BMPs for Healthy Tree Roots in Urban Environments

Alison O'Connor, PhD
astoven@larimer.org
csuhort.blogspot.com

COLORADO STATE UNIVERSITY EXTENSION

Please note!

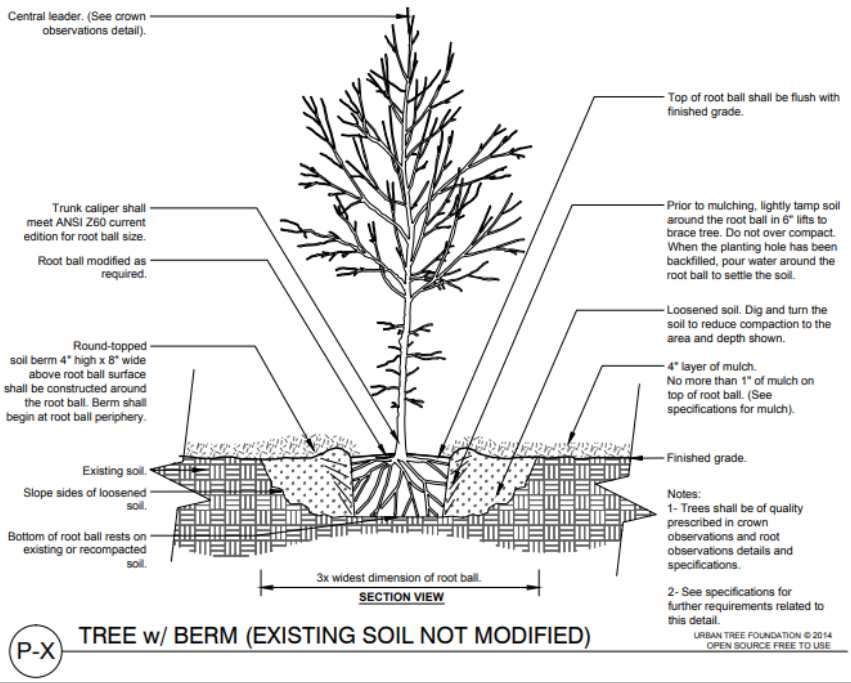
- I have removed some of the photos that I presented in class, but retained all content. The photos were given to me from fellow researchers and I want to respect their copyrights.
- If you have any questions or need clarification on the content, please email me: astoven@larimer.org
- Thanks for attending ProGreen 2019!

Urban Tree Foundation Specs

- Updated ANSI A300 specs
- Dr. Ed Gilman, Jim Urban, Brian Kempf and Tyson Carroll have developed a modern, up-to-date and peer-reviewed set of details and specifications in AutoCAD and PDF formats for the green industry
- These should be the currently used specifications for all woody plant material aspects of planting and installation

https://hort.ifas.ufl.edu/woody/details-specs.shtml

Or Google “planting specs U of Florida”



In a perfect world, a successfully transplanted tree will:

- Have a properly developed root system
  - No circling roots, J-roots, girdling roots
- Establish quickly with rapid root growth into the landscape soil
  - In ideal conditions, trees, regardless of production method, would have equal root growth to each other

Tree Size and Establishment

In Hardiness Zones 4-5 with good soil conditions, **root establishment takes one season per inch of trunk caliper**.

<u>With good planting techniques</u>

- 1” tree = 1 year
- 2” tree = 2 years
- 3” tree = 3 years

Big Trees or Small Trees?

- Pros of large trees
  - Instant landscape
  - Larger trees increase properly values immediately
  - Greater shade potential
  - Environmental benefits
  - Less potential to vandalism
- Cons of large trees
  - Expense
  - More difficult to transport and plant
  - Additional labor needed
  - Longer production and carrying time for nurseries
  - Bigger planting hole
  - Greater potential for transplant shock

Texas A&M's Study

- Three tree species (red maple, bald cypress and chaste tree) were grown in five container sizes and planted into two different landscape environments (#s 1, 3, 7, 25, 45)
- Growth was compared for the first season and beyond

Garcia-Chance, L. et. al. 2016. Differential Environments Influence Initial Transplant Establishment Among Tree Species Produced in Five Container Sizes. J. of Arboriculture. 42(3): 170-180.

What Did They Find?

