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Leveraging Healthy Urban Forests with Minimum Soil Volume Policies
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Arborists and Foresters face a difficult dilemma; all around them there are constituents, public officials, large & small businesses praising the merits of trees with excitement close to fervor. Many advertisements portray nature (good) with big trees (heroic). Nowadays, with climate change, being green has a significant payoff. Many companies and municipalities have embarked on impressive sounding tree planting efforts. Politicians extol the benefits of trees, and how they will be known, or remembered as the mayor that helped make trees a huge part of their community. Tree planting will save the city. In almost all cases the emphasis is on planting trees for numerical impressiveness. Big numbers, 1 million, 2 million, 5 million tree planting projects have become a numbers game - the more you plant the more good you do. Almost everyone, including many professionals, believes that the mere act of planting a tree confers miraculous benefits. Many arborists know different, pleading science, while the masses only want to hear sermons. Planting a tree in an urban tree pit is seen as enough - small input big returns. It almost sounds too good to be true, and it is, too good to be true.

McPherson describes our current situation as a tree numbers paradigm. He urges us to move to a tree performance paradigm. Taken the huge number of million tree planting programs gives truth to this insight.

Christopher Alexander et al, in his book *A Pattern Language,* describe trees as a critical factor for quality of life in all cities. This book has been prescribed to thousands of architectural students for two decades. The book is made up of 253 “Patterns” of planning, building, constructing for the healthy growth and sustenance of cities. After years of trials, in cultures around the world, the authors state that some of these Patterns have shown the characteristics of a true invariant, that the solution stated summarizes a *property* (sic) common to *all possible ways* (sic) of solving the stated problem. “Tree Places” is one of those invariants. Alexander discusses “Tree Places” as such; *"…the trees that are being planted and transplanted in cities and suburbs today do not satisfy peoples craving for trees"*..... Further he goes on; *"trees in a city round a building in a park or in a garden are not in the forest. They need attention."* additionally he says; *"…as soon as we decide to have trees in a city we must recognize that the tree becomes a different sort of ecological being. In a forest trees grow in positions favorable to them. In a city a tree grows where it is planted."*

Because of this dichotomy in thinking and not distinguishing between planting numbers and planting success, arborists are left to clean up the mess. Citizens/Business say they care, however their actions do not prove it.

Skiera & Moll found that in the top 20 largest cities in North America, street trees had an expected lifespan of 13 years. Coder’s studies *on Occurrence Priority of Stress in Trees* shows water availability as the number one stressor. The second and third largest limitations or tree stressors are drainage and soil aeration. However, Coder shows that the combined stress impact of soil drainage and soil aeration out weighs any other single factor. Grabowski, Trowbridge and Bassuk in their 2002 study found that the ideal ratio of soil volume to tree canopy area for tree growth is: 2 $ft.^3$ of loam soil for every one square foot of crown projection. Urban showed in data adapted from several individual studies by Daddow, Warrangton, Linder, Lichter, Brady on soil compact ion and bulk density ratios, that from Clay to well-graded Loamy Sand the bulk density was from 1.30 to 1.65. This bulk density translated to 75% to 80% Proctor density. The standard for compaction under pavement in the United States is no less than 95% Proctor density and is often 100% Proctor density. USFS Tree Root video footage from the 1950's shows tree roots growing in a bulk density of 1.1, roots repeatedly move laterally away when bulk densities are above 1.65.

Based on the above studies, I have concluded that soil volume and soil aeration is equal to 42% adequate and moisture 30% or approximately 70% of what a tree needs to be successful. Two street tree studies in Bethesda Maryland and Charlotte North Carolina (1985) at 27 years have shown almost the exact same growth in height, TBD and crown diameter. These two case studies have widely different levels of tree care, and yet they remain close to the same size. What both share or the common variable is that the trees average between 600 and 700 $ft.^3$ of aerated soil volume per tree. Both sets of trees are growing primarily under pavement with almost no access to open ground.

