

***Tree Performance In Load  
Bearing Paving– Tree  
Growth, Health, Storm  
Water Results.***

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“In the medical field there are so many studies that it is often difficult to make a decision, while in the urban tree field there are so few studies that it is easy to deceive.”

*Ed Gilman, a casual observation.*

**“Science is not truth, it is moving away from falsehood.”**

*Albert Einstein*



# Tree Requirements



**5.** Room for canopy growth



**6.** Quality nursery stock



Trunk Flare

**3.** Water in



**2.**



**1.** Sufficient soil volume



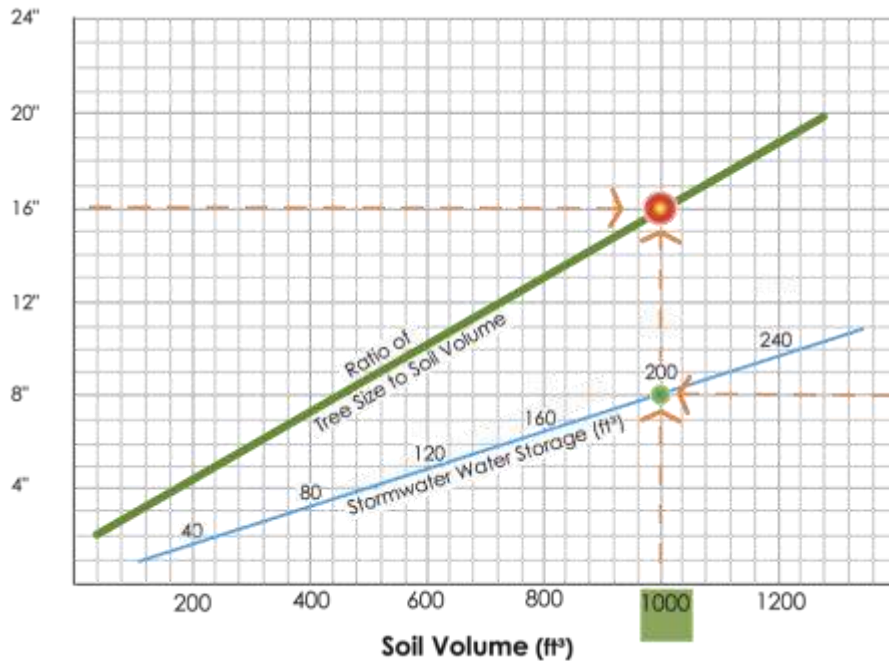
**4.** Water out



Zone of rapid root taper



## Soil Volume Below Pavement *Current Research*



There are many approaches to improving soils below pavement.

But they are not equal. How do we evaluate relative effectiveness vs cost?

# Trees in Hard Landscapes A Guide for Delivery



# COMPARATIVE RESEARCH AND ANALYSIS

26 research papers, and conference presentations

Controlled research plots

and

Monitoring / analysis of trees planted in built landscape projects.