- Red maple and bald cypress trees from #3 containers (3 gallon) exhibited the best growth after the first season
- All three species transplanted from the #25 and #45 containers grew poorly
- Trees from the smaller containers established more quickly and grew better than the larger plants

Three Years Later…

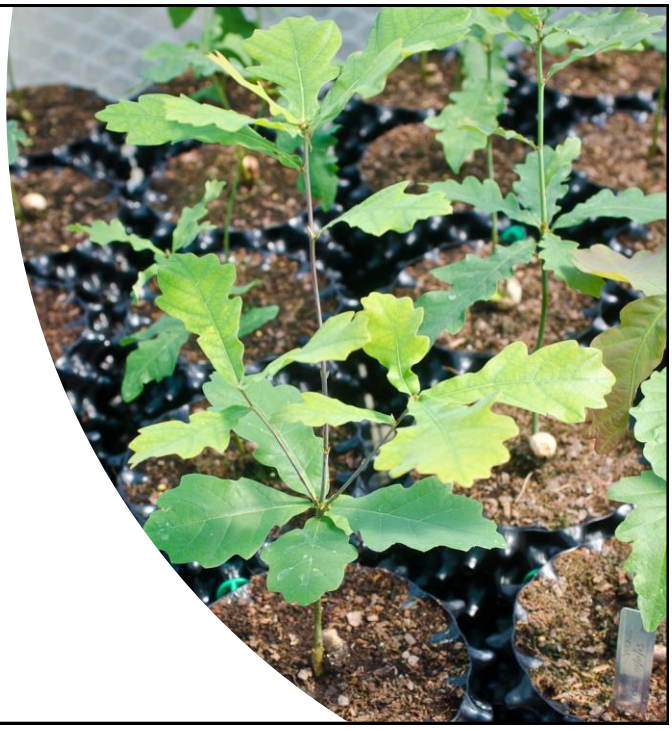
- The chaste tree planted from #1 containers caught up to and grew more than the trees from #45!
- Bottom line: All trees from #3 and #7 containers recovered more quickly from planting and reached establishment sooner
- *The bottom line*: Planting smaller trees, if possible, is a great option

Economics: the bottom line

- Cost analysis after two growing seasons indicated a greater increase in value for #3 and #7 trees compared to losses in value for some #45 trees
- Trees from smaller size containers experienced shorter establishment times and increased growth rates, thus creating a quicker return on investment for trees transplanted from the smaller container sizes
- Also trees in #3 containers cost eight times *less* to plant than the #45 trees

Nursery Production Practices and Planting

- How trees and shrubs are grown does matter
- Liner production—root structure
- Initial planting depth of liners into containers
- Container type
- Field production practices
- Harvest methodology



Important Points About Landscape Roots

- They are not as deep as you think
  - Most smaller roots are in the upper 12” of the soil profile
- Typically grow above the water table and the hard pan
- Main roots should grow more or less straight out from the trunk
- Ed Gilman: “Straight roots! Some at the surface!”

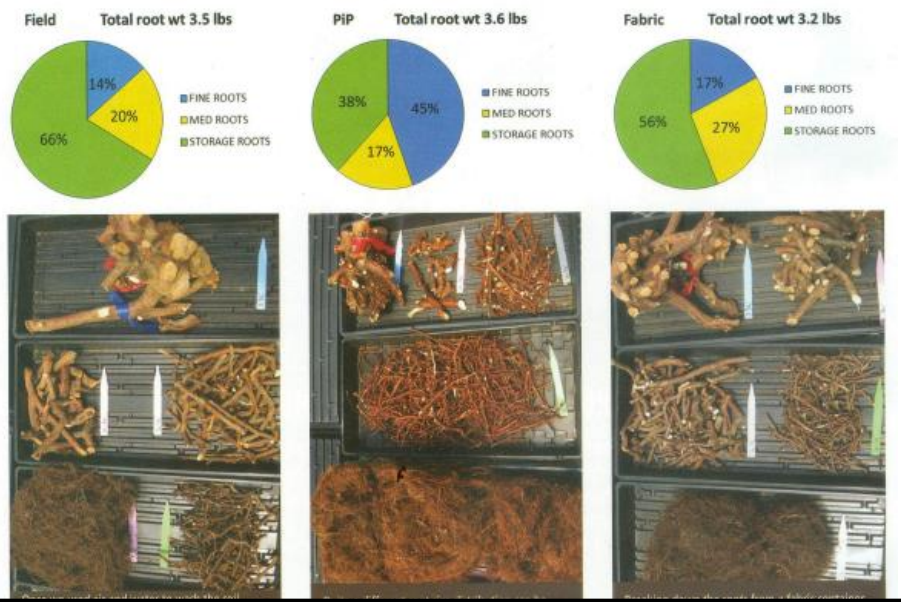
Production Method Can Affect Establishment

