Assessing & Mitigating Urban Soil

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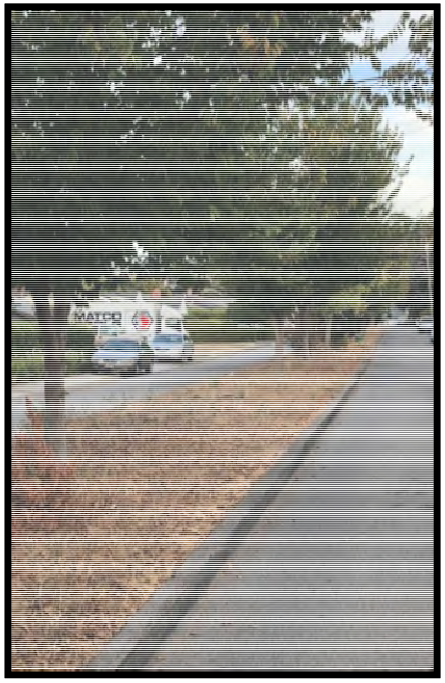
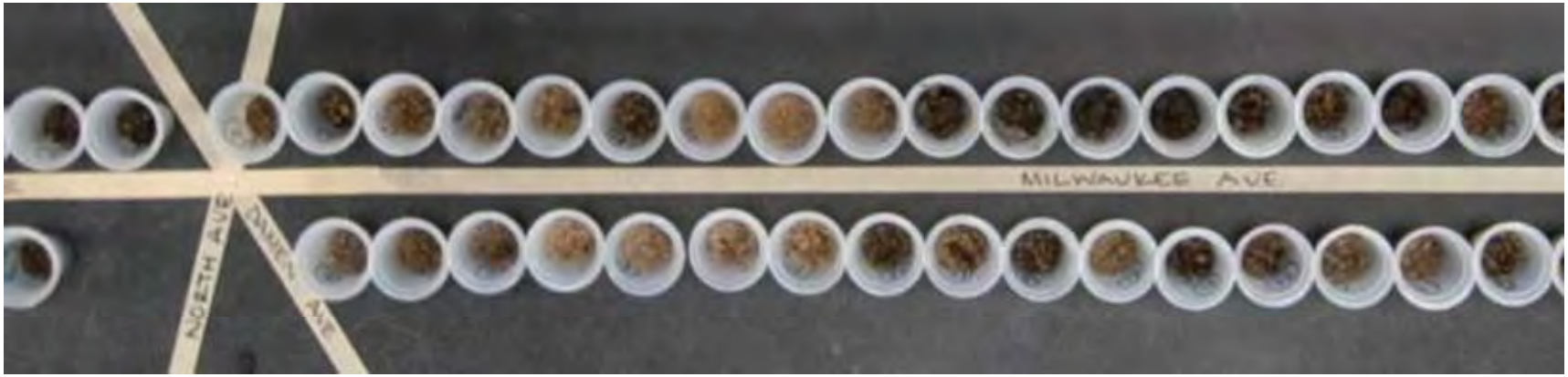
Texas Tree Conference 2019

Urban soils are…

- Disturbed
- Compacted
- Nutrient deficient
- Low organic matter
- Shallow / limited volume
- "Dead" (no microbes)
- **<u>DIVERSE</u>**



Huge differences in soil may exist, even on the same urban street



Urban soils are…
often limiting to tree growth + health

- Disturbed
- Compacted
- Nutrient poor
- Low organic matter
- Shallow / limited volume
- "Dead" (no microbes)
- **DIVERSE**

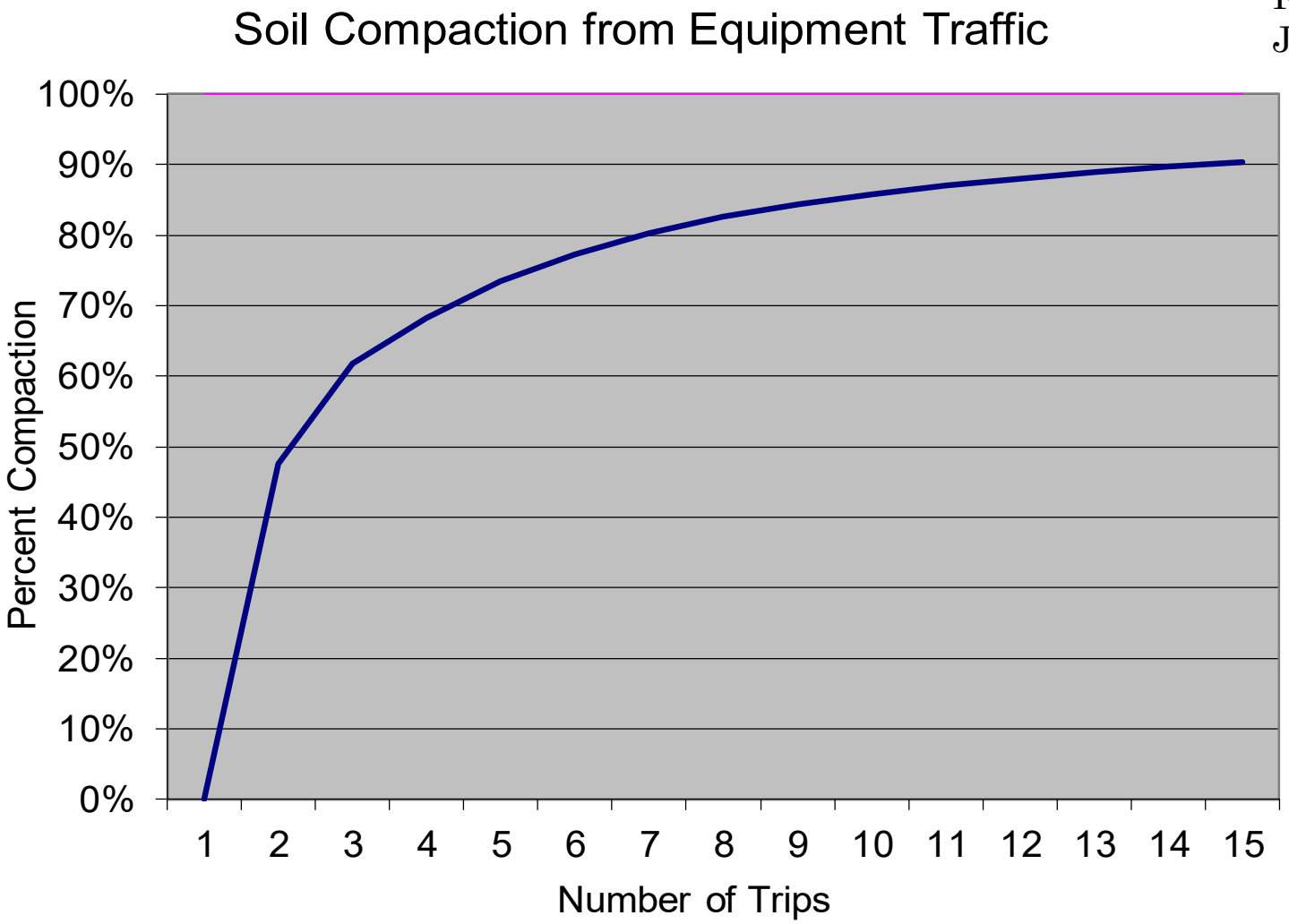
Compaction

- Restricts root growth
- Restricts water penetration, distribution, drainage
- Sub-surface compaction can lead to surface rooting, damage to infrastructure.
  - Possible increased risk of failure

How does soil become compacted?