Based on this conclusion than > 70% of the success of the tree is due to adequate moisture, soil volume, and adequate aerated soil volume. Therefore, a proxy for tree care in urban areas is to devote resources to solve volume and soil aeration above all. This proxy for tree care helps us understand that McPherson's point of switching from a tree numbers paradigm to a tree performance paradigm is central to any attempt to increase quality of our urban forests. In previous presentations and papers I have presented on the Urban Forest is Broken and that tweaking alone will not fix it, it must be remade and soil is the first place to start.

Providing soil volumes to move to a high-performance tree paradigm, is an order of magnitude more expensive than the current cost of planting trees in tree pits. This expense is seen by many as cost prohibitive. However, based on i-tree modeling it is clear that a tree using the tree performance paradigm outstrips the high number planted tree paradigm at about year 20, thus the tree's promise can be fulfilled, moving from wishful thinking to critical thinking.

Within an urban street cross-section, from building face to building face this public right away has life span values assigned to all its parts e.g. curbs, light fixtures, parking meters, receptacles, benches, sidewalk, pavement, etc. Most of these pieces of infrastructure are expected to have a useful life of between 20 and 30 years depending on the item in particular. Currently, the only item of infrastructure within the cross-section of the street that has no useful life expectancy is the trees. Based on an average street tree lifespan at 13 years, this is well below the life expectancy of static pieces of infrastructure. However, providing the correct soil volume will almost quadruple the trees useful lifespan to 50 years. On average, that would be double the life expectancy of any other gray infrastructure items. A tree that grows 50 years is truly a piece of green infrastructure, and more closely resembles the role of trees in cities per Alexander's Tree Places.

In numerous studies of tree values based on size (McPherson; Nowak) these ecological services increase by orders of magnitude. For example, a 40-year-old Hackberry intercepted 5500 gallons of storm water per year in its canopy. Further examination reveals that a 20 year old tree did not intercept half of that value but instead intercepted about ¼ of the 40 year old tree.

Another dramatic example of this geometric progression is a comparison study (McPherson, Xiou) between a 2 inch caliper Jacaranda and a 22 inch DBH London Planetree. The 2 inch caliper Jacaranda intercepted 15.9% of a 1 inch rainfall in 24 hours within its canopy. The 22 inch DBH London Planetree intercepted 79.5% of rainfall for a 1 inch 24 hour storm within its canopy.

In a raw comparison of DBH and canopy diameters, and stormwater reduction impacts, the Jacaranda is 1/11th the Planetree's diameter. The Planetree within its canopy at any single point is intercepting five times the amount of rain that the smaller tree is intercepting within its canopy. The Jacaranda within its 4 foot diameter canopy has a canopy area of approximately 13 ft.^{2} The 30 foot diameter canopy of the Planetree has a canopy area of approximately 735 square feet. The Jacaranda, in terms of ratios is 1/50th of the Planetree. The combination of a five times interception rate per square foot of canopy multiplied by 50 times the canopy area is over 200 times more interception. This has become a geometric progression. The Planetree is providing over two orders of magnitude more significant interception of storm water than the Jacaranda and more fortuitously this multiplier increases as the Planetree matures and enlarges.

The central question becomes: if large trees with adequate healthy soil volumes are orders of magnitude more valuable than their typical unhealthy street tree predecessors. Why would any city endorse a tree numbers paradigm over a tree performance paradigm?

Hence, we are asking the question of these municipalities with minimum soil volumes their care for trees and how much do they care. This care is best demonstrated by how much they are willing to spend for the proper care of large long-lived trees.

Thus, we conducted a survey of tree professionals in self identified cities in North America that have an established a minimum soil volume policy that is code or is required, not voluntary.

Here were the 8 questions of our survey to the cities:

1) What are your agency/organization's standards, codes, or recommendations regarding minimum soil volumes for trees? Please specify which of these are required vs. recommended.
2) What specific obstacles were encountered in establishing your minimum soil volume requirements?
3) How were those obstacles overcome?
4) Who had to be involved in order for it to make it through the approval process?
5) What year was your minimum soil volume standards enacted?
6) How long did the process of setting soil volume standards take, from beginning to end?
7) What prompted the development of your soil volume standard?
8) What have you learned since these standards were enacted?
- What has worked well?
- What would you do differently?

Results will be presented.

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