## OPTIONS CONSIDERED



**Suspended Pavement:**  
***Silva Cells*** (post and beam soil cells)



***Stratacells*** (segmented soil cells)



**Structural Growing Media:**  
***Gravel Based Structural Soils***

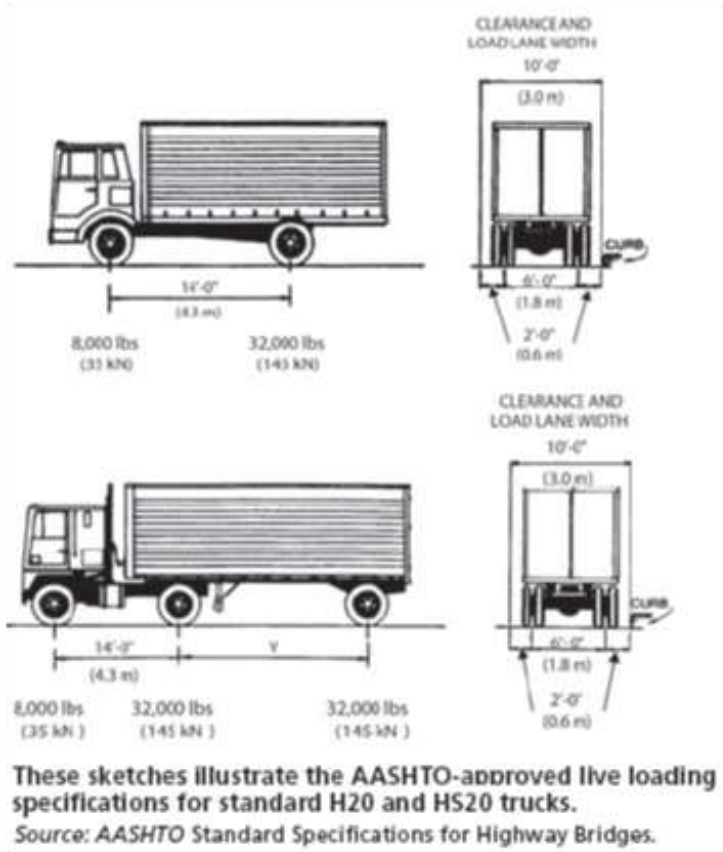


***Compacted Sand Structural Soil***



***Arbor Raft*** (Hybrid system – depends on compacted sand below raft for soil volume)

# LOAD BEARING DEFINED



**Spanning Structures**  
*AASHTO H-20 Loading*  
*145kN (32,000 lb) load*

**Pavement subbase**  
*Standard Proctor Test*  
*95% of Maximum Dry Density*

# RELATED FACTORS IN THE EVALUATION OF AN OPTION

## Soil limitations

Unscreened Loam vs Screened loam  
Vs Sand soils



Unscreened loam soil



Screened loam soil



Manufactured sand soil

## Existing soils

Soil beyond the system  
supporting pavement



Large trees in  
compacted soil



Rooting soil under parking lot



Deep rooting resource

## Water harvesting

Water into the system



Pervious pavers



Clogged water access



Sub-paving distribution



# RELATED FACTORS IN THE EVALUATION OF AN OPTION

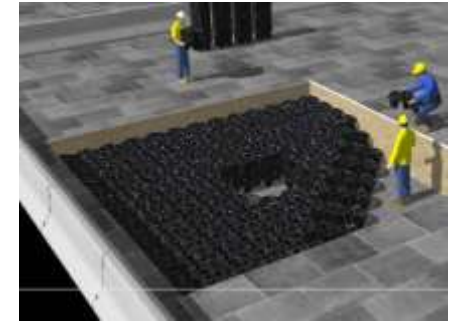
## Storm water

Quality / quantity.



## Layout flexibility

Conflicts with existing and proposed structures, and dimensional variations within the design.



## Volumetric effectiveness

Effective loam soil volume.

Does each approach provide Equivalent loam soil volume in the same space?



## CONCLUSIONS - Soil Volume:

1. Soil volume to tree growth is based on **unscreened loam soils**. Compaction, or screening, blending, sandy soils or rocky soils will require greater amount of material to compensate for the growth limitations of these soils.
2. Evaluation efforts must account for the effect of **adjacent existing soils** in the overall amount of soil available to the tree.