- Quickly:
  - Construction
- Longer term
  - Traffic (foot)
  - Rain (exposed soil)

Adapted from:
Kozlowski, 1999. Scand. J. For. Res. 14: 596-619

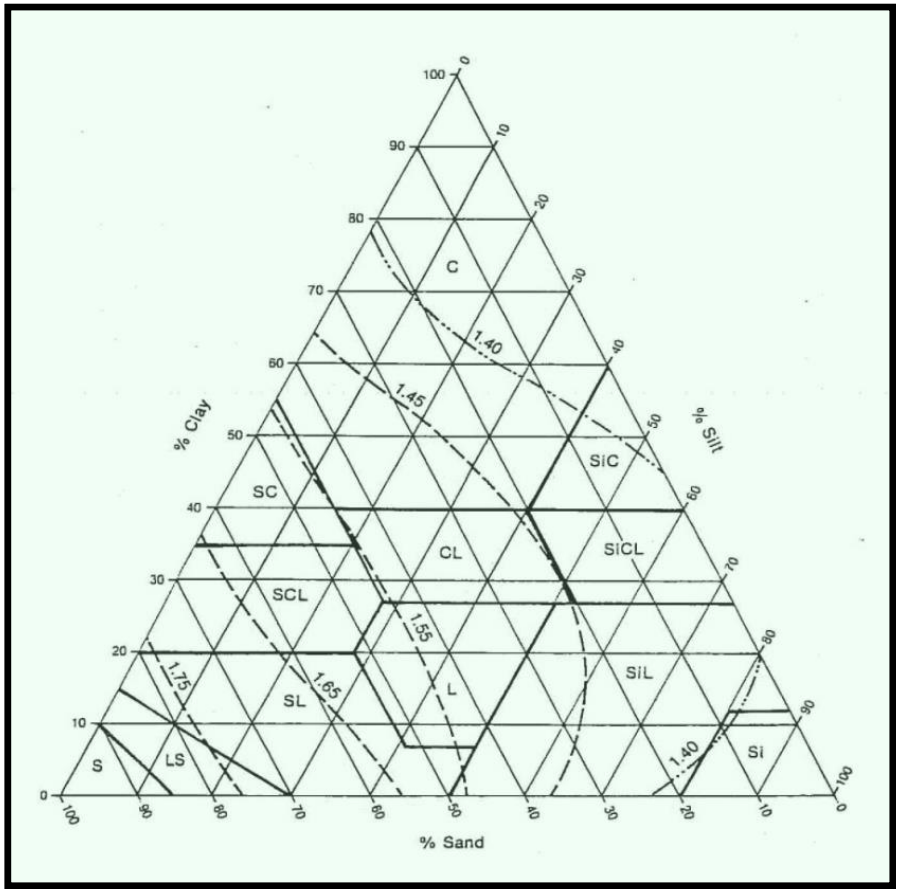


Assessing Soil Compaction

- Bulk Density Analysis
  - Density = Mass (dry) / Volume
  - Grams per cubic centimeter

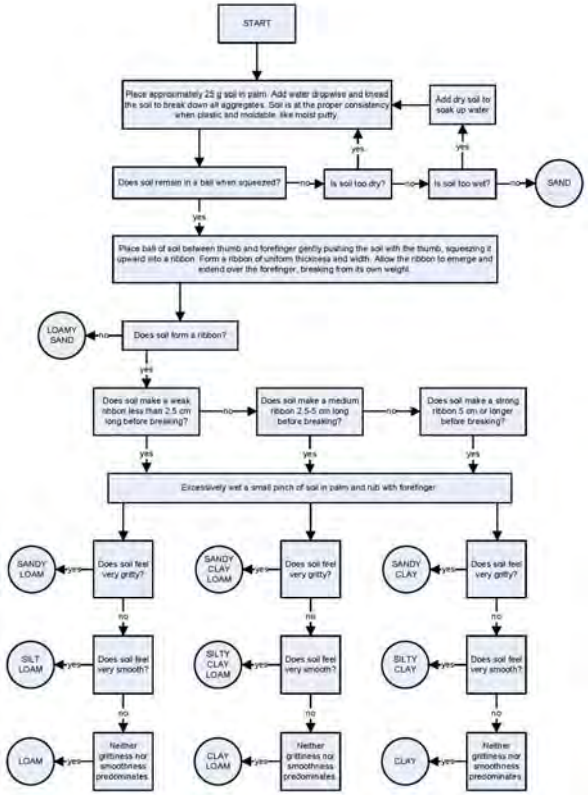
How compacted is ***TOO*** compacted?

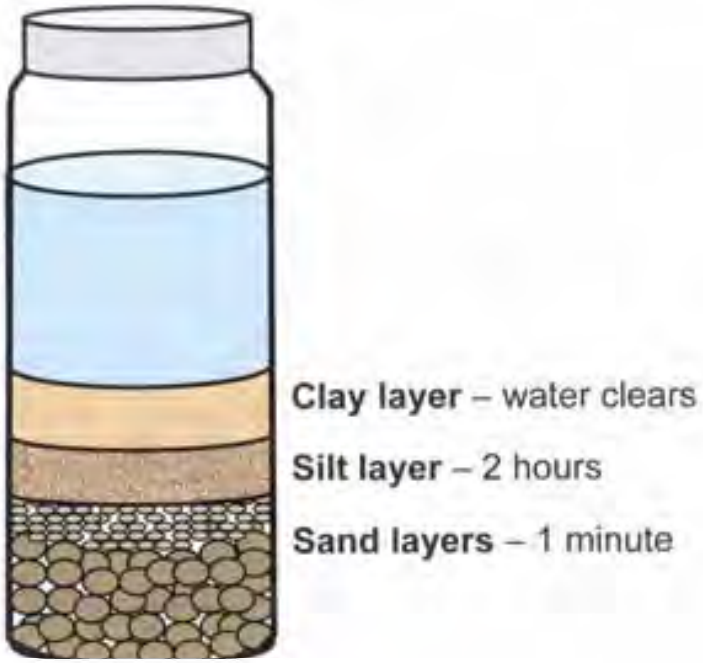
- It depends…
- Bulk Density = 1.55 g/cc
  - Is that restricting root growth?
- In clay, yes…
- In sandy loam, no.

