.8</td>
<td>0.3</td>
<td>0.24</td>
</tr>
<tr>
<td>pH</td>
<td>8</td>
<td>0.5</td>
<td>0.2</td>
<td>0.10</td>
</tr>
<tr>
<td>Compaction</td>
<td>400</td>
<td>0.8</td>
<td>0.5</td>
<td>0.40</td>
</tr>
<tr>
<td>SQI</td>
<td></td>
<td></td>
<td></td>
<td>0.74</td>
</tr>
</tbody>
</table>

Soil B

<table>
<thead>
<tr>
<th>Parameter</th>
<th>V</th>
<th>S</th>
<th>W</th>
<th>SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOM</td>
<td>4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.12</td>
</tr>
<tr>
<td>pH</td>
<td>8</td>
<td>0.5</td>
<td>0.2</td>
<td>0.10</td>
</tr>
<tr>
<td>Compaction</td>
<td>800</td>
<td>0.1</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>SQI</td>
<td></td>
<td></td>
<td></td>
<td>0.27</td>
</tr>
</tbody>
</table>
Healthy

Physical

Biological

Trees

Urban

Chemical
Literature


Thank you

bryant.scharenbroch@uwsp.edu

ISA Course Code: PP-20-003
Subangular blocky
Angular blocky