# Recommendation

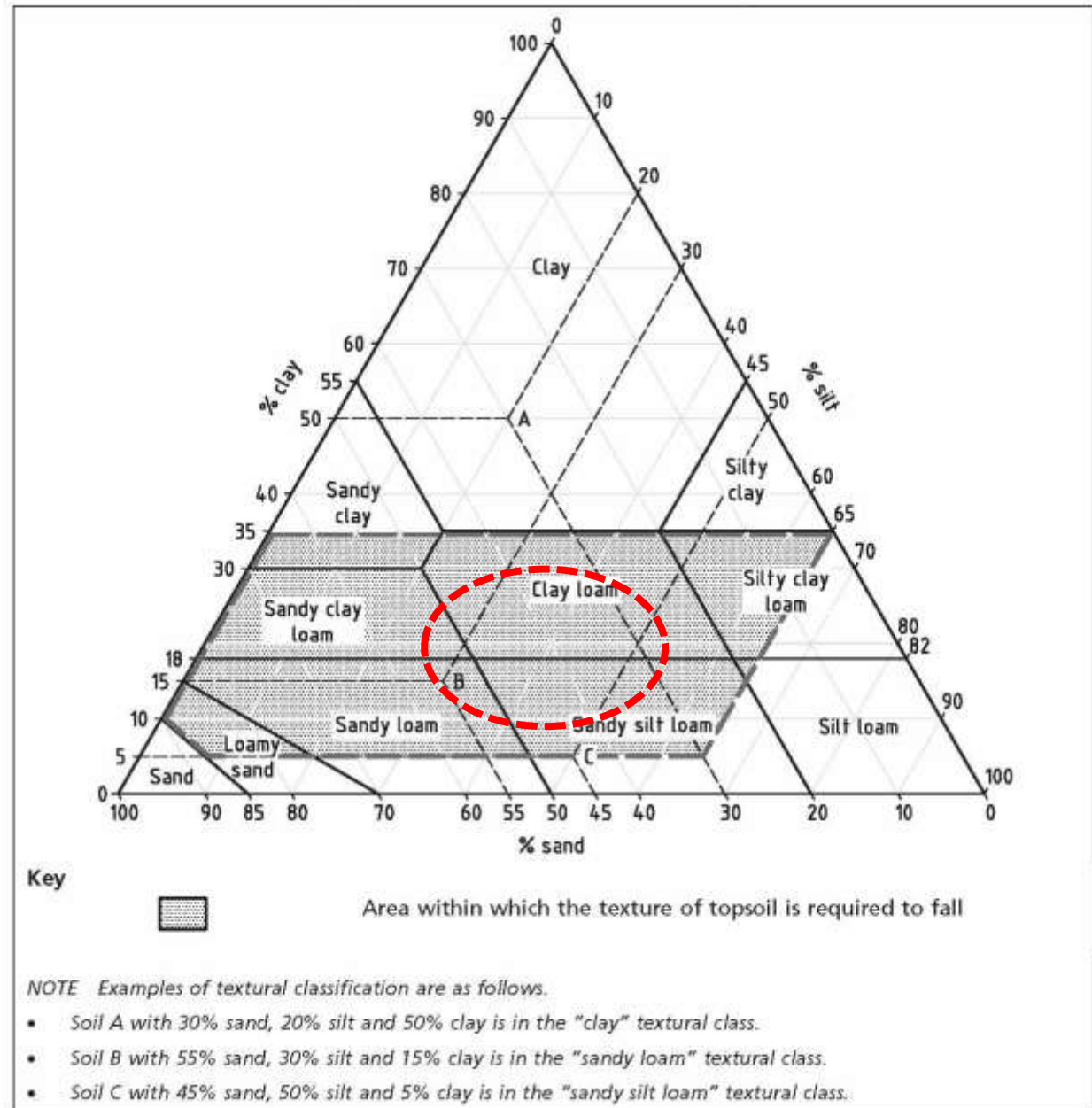
The “British Standard Specification for Topsoil” is NOT a reasonable tool to determine acceptable soil in load bearing applications