- The study compared B&B trees, pot-in-pot trees and in-ground fabric containers using swamp white oak and river birch
- Trees were grown to 2” caliper before harvesting
- Tree height and trunk were similar for the oaks; river birch was larger in B&B trees
- Root defects were most severe in PiP trees; fabric containers had few circling roots

University of New Hampshire and University of Massachusetts (2014)

Neal, C. and D. Lass. Getting to the Roots: Production Effects on Tree Root Growth and Morphology. American Nurseryman. July 2014.

Production Method Can Affect Establishment



After planting in the Landscape

- All production types established new roots after 18 months and increased caliper up to 3.7" (B&B)
- Circling roots from unpruned PiP root balls were prominent and enlarged
  - Root pruning at transplant corrected problems and no additional defects were observed
- Trees from fabric containers had generally good root structure

In a perfect world, a successfully transplanted tree will:

- Have a properly developed root system
  - No circling roots, J-roots, girdling roots
- Establish quickly with rapid root growth into the landscape soil
  - In ideal conditions, trees, regardless of production method, would have equal root growth to each other

Fixing bad roots at planting

- Growers are producing more containerized trees than B&B trees for many reasons
  - Shorter production cycles
  - Flexible marketing and shipping
  - More efficient use of nursery space
- For landscapers, containerized trees are light-weight and easier to handle

Correcting circling roots at planting

- Root manipulation prior to planting isn't a new idea
- The various approaches had mixed results in terms of improving root development and transplanting success
  - Scoring (vertical slits)
  - Teasing (pulling apart root systems)
  - Slicing (butterflying)
  - Shaving (cutting off a portion of the root ball)

A review of the research…

- Weicherding et al. (2007) measured new root growth of pot-pound littleleaf linden and willow that were subjected to teasing, scoring, and slicing—no difference in new root growth after 14 months after transplanting
- Gilman and Masters (2010) sliced root balls of live oak prior to planting and did not find effects on caliper or root development three years later
- Gilman et al. (2016) and Arnold (1996) found that scoring reduces circling roots, but it also increased moisture stress and decreased new root growth (especially when the bottom mat of roots were removed)

The Recommendation: Shave the roots

- Gilman and Weise (2012) found that shaving increases root growth into the backfill of the planting hole
- Gilman et al. (2016) found that shaving reduced circling roots AND increases new growth in maples
- Cregg and Ellison (2018) found that shaving increased new root growth, improved root architecture, and reduced circling roots

Shaving does work!

- Cregg and Ellison (2018) from Michigan State confirmed what Gilman found in Florida—root ball shaving increases root egress into surrounding backfill soil
- The four year study did not find improved growth (height, caliper) from shaving at planting, BUT the researchers speculate it will improve tree stability and fewer root issues long-term

Does shaving add to post-planting water stress?

- No. While you may remove up to 25% of fine root growth by shaving off the outer inch of a #25 container, there was no evidence of increased water stress
- However, water was routinely applied to the newly planted trees—an important component of any tree planting practice

Shaved Root Ball Biomass results

- Experiment 1 (loamy soil): In two growing seasons, trees expanded root growth outside the root ball by 66%
  - –Lots of roots near the bottom of the root ball
- Experiment 2 (clay, poorly drained soil): In four growing seasons, trees expanded root growth outside the root ball by 36%
  - –Lots of roots from sides of root ball

Planting trees correctly: depth

- There is extensive documentation of trees being planted too deeply, but what consequences does this have long term?
- Combination of both nursery and landscape practices
- A study conducted by the Morton Arboretum looked at root depth on established trees in Greensboro (VA), Snoqualmie (WA), and Glen Ellyn (IL)
  - Commercial property or residential site
  - Trees ranged from 5-10 years old
  - All trees B&B with a mulch ring