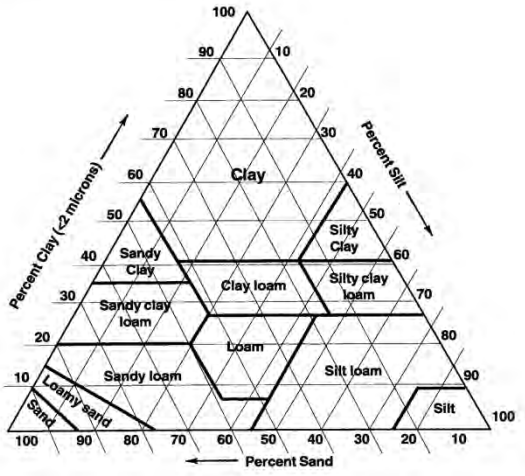


Assessing soil texture

- Soil 'ribbon test'
- Jar test

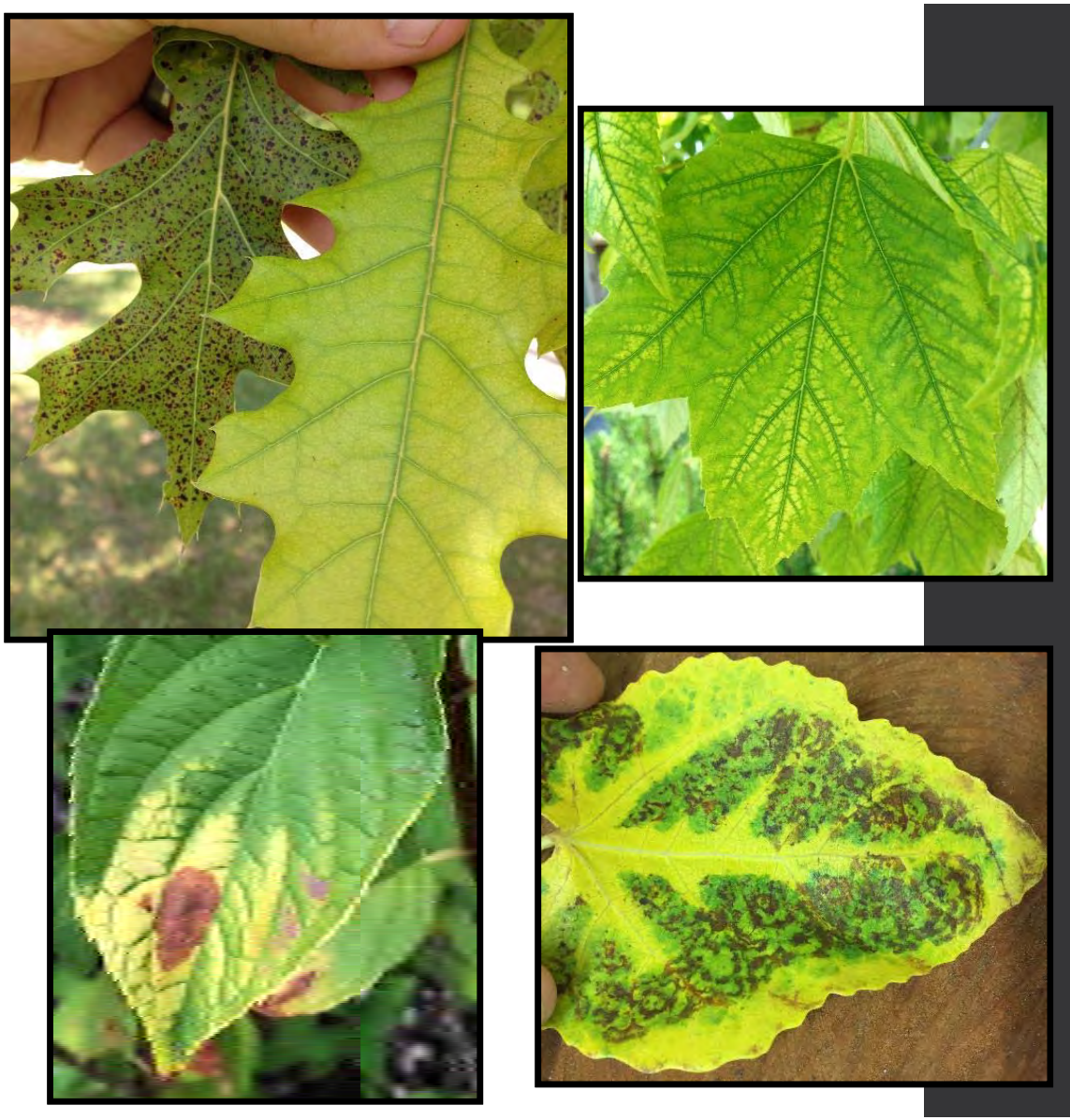






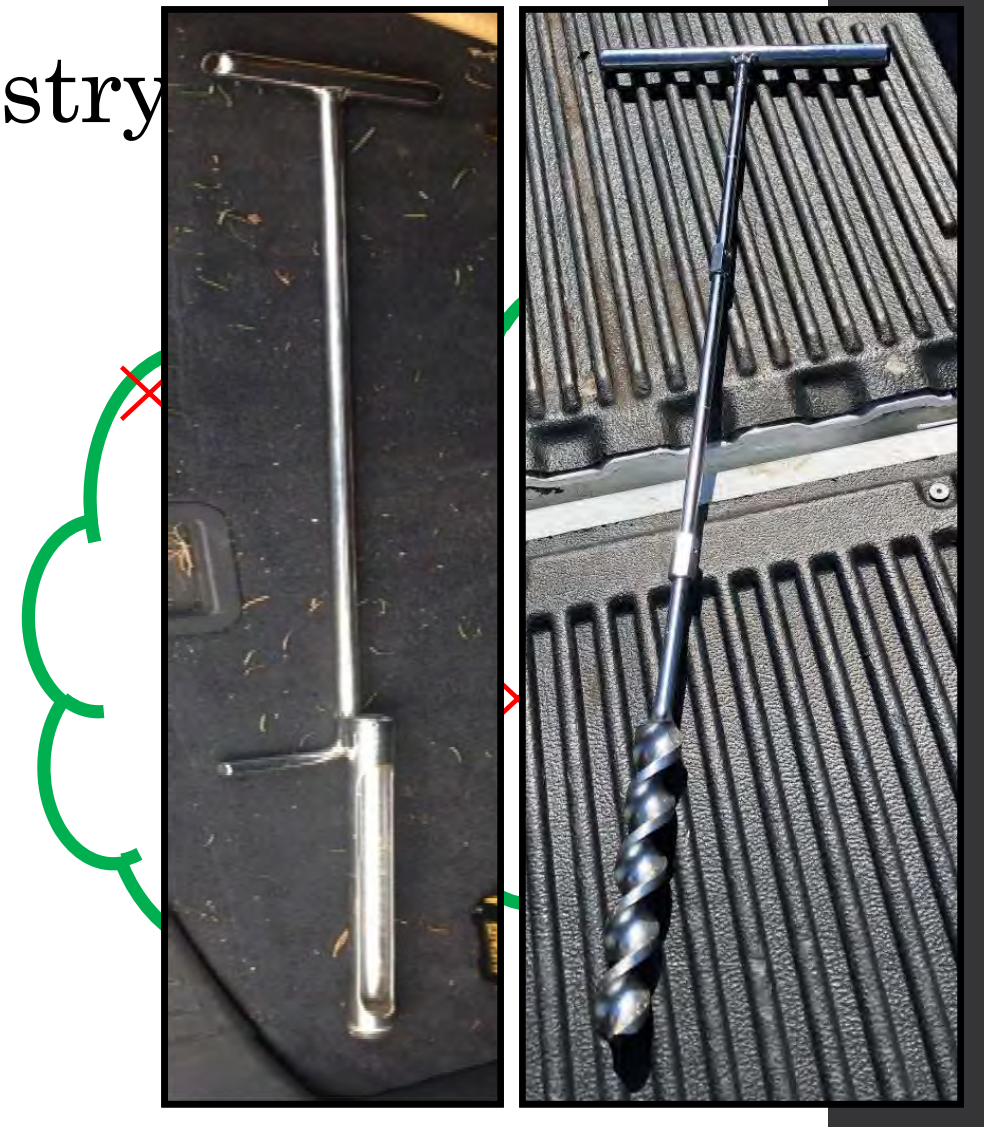
Soil Chemistry

- Nutrients
  - and Organic Matter
- pH – nutrient availability
- Impacts on:
  - Growth rate (C assimilation)
  - Growth partitioning (R vs S)
  - Defense compounds
  - Appearance
  - Stress tolerance



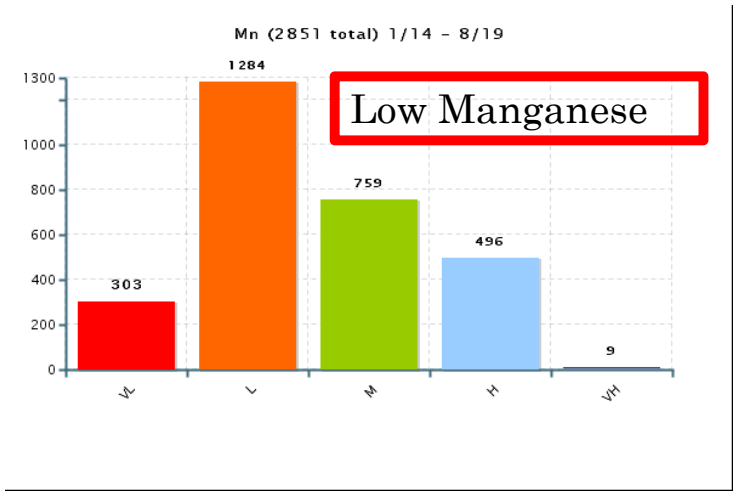
Assessing soil chemistry

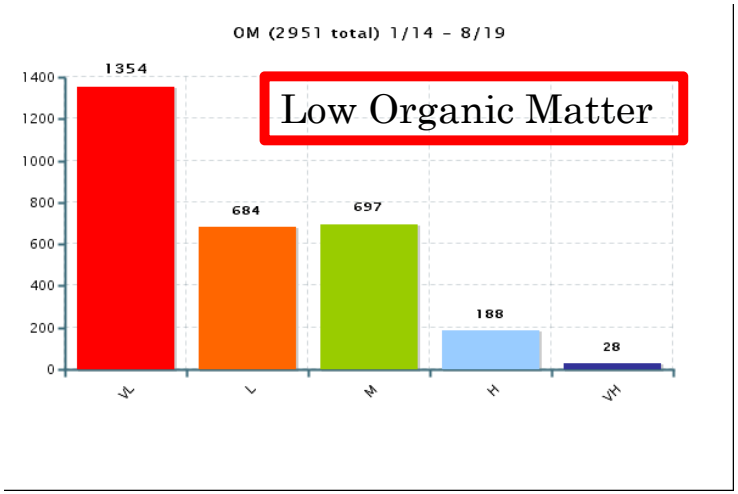