Specification for topsoil

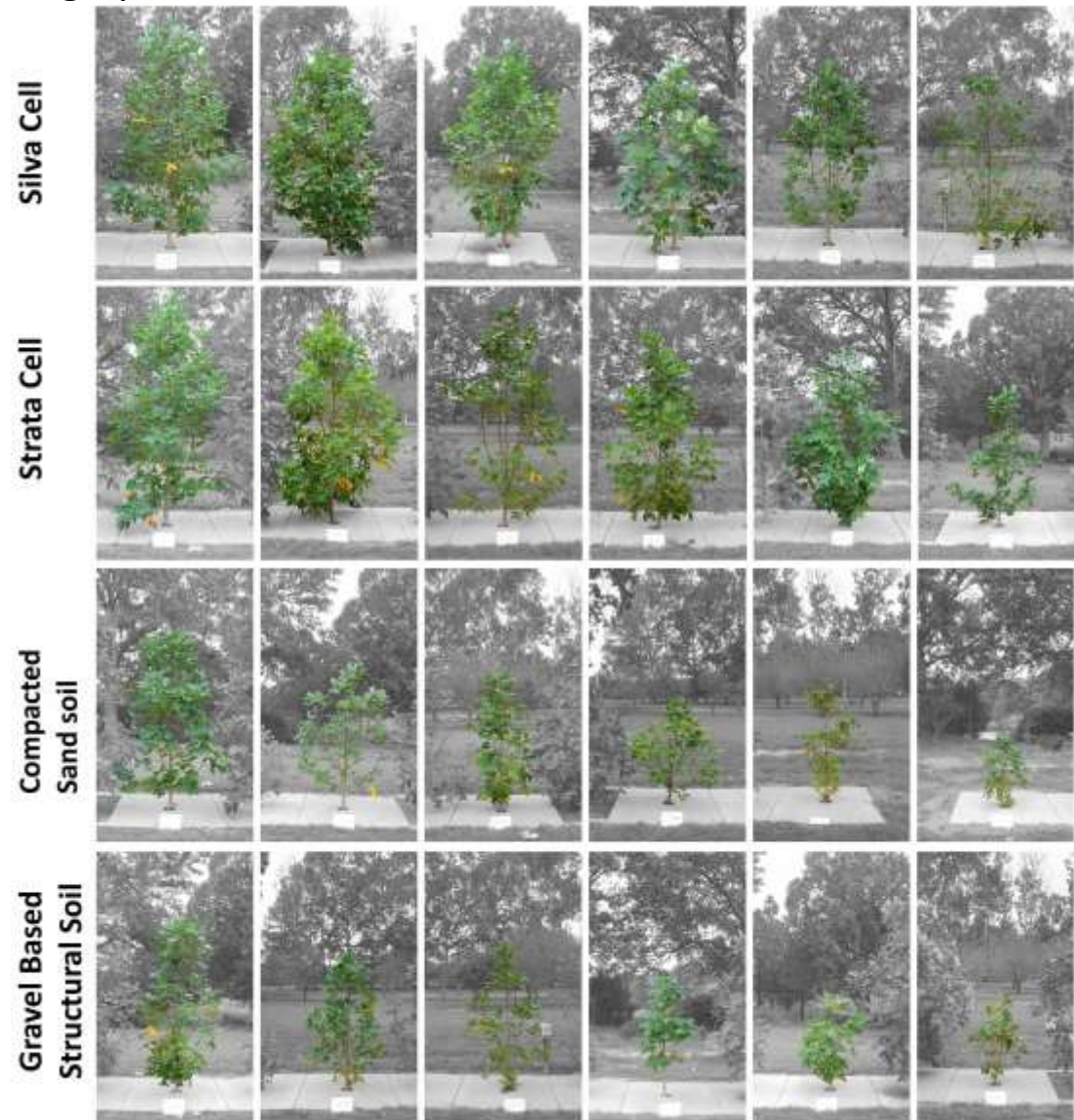
# British Standards

Figure 1 Textural classification (limiting percentages of sand, silt and clay sized particles for the mineral texture class) and the area of textures that are acceptable within BS 3882:2015



## CONCLUSIONS - System effectiveness:

**Suspended pavement systems** that are filled with **unscreened loam soils** are the most effective at growing trees and are equivalent to loam soil provided that the volume of the structural elements holding up the sidewalk are subtracted from the overall volume of the installation.





