Urban Soils and Tree Health in the Built Environment
“The stuff that lies beneath the grass isn’t dirt. It is the elixir of life.”

Phillip J. Craul

As quoted in the Geraldine R. Dodge Foundation Report, 1996, p.69
• Trees are living systems driven by chemical and biological processes

• Understanding how trees and soil are connected is important because soil is the foundation within which a tree grows

• Trees must obtain oxygen, water, and essential nutrients to meet daily energy requirements from the soil in which it is growing
What Large Trees Mean

- More shade = more energy savings
- Cleaner air = better health and fewer hospital visits
- More stormwater management = lower costs for stormwater controls
- More shaded streets = longer time between resurfacing
“The mortality rate for urban trees is very high, with studies suggesting that 40% to 60% of (newly planted) urban trees die within the first 10 years”

Bryant Scharenbroch
Director, The Morton Arboretum Soil Science Laboratory
A Brief History of the Appalachian Mountains

- Approximately 300mya the Appalachian Mountains and Stone Mountain were formed by a continental collision with Africa.
- Mountain peaks were estimated to be as high as 30,000 feet.
- From approximately 300mya to present these Appalachian mountains have been eroding to provide us with the soils we see today.
The Evolution of Trees

- First woody land plants appeared approximately 370mya.
- The earliest trees were conifers (monocots) appearing approximately 220-195mya.
- Tree types we would recognize today (dicots) appeared approximately 140-70mya.
Figure 120: Millwood Plantation belonged to James Edward Calhoun, descendant of early South Carolina farmers. Erosion from poor farming practices common in the region is visible in the foreground.
PROPERTIES OF SOIL

**PHYSICAL:**
- Parent Material
- Texture
- Structure
- Soil Horizons

**CHEMICAL:**
- pH
- Buffering Capacity
- CEC

**BIOLOGICAL:**
- Rhizosphere
- Mycorrhizae
- Nutrient Cycling
A Soil Profile

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**O horizon** - Leaf litter and other organic debris

**A horizon** - A surface mineral horizon showing coloration due to organic matter accumulation

**B horizon** - A subsurface horizon showing depletion of organic matter and an accumulation of clay. Clay is typically iron and aluminum based compounds.

**C horizon** - A subsurface layer of soil forming parent materials. Could be weathered rock, unconsolidated floodplain sediments or loose sands

**R horizon** - Hard bedrock
A healthy food web is critical for nutrient cycling within the rhizosphere
Litter input includes leaves, stems, roots, and dead animals.

Small organic compounds and inorganic nutrients are released into the soil solution, from which they can be taken up by plants and microorganisms.

Animals living in the soil break the litter into progressively smaller fragments, increasing its surface area.

Bacteria and fungi release enzymes that act on the exposed surfaces of the fragments to convert organic macromolecules into soluble nutrients.
Healthy, biologically active soils are the single most important factor for tree growth
CHEMICAL PROPERTIES OF SOIL

Range of pH common for humid-region soils

Range in pH for arid-region soils

Range in pH for most inorganic soils
• pH of 6.0 to 7.0 is favorable for most plant growth
• An important effect of pH on tree growth is the availability of essential nutrients
• At certain pH levels, nutrients may be made insoluble
• In acidic soils aluminum will become soluble
• In alkaline soils iron and manganese may be unavailable
In the Piedmont, the parent material is acidic. We set the plants up for failure before they are even planted.

- The igneous and metamorphic parent material of the Piedmont is predominantly an Alumnosilicate rock.

- In an acidic environment, aluminum is released into the soil solution forming $\text{Al}^{3+}$. This is toxic to the apical meristem of plants, restricting root growth, or even killing the plant.
This is what we should be planting in.