- Take the right sample
- Send to a lab
  - pH field kits are good
- "Right Sample"
  - Represents entire *root* zone
  - Remove roots / mulch / rocks
  - More samples = Better data



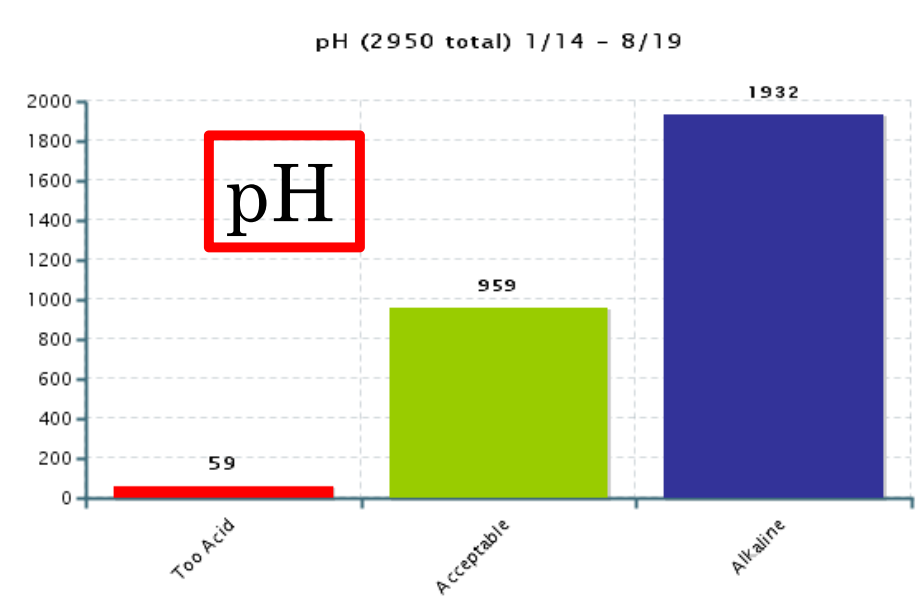
Common Soil Chemistry 'limitations' in Texas

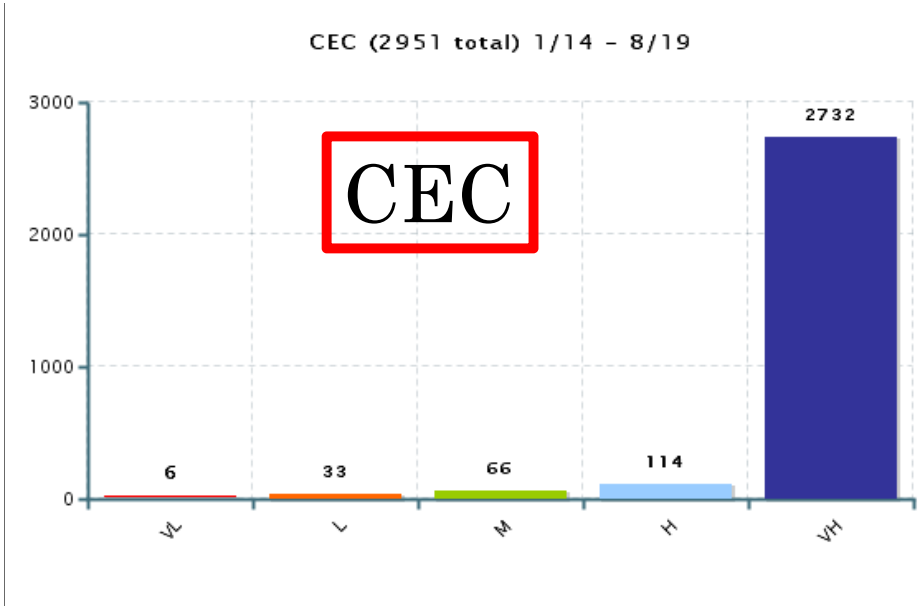
- Based on 3,000 samples from Bartlett arborists
  - More 'landscape' than 'urban' soils
  - Trends are more clear region by region
    - These data combine Houston, Dallas, Austin, San Antonio areas