2010



2011

### Sugar Beach, Toronto – Silva Cells



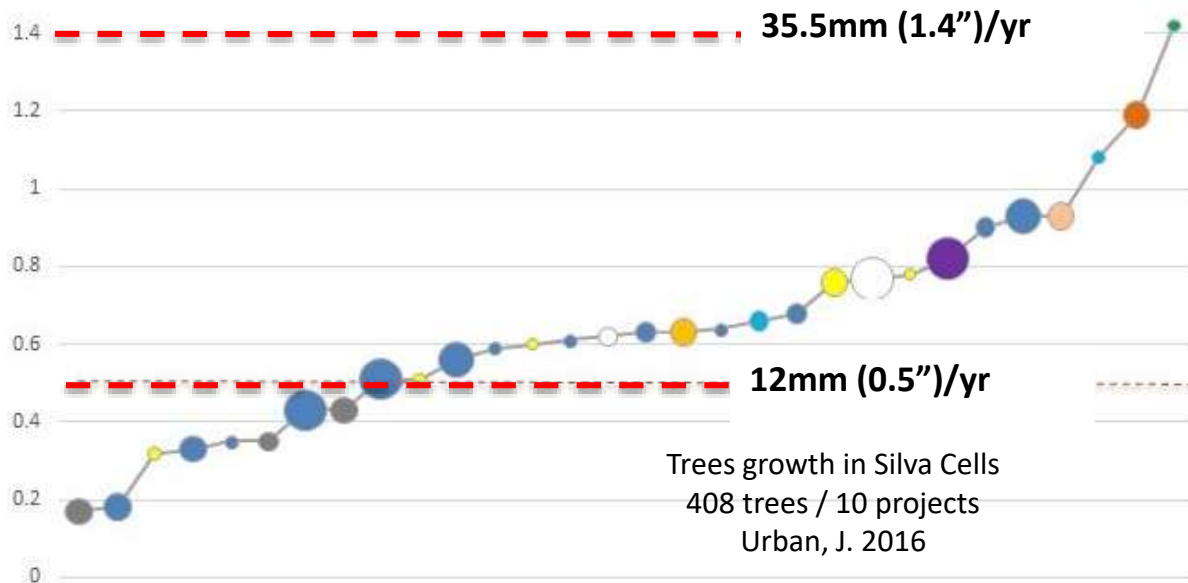
2012



2013



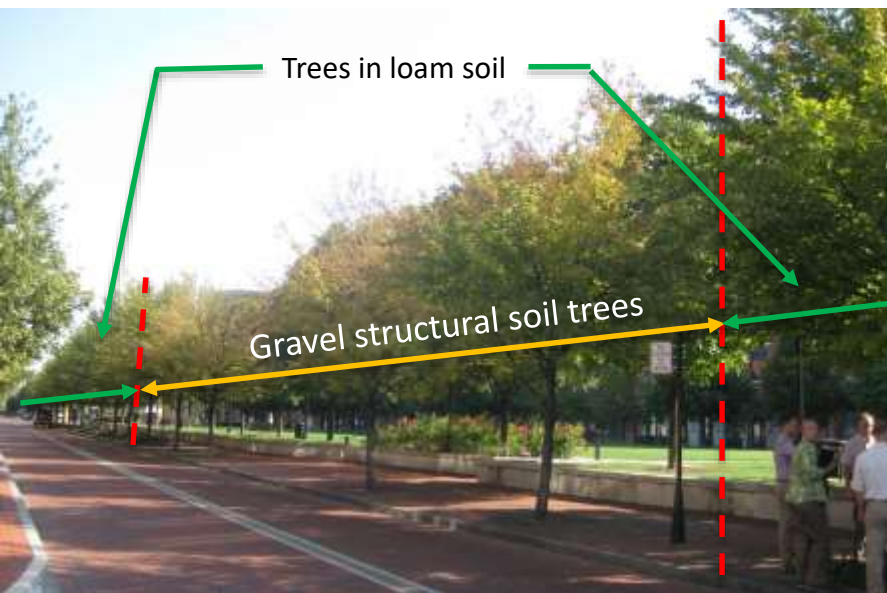
2016



## CONCLUSIONS - System effectiveness:

**Gravel based structural soil** with clay loam soil; the effective amount of soil in the material is between 20 and 25%. Trees can be expected to grow at reasonable rates until the roots fill the available soil space but much more material volume is needed.