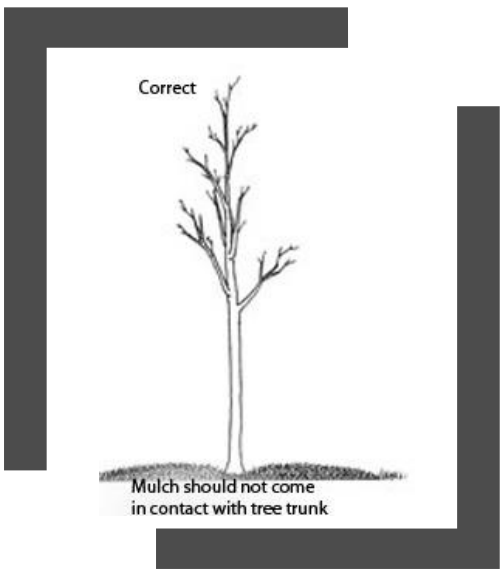
2012. Watson and Hewitt. The relationship between structural root depth and vigor of urban trees. Arboriculture and Urban Forestry. 38(1): 13-17.

Tree Root Depth Study

- Tree performance ranged from 1-7 (1 = very vigorous; 7 = dead)
- Root depth was varied for all sites; most ash and littleleaf linden had average structural root depth at 3” below grade, but ranged up to 8” below grade
- There was a significant relationship between root depth and tree performance for most species
- Drought tolerant species: ash, crabapple, Kentucky coffeetree, and elms, were found to be most tolerant to deep planting

General Conclusions of Planting Depth

- While some trees were tolerant to being planted too deeply, growth and vigor was reduced as much as 50% among species
- 25% of all trees were planted at least 3” too deep
- The potential reduction in ecosystem services by underperforming trees could be substantial



Planting trees correctly: Mulch

- Cregg and Ellison (2018) found following planting, mulch was a critical factor in increasing soil moisture, especially in the first two years
- Mulch helped keep soil moisture more consistent and resulted in large increases in both tree height and caliper compared to unmulched trees

Mulch: so important in our climate!

- The benefits of mulch are numerous: improvement of soil health, increased soil moisture, decreased weeds, elimination of mechanical injury, and improved plant establishment and growth
- There are some disadvantages, such as blowing, expense, refreshment, and potential for fire

Mulch: improved soil moisture

- Weeds or grass around trees can increase soil evapotranspiration by up to 25% on a summer day
- Mulches will increase soil moisture by reducing evaporation
  - A 1.5” thick layer of straw was found to reduce soil evaporation by 35% compared to bare soil
- Mulches can vary in their ability to allow for percolation—plastics, geotextiles, fine mulch, and sheet mulch generally do not lead to permeability

Mulch: improved soil moisture

- In general, mulch will significantly reduce the amount of irrigation needed for landscapes and could eliminate the need for supplemental irrigation (with proper plant selection) after establishment
- Mulched trees and shrubs will also be able to withstand other environmental stressors, like cold injury

Mulch: reduces salt and pesticide contamination

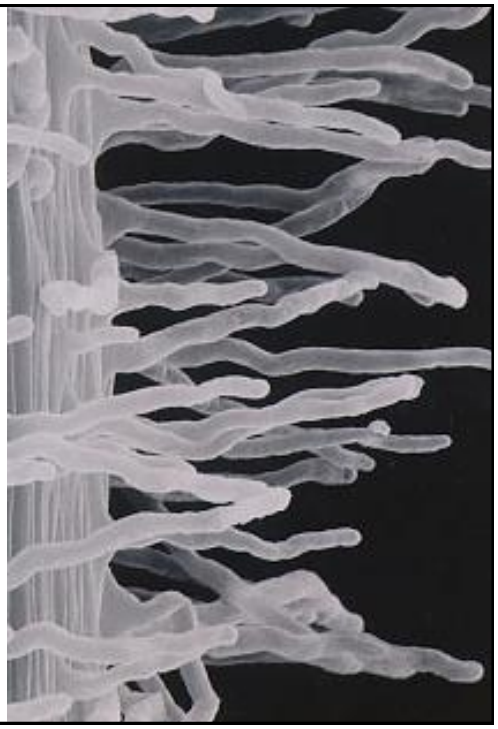
- Salt residue from de-icers, greywater, fertilizers, etc. can lead to plant injury
- Mulches reduce evaporation, so there is more water in the soil to aid in dilution of salts
- Organic mulches can also help degrade pesticides by providing higher microbial populations that aid in degradation

Mulch: leads to improved plant establishment

- Numerous studies have found that mulches improve water retention and reduced weed growth, leading to increased root growth
- Mulch also allows woody plant roots to extend beyond the trunk compared to bare soil…leading to increased stabilization