High pH is major issue in Texas





- High Cation Exchange Capacity means pH is harder to change…

Problems associated with common soil chemical limitations in Texas

- Low Manganese
  - Reduces stress tolerance
    - Plays role in oxidation-reduction reactions, free oxygen quenching.
  - General cell function and maintenance
    - Co-factor for many important enzymes.
- High pH and CEC
  - Reduces availability of Iron and Mn
  - Highly buffered, hard to change pH in bulk soil
- Low Organic Matter
  - Soil structure, drainage, microbial community, N-available

Potassium – low in some areas

- Very important 'macro' nutrient for stress
  - Regulates stomata opening/closing – **limits water loss**
  - Involved in osmotic adjustment at root tips – **water uptake**
  - Transport of carbohydrates – **growth and repair**
  - Cell wall integrity – **cellulose synthesis and anti-fungal**

The Critical Role of Potassium in Plant Stress Response

Min Wang, Qingsong Zheng, Qirong Shen and Shiwei Guo *

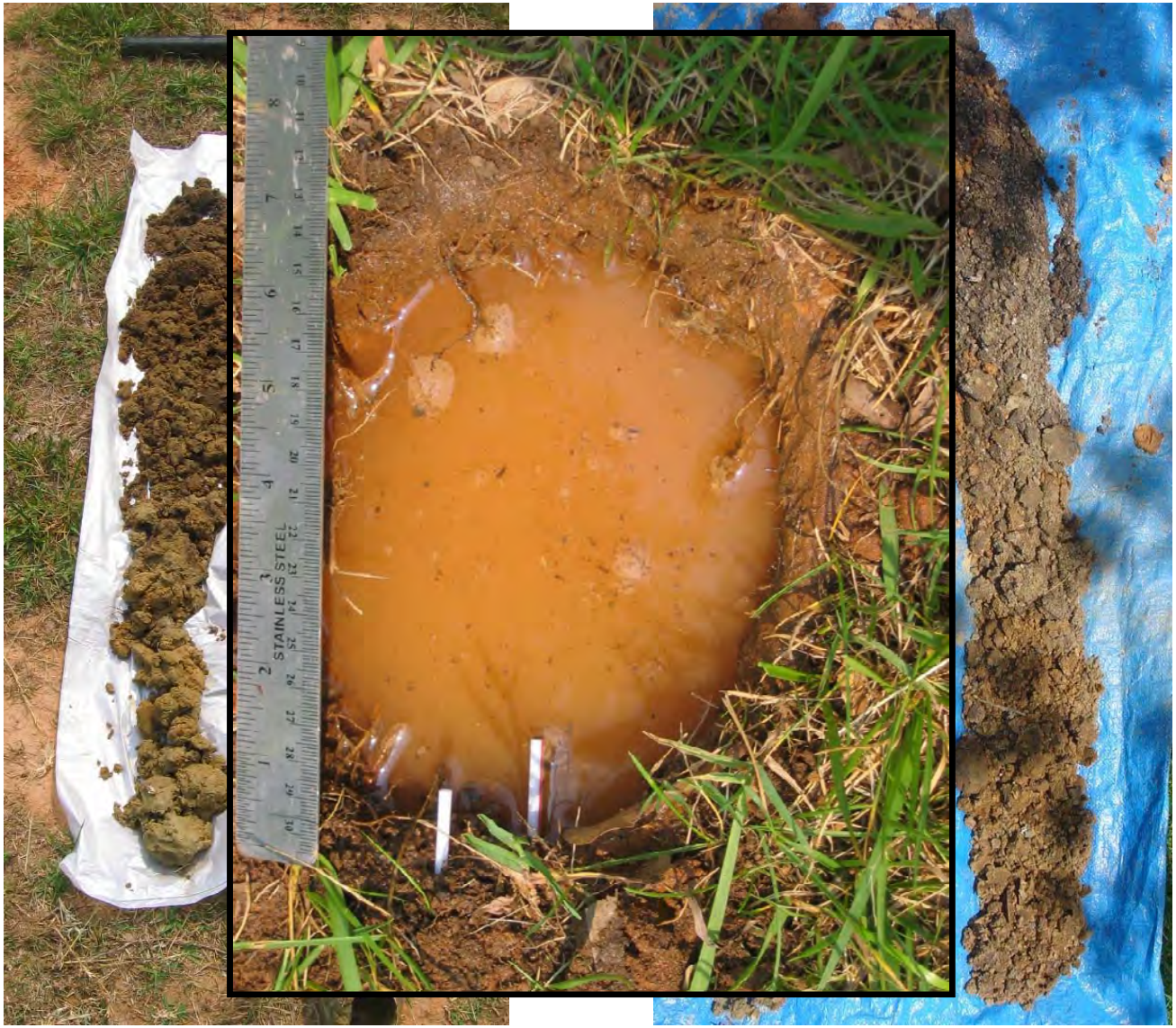
International Journal of **Molecular Sciences**

Int. J. Mol. Sci. **2013**, 14, 7370-7390

Soil Profile Analysis

- The best way to know what is wrong…

- Of note:
  - Roots (where)
  - Color change
  - Smell
  - Texture change
  - Sub-surface layers



Review: what to assess

- Compaction – Bulk density
  - Combined with **soil texture** analysis
- Soil Chemistry – lab testing
  - Nutrients, pH, CEC, organic matter content
- Profile analysis – auger
  - Color, smell, drainage, root locations, texture, material
  - Changes in any of the above through profile
- Volume…

Rapid Urban Site Index…

- Great idea, not mine
  - Bryant Scharenbroch, et al. 2017. "A rapid urban site index or assessing the quality of street tree planting sites". Urban Forestry & Urban Greening, 27 (279-286)