More research is needed to determine if the long term soil to tree growth ratio is different for Stockholm soil.



Columbus, OH USA



Stockholm, Sweden  
Trees in Stockholm soil

# RESEARCH STRUCTURAL SOIL SYSTEMS

Gravel based structural soil GBBS – Stockholm Soil



*Creation of structural soil for trees in paved area. The pictures show structural skeleton with aerated bearing layer, an air inlet of type TLP 2333 Clarova with cover, addition of planting soil type D and aerated bearing layer around the air vent. (Photo: Örjan Isdahl).*

481 trees planted in built landscapes.

Critique of three plantings in built landscapes plus a controlled experiment. Different results for different reasons.

Problems with mixing. Trees growing well in large open soil volumes.

In controlled test plots Trees in structural soil similar to negative control

Structural soil research and  
examples in Norway  
Solfjeld, I. 2014

## DBH Increase

Structural soil <b>with</b> Storm water	1.18cm (0.46")/yr
Structural soil <b>without</b> Storm water	0.75cm (0.29")/yr
Open soil bed	1.12cm (0.44")/yr

Stockholm solutions: Experiences of  
different planting methods  
Ostberg, J. 2014

## CONCLUSIONS - System effectiveness:

**Compacted sand structural soil** is difficult to evaluate for efficiency. Base on current findings, it may be reasonable to rank this option at between 30 to 50% effectiveness compared to loam soil with the further **understanding that trees may never growing as fast or as large** due to limitations other than volume.

The **arborraft** hybrid system should **not be considered a load bearing approach** without using compacted sand soil or gravel structural soil below the raft in sufficient volume to support tree growth expectations.



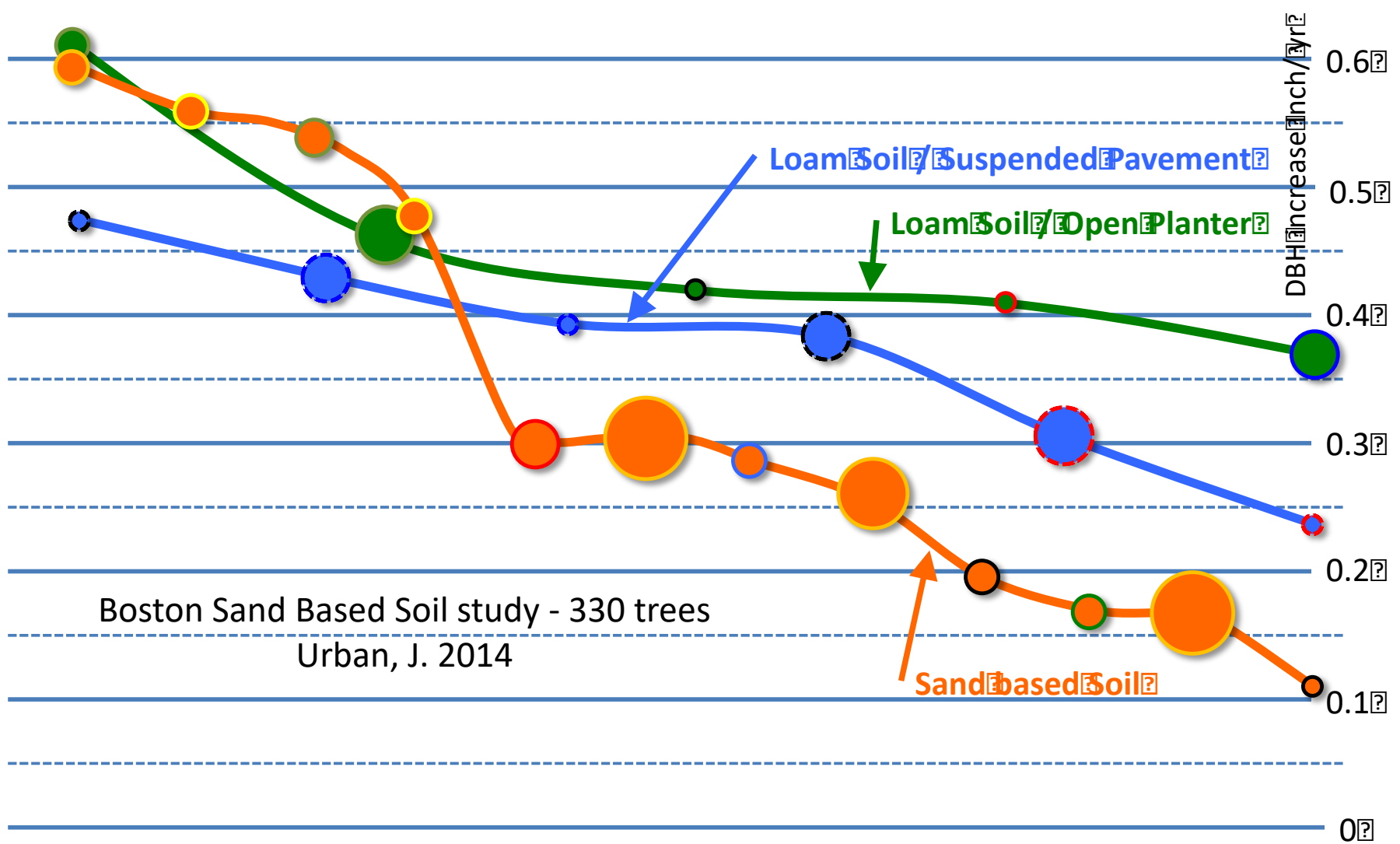
Trees with access to adjacent park soil.