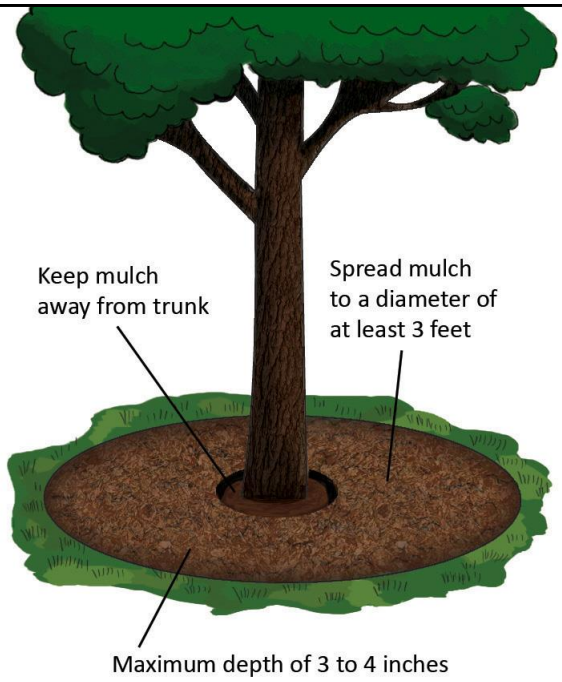
Mulch: better root growth and density

- In a comparison of organic mulch, bare soil, plastic, and living mulch, root development and density was best under organic mulch
- While roots grow into organic mulch, these fine roots exploit water and nutrients until they are killed by dry conditions in summer
  - New feeder roots grow where resources are more available



Mulch: historically better

- Mulch was proven to improve tree growth in 1942—mulched trees grew 62% better than trees grown with bare soil
- There have been proven increases in plant height, caliper, leaf size, and flower, fruit and seed production
- Best mulches for landscape use: organic wood products (chips or bark) and rapid decomposers (grass clippings, leaves, compost)
- Living mulch was found to reduce growth, even worse than bare soil



Mulch: economics

- In 1963, researcher Hunt found that the increase in plant survival of mulched plants more than compensates for the actual mulch expense
- Other cost savings include the reduction of herbicides and repurposing locally-produced debris

Planting trees correctly: Fertilizer?

- Cregg and Ellison (2018) found that applying fertilizer at planting did not provide an obvious or consistent benefit to trees
- It did not result in height or caliper increases two years after transplanting
  - This is consistent with many other studies
- Trees that were fertilized at planting had a foliar nitrogen concentration of 2.3%; those not fertilized were 2.3%--these numbers are within the sufficiency range for nitrogen fertility

Fertilizing Trees

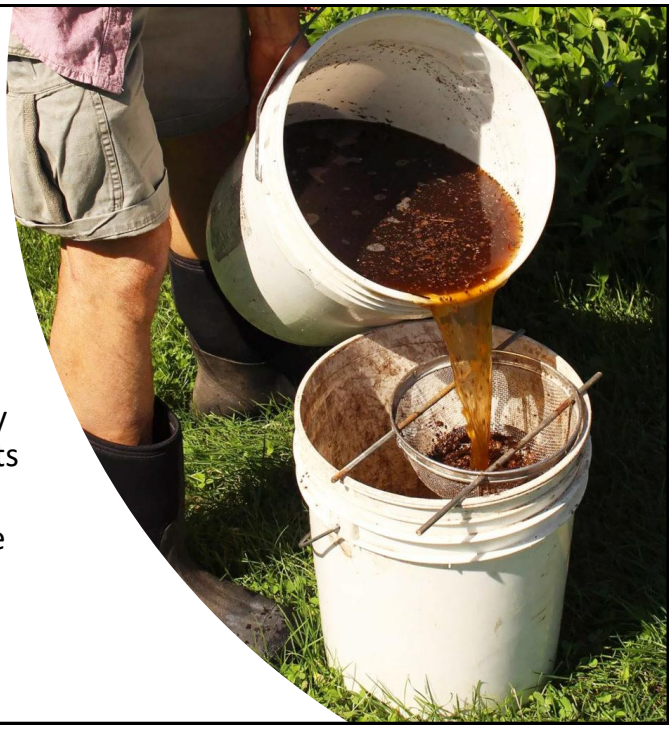
- If growth is the goal, consider other limiting factors, such as irrigation availability, soil drainage, tree species, and rooting volume
- Trees are "juiced" in the nursery to decrease production time
- Trees often store nutrients or delay use, resulting in a carry-over effect
- Turf and trees share turf-applied fertilizer
- Soil tests may indicate that nutrient levels are at or above optimum levels for plant growth