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

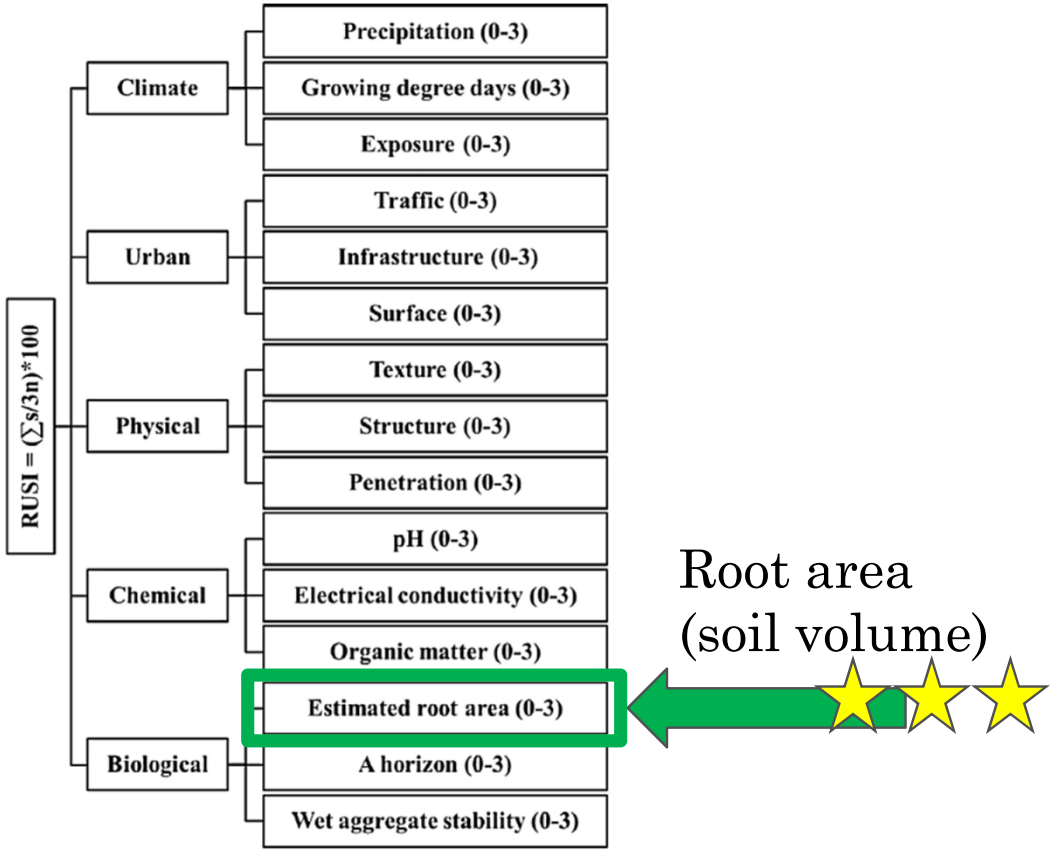
Original article

A rapid urban site index for assessing the quality of street tree planting sites

Bryant C. Scharenbroch[a,b,*], David Carter[c], Margaret Bialecki[d], Robert Fahey[b,e], Luke Scheberl[a], Michelle Catania[b], Lara A. Roman[f], Nina Bassuk[g], Richard W. Harper[h], Les Werner[a], Alan Siewert[i], Stephanie Miller[j], Lucy Hutyra[k], Steve Raciti[l]

15 Parameters, about 5 minutes

- Scored 0-3
- Tested in 8 cities
- Some factors more important than others
- Volume was most important



Same site, same age, same soil, same species, same climate, same pollution, same etc. etc. etc.

Soil-related Plant Health Issues

- Compaction & Poor Drainage lead to saturation
- Saturation often leads to:
  - Ambrosia beetles
  - *Phytophthora* root disease

Flooding and Beetles

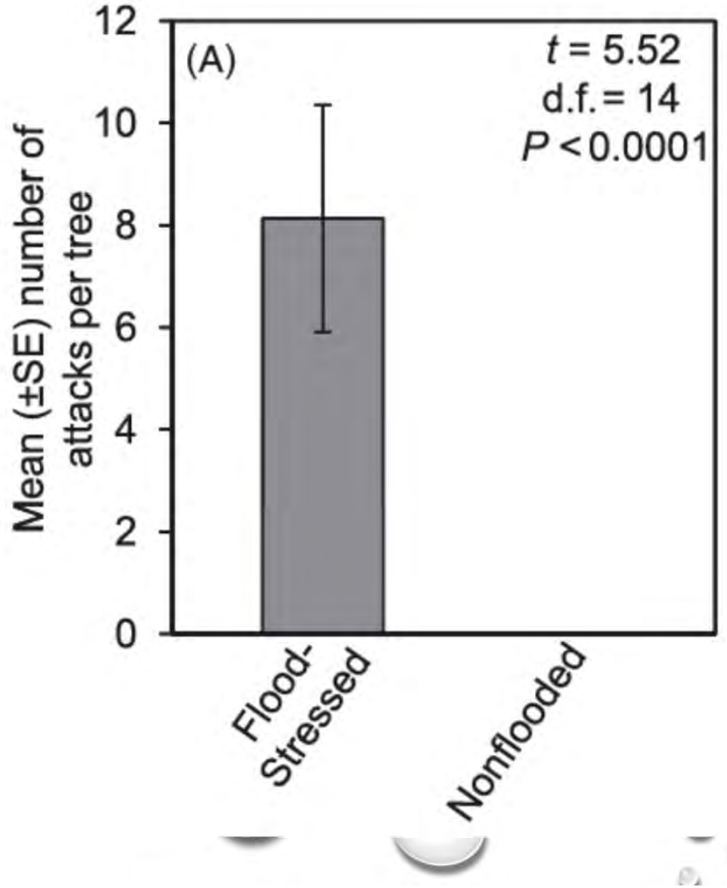
- Generally – stressed plants more attractive to borers
  - Ethanol is common cue, even if it is not flooding-related
  - Some beetles require plant stress to overcome defenses (pines)
  - Others attack healthy trees (especially exotic species)

- Flooding & Beetle Attack link very clear with Ambrosia beetles
  - Beetles introduce ‘ambrosia’ fungi to feed larvae
  - Do not feed on plant tissue (harder to control)
  - Fungi vary in pathogenicity, some quite lethal