- Low pH
- Aluminum Toxicity
- No Organic Matter
- No Biological Activity
- No Nutrient Cycling

This is the soil that the tree actually gets planted in.
Roots unable to penetrate severely compacted soils will redirect to the surface with very little drought tolerance.
When water replaces air in pore space, it slows the diffusion of oxygen to 1/10,000 of that in air. Literally suffocating the root system.
An estimated 80% of urban tree problems can be attributed to a poor soil environment.
SO WHAT DO WE DO?
Invigorating Sterile Soil to Improve:

Soil Properties and Soil Microbiology

- Soil fracturing to relieve soil compaction
- Add Gypsum to remediate soil properties
- Mix 5% to 10% COMPOSTED wood mulch into the planting bed
- Incorporate organic soil amendments
Pneumatic Soil Fracturing
Gypsum is one of the earliest forms of fertilizers, in use for more than 250 years in the United States.

- Gypsum can improve physical and chemical properties of soil.

- Currently a large amount of flue gas desulfurization (FGD) gypsum is produced from coal fired electric generating plants that is suitable as a soil amendment.
Figure 2-8. Gypsum as a soil amendment to remediate subsoil acidity. Gypsum is 200 times more soluble than lime and calcium and sulfur movement into soil profiles is enhanced by the addition of gypsum. (Sumner and Larimore, 2006.)
Benefits of Composted Wood Mulch

- Reduce evapotranspiration
- Insulates soil from temperature extremes
- Adds soil microorganisms and macroinvertebrates
- Improves soil physical properties
Southern Organics & Supply

Ron Danise
4813 East Fork Lane
Monroe, NC 28110

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How mulch works

Sunlight

Mulch keeps sunlight from reaching the soil, minimising evaporation.

Rain

Mulched bed

Bare soil

Plant wilts from moisture stress.

Moisture is lost to evaporation.

Rain and sprinklers splatter and erode unmulched soil.

Soil

As an organic mulch breaks down, it releases nutrients that plants use.

Weed seeds germinate when exposed to light, but stay dormant under mulch.

Heat builds up.
The problem of connecting soil and trees in an urban setting:

• We only see the above ground portions of the tree
• Soil is given little value in urban environments
• Soil is poorly protected in urban environments
• Newly planted trees often have limited soil volume
• Soil compaction results from foot traffic and mechanical vibration
• There is often poor drainage in the urban soil profile
• Turf is often planted over tree root systems
• Typical urban soils are completely devoid of essential nutrients
• The urban soils we often plant in are likely to be sterile or even toxic to plant roots
Trees as Green Infrastructure

- Trees provide natural stormwater management
- Trees remove pollutants from the air
- Trees cool the surrounding environment

BUT

The trees have to be BIG
SO WHAT DO WE DO?
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# The Large versus Small Stature Tree Argument

## Table

<table>
<thead>
<tr>
<th>Choice A</th>
<th>Choice B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Trees</td>
<td>$65.18</td>
</tr>
<tr>
<td>Medium Trees</td>
<td>$36.04</td>
</tr>
<tr>
<td>Small Trees</td>
<td>$17.96</td>
</tr>
<tr>
<td><strong>Total Trees</strong></td>
<td><strong>2,705</strong></td>
</tr>
</tbody>
</table>

Note: Each “tree” represents 259 trees planted.
Black Castings™
(1-0.5-0.2)

ALL NATURAL ORGANIC PLANT FOOD

Lawns, Turf, Trees & Shrubs
Fruits
Gardening & Houseplants
Vegetables

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Environmentally friendly - Does NOT burn
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Reduces watering requirements - Promotes greater root systems

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Available Phosphoric Acid (P₂O₅) derived from Phosphate Rock.

SEE BACKSIDE FOR
Optimal conditions for NutriSmart™ to perform.

CAUTION
Dust from this product may cause irritation to the eyes and nose. Avoid contact with eyes and skin. Avoid inhaling dust.

HANDLING AND STORAGE
• Always keep granules dry and intact before application.
• Always wear protective gloves.
• Store bags and product in cool and shady areas away from humidity, high temperatures, fungicides, and strong magnetic and electric fields.

Net Weight: 50 pounds (22.7 kg)
Expiration Date: Batch Number: Date coded on side of bag
Soil Profile

- A soil profile is a vertical cross section of a soil, showing the soil horizons.
- The soil profile may be altered by land disturbing activities such as grading, cutting and filling, and agricultural practices.
Soil is an ecosystem containing billions of organisms
Physical Properties of Soil