Mycorrhizae

- Soil applications of mycorrhizae have been proven beneficial to trees in soils lacking appropriate fungi (reclamation sites)
- In arid areas, mycorrhizae may also be low, but growth rate of trees has been unaffected with treated with commercial inoculants at planting
  - Vigor and suitability of the inoculum are important factors
- Mycorrhizae can also develop or be restored in favorable soil environments

Humates and Compost Tea

- Humates (and plant extracts) have shown limited benefit to root growth of trees
- The dose and species response widely varies—there is not a "one product fits all"
- Compost teas are thought to enhance soil biology and provide some nutrients, but research is limited and inconclusive



Amendments at planting

- In general, if only adding 5-10%, will not hurt, but won't really help—it's better to focus on proper planting practices
- Replacing >30% of the backfill with organic matter can lead to problems

Improving root growth in compacted soils

- Many developed urban sites are compacted subsoil with very little topsoil remaining
- When topsoil is removed, it also removes organic matter and nutrients; mycorrhizae and soil structure are often destroyed

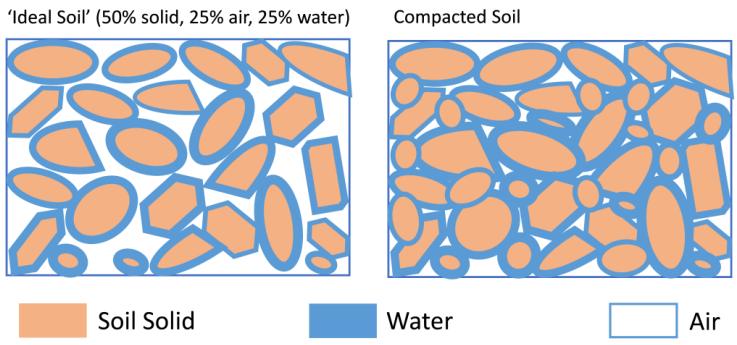


Figure 1. Soil compaction causes a reduction in available space for soil air and water, and limits pathways for crop roots.

Growing trees in compacted subsoil

- Trees struggle to grow in compacted subsoils for many reasons
  - Poor soil porosity
  - Improper drainage
  - Inability for root extension

What do many do to improve plant growth?

- Let's fertilize the tree!
- At what cost?
  - Applications can contaminate ground and surface water
  - Gaseous losses of soil carbon
  - Salt accumulation
  - Affects plant resources and may lead to decreases in plant defensive compounds and increase herbivory (Herms and Mattson)

Can you improve growth for an existing tree?

- Yes, according to a study at the Morton Arboretum
- Studies for 5 and 7 years
- Research plots were purposefully compacted and 8” of topsoil was removed
  - 1” was replaced (~3 cubic yards/1000 square feet)
- 120 trees (60 red maple, 60 river birch) were planted and the area was seeded with bluegrass

2014. Scharenbroch and Watson. Wood chips and compost improve soil quality and increase growth of *Acer rubrum* and *Betula nigra* in compacted urban soil. Arboriculture and Urban Forestry. 40(6): 319-331.

Treatments used in the study

- Annual treatments were applied for three years
  - Control
  - Aerated compost tea
  - Commercial biological product (various microbes)
  - Fertilizer (30% N)
  - Compost (topdressing)
  - Wood chip mulch (topdressing)

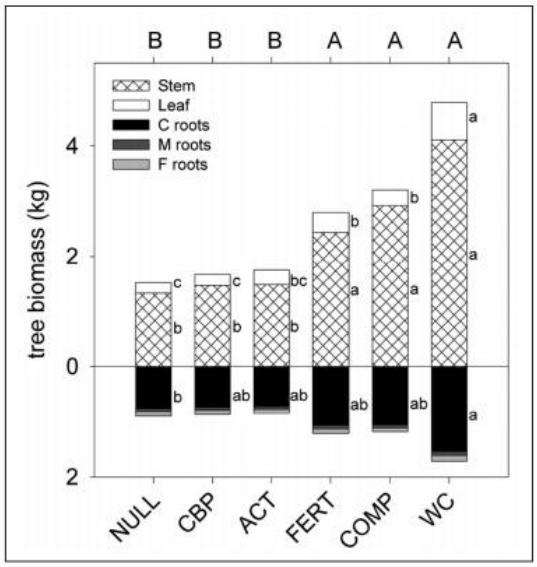
Sampling measurements

- Soil bulk density
- Soil pH
- Phosphorous levels
- Soil microbial respiration
- Carbon dioxide sequestration
- Soil organic matter content
- Tree biomass (destructive harvesting)
  - Fine, medium, and coarse roots were separated

What did they find?