Research: flooding & ambrosia beetles

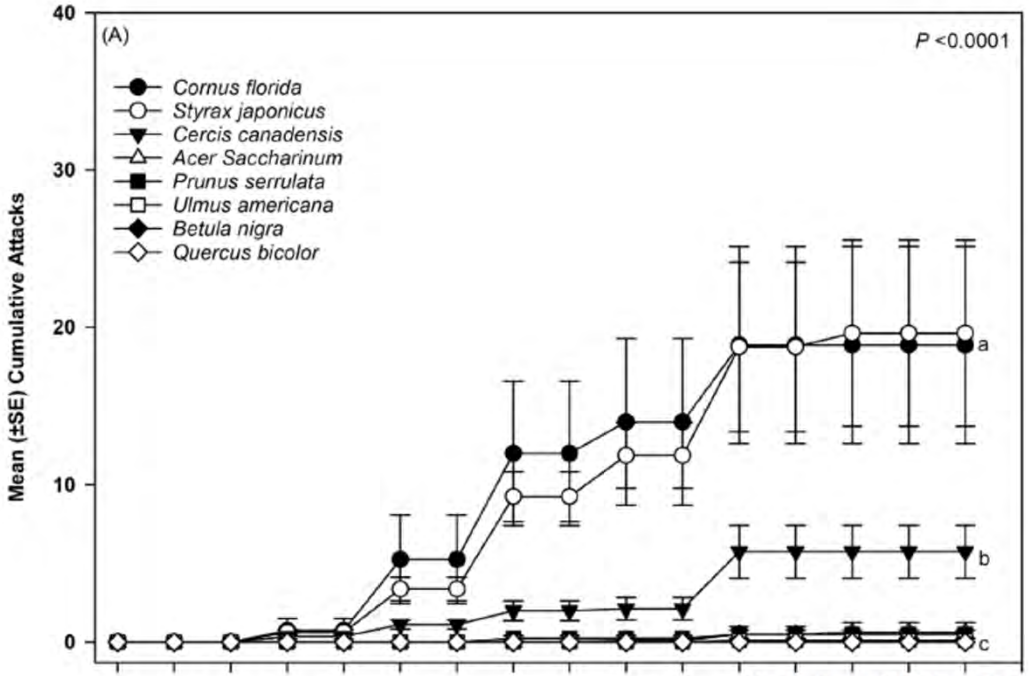
- Experimentally flooded dogwoods
- Very clear-cut results
- Ethanol was major attractant
- Ranger et al. 2013

Agricultural and Forest Entomology (2013), **15**, 56–64



Results Varied by species, tolerance

- Not all trees are so quickly stressed
- Species native to wet areas were not impacted
  - Swamp white oak
  - River birch
  - Creek maple (silver)
- Again linked to ethanol



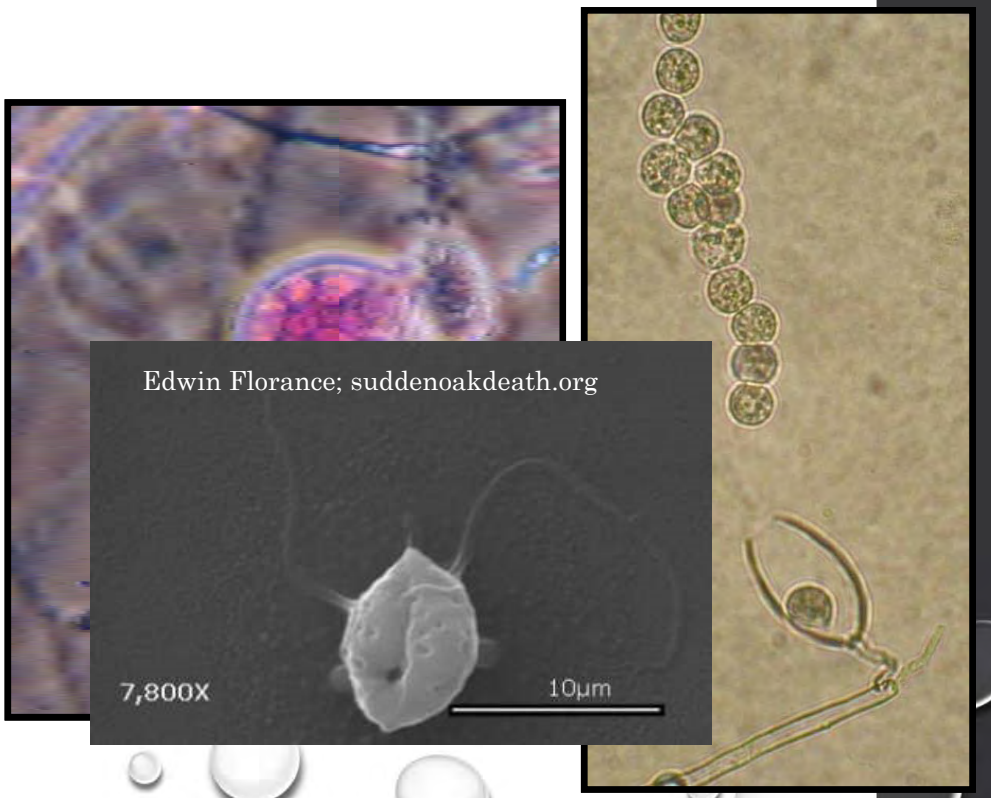
Citation: Ranger CM, Schultz PB, Frank SD, Chong JH, Reding ME (2015) Non-Native Ambrosia Beetles as Opportunistic Exploiters of Living but Weakened Trees. PLoS ONE 10(7): e0131496. doi:10.1371/journal.pone.0131496

Flooding and Root Disease

- *Phytophthora* root disease
- Dozens of pathogenic species
  - Thousands of host plants
- Life-cycle directly linked to soil saturation
- Phyto / phthora = Plant / destroyer

Phytophthora needs saturated / flooded soil to cause disease

- 'Sporangia' produce 'zoospores' very quickly when saturated
- Infective spores (z) literally swim
  - Have 2 flagella
- Chemically attracted to roots
  - Stressed roots more attractive



Phytophthora – most common when soils are occasionally saturated

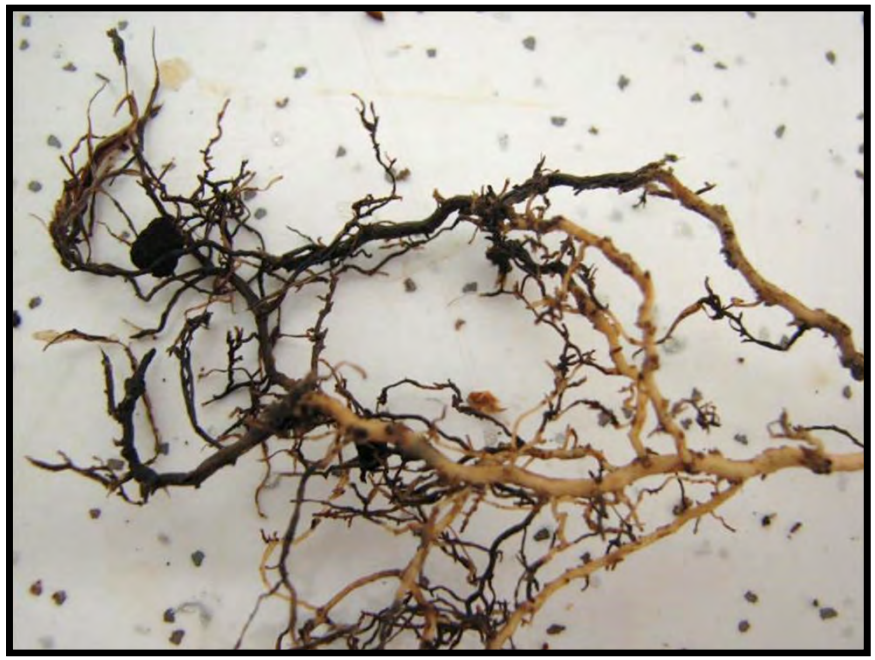
- Poorly drained, clay soils
- Over-irrigated
  - Especially when irrigation is designed for turf
- Near downspouts (gutters)
- Low areas in landscape