- Tree biomass was greatest with wood chips, compost, and the fertilizer treatments
- After five years, mulched trees were 170% larger than control trees; trees topdressed with compost were 82% larger than control trees; fertilized trees were 69% larger
- Trees treated with compost tea and the biological product did not differ from the control

2014. Scharenbroch and Watson. Wood chips and compost improve soil quality and increase growth of *Acer rubrum* and *Betula nigra* in compacted urban soil. Arboriculture and Urban Forestry. 40(6): 319-331.



2014. Scharenbroch and Watson. Wood chips and compost improve soil quality and increase growth of *Acer rubrum* and *Betula nigra* in compacted urban soil. Arboriculture and Urban Forestry. 40(6): 319-331.

So what does this mean?

- Fertilization is often the first go-to for many landscape contractors and arborists to improve tree growth
- While fertilization improved growth compared to the control, it did not improve soil properties, nor soil quality
- The ultimate predictor for improved tree growth was soil organic matter
  - Mulch and compost both improved organic matter

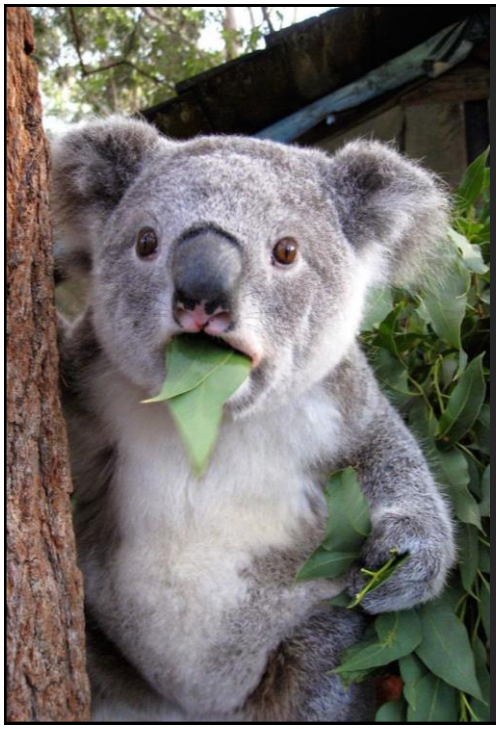
We should focus on soil organic matter!

- If the goal is to re-build soil organic matter, use things that decompose quickly (C/N ratio <25)
  - Grass clippings
  - Manures
  - Municipal waste (sewage sludge)
  - Food waste
- If the goal is to improve soil structure, then use products that break down more slowly (C/N ratio >25) (these will increase SOM over time)
  - Wood chips
  - Straw
  - Leaves

What's the cost?

Treatment	Control	Biological	Compost Tea	Fertilizer	Compost	Wood Chips
Materials	$0.0	$3.50	$7.50	$6.50	$3.00	$10.00
Equipment	$0.50	$3.50	$28.50	$3.50	$1.00	$1.00
Labor	$7.50	$11.30	$30.00	$11.30	$15.00	$15.00
TOTAL COST	$8.00	$18.30	$66.00	$21.30	$19.00	$15.00
Growth (g)	22.8	23.9	24.1	38.7	41.5	61.3
Efficiency ($/g)	$0.35	$0.77	$2.74	$0.55	$0.46	$0.42

2014. Scharenbroch and Watson. Wood chips and compost improve soil quality and increase growth of *Acer rubrum* and *Betula nigra* in compacted urban soil. Arboriculture and Urban Forestry. 40(6): 319-331.



What if you did both compost AND mulch?

It could be the best treatment ever...but that needs more research

To sum it up…

- Consider planting smaller trees
- Plant trees properly
- Make sure they are maintained with sufficient water
- Use mulch…or compost
- Focus on good cultural practices…not as much on additives
- Educate coworkers, staff, and your clients

Questions?

Resources:
extension.colostate.edu

CO-Horts Blog:
www.csuhort.blogspot.com

Alison O'Connor
CSU Extension in Larimer County
astoven@larimer.org