Phytophthora diagnosis can be tricky

- There are no 'signs' of infection
  - No mushrooms or conks
  - No odor
  - All features are microscopic
- Conditions that promote disease can harm plants directly
  - Poor drainage
  - Compacted soil
  - Over-irrigation
  - Low organic matter

Must inspect / test roots

- Look For:
  - Dark discoloration
  - Easily break when pulled
  - Lack of fine roots
  - Root sheath easily sloughs off



Mitigation Options

- Depend on the limiting factor(s)

In some cases… no good options

Soil Chemistry - Mitigation

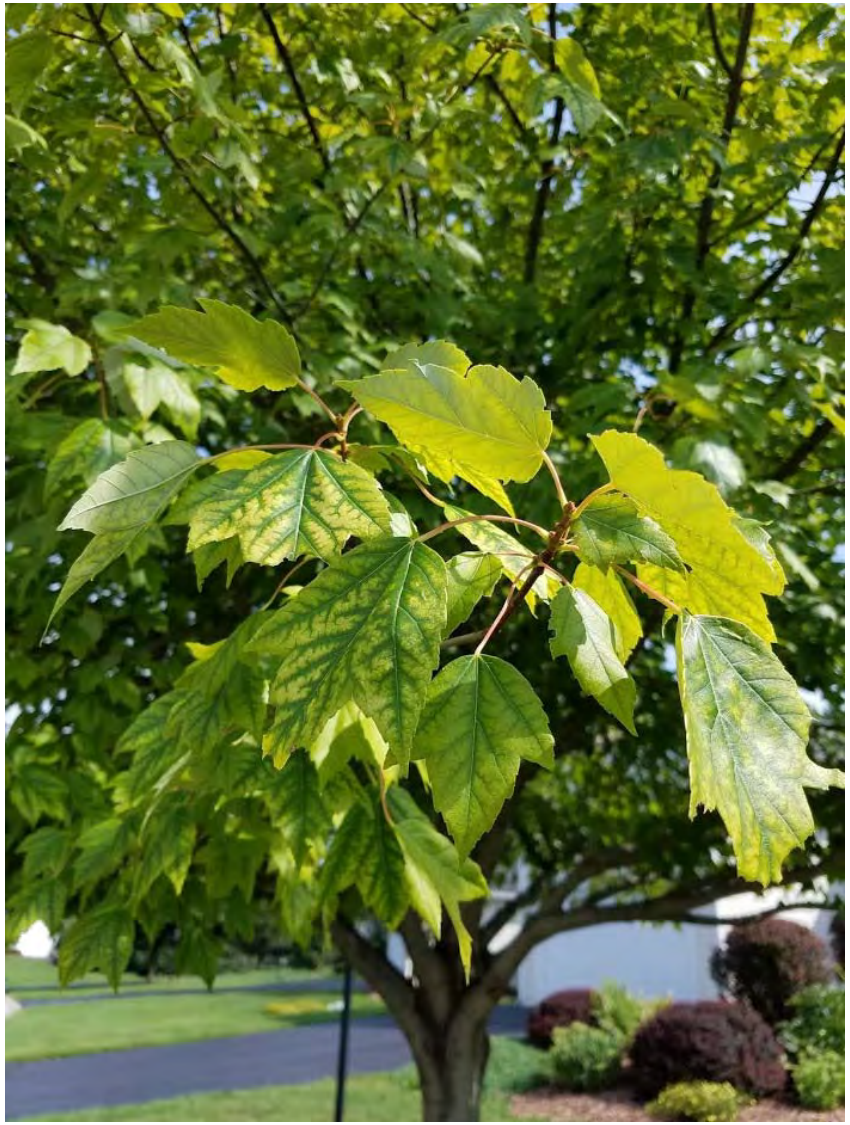
- Nutrients unrelated to pH – just add more
- Change soil pH?
- Extremely difficult
  - High CEC buffers change
  - Can't change parent material
- Improving pH limited uptake without changing soil pH
  - Injections?
  - Other options

Trunk - Injections are effective, but…

- Drilling holes
- Injecting concentrated nutrients
- Possible phytotoxicity
- Annual, repeat injury

Investigating high-concentration chelates and liquid acidifiers

- EARLY in the trials!!!!!!
- Some promising results
  - High variability
- Mn and Fe chelates with or without acidifying liquids



Create better soil

- What if we could…
  - De-compact soil
  - Add nutrients according to analysis
  - Improve drainage
  - Add organic matter

Using a pressurized air device…

- De-compact
- Amend
  - Nutrients
  - Organic matter
  - Biochar
  - Mycorrhizas (?)
- Mulch
- Water

Austin, TX

2007

2013

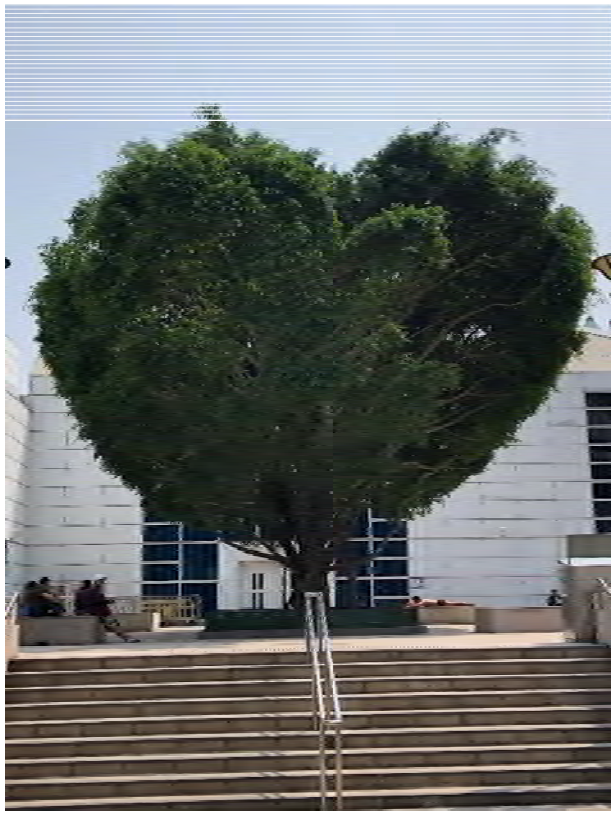
Q. fusiformis
San Antonio, Texas
January 2007 – January 2009

August 2006

August 2007

Lagerstroemia indica

Suitable for urban areas, with some protection for surroundings



More details:

- US patent description: US6845587B2
- Papers by Dr. E. Thomas Smiley

Arboriculture & Urban Forestry 2011. 37(6): 293–300

ISA International Society of Arboriculture

ARBORICULTURE & URBAN FORESTRY
Scientific Journal of the International Society of Arboriculture

Evaluation of a Soil Decompaction and Amendment Process for Urban Trees

Kelby Fite, E. Thomas Smiley, John McIntyre, and Christina E. Wells

Thank You!

TEXAS TREE
conference

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