**Washington, DC USA**  
**Compacted Sand Structural Soil**

Trees with no access to adjacent park soil due to security barrier footing.





**Tree growth in Sand Mix similar to “Amsterdam soil” compacted to 80% standard proctor was only about 20% of trees in sandy loam topsoil.**

“Growing trees in road foundation materials.”  
Kristoffersen, P. 1999



**LOAM SOIL**  
1000 c.f.  
28.3m<sup>3</sup>



100%  
EFFICIENT



**Post Soil  
Cells**  
30.3m<sup>3</sup>



93%  
EFFICIENT



**Segmented  
Soil Cells**  
1290 c.f.  
36.5m<sup>3</sup>



71%  
EFFICIENT

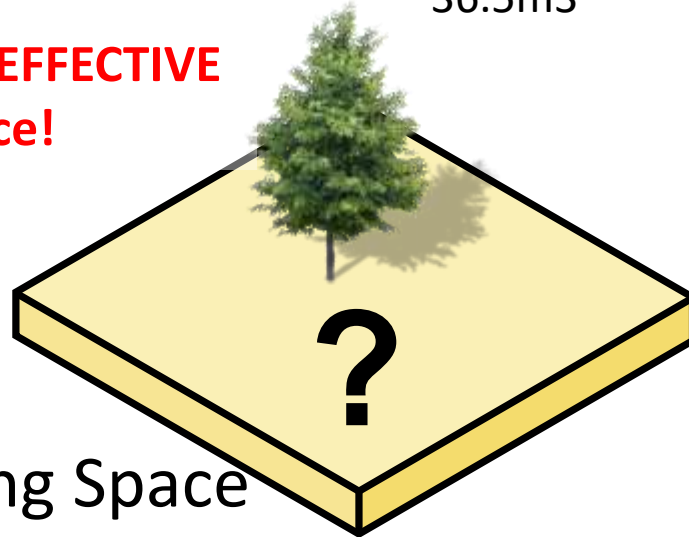
**Calculating EFFECTIVE  
rooting space!**



**COMPACTED  
SAND SOIL**  
2000 c.f.  
56.6m<sup>3</sup>



50%  
EFFICIENT



**GRAVEL BASED  
STRUCTURAL SOIL**  
5000 c.f.  
141.6m<sup>3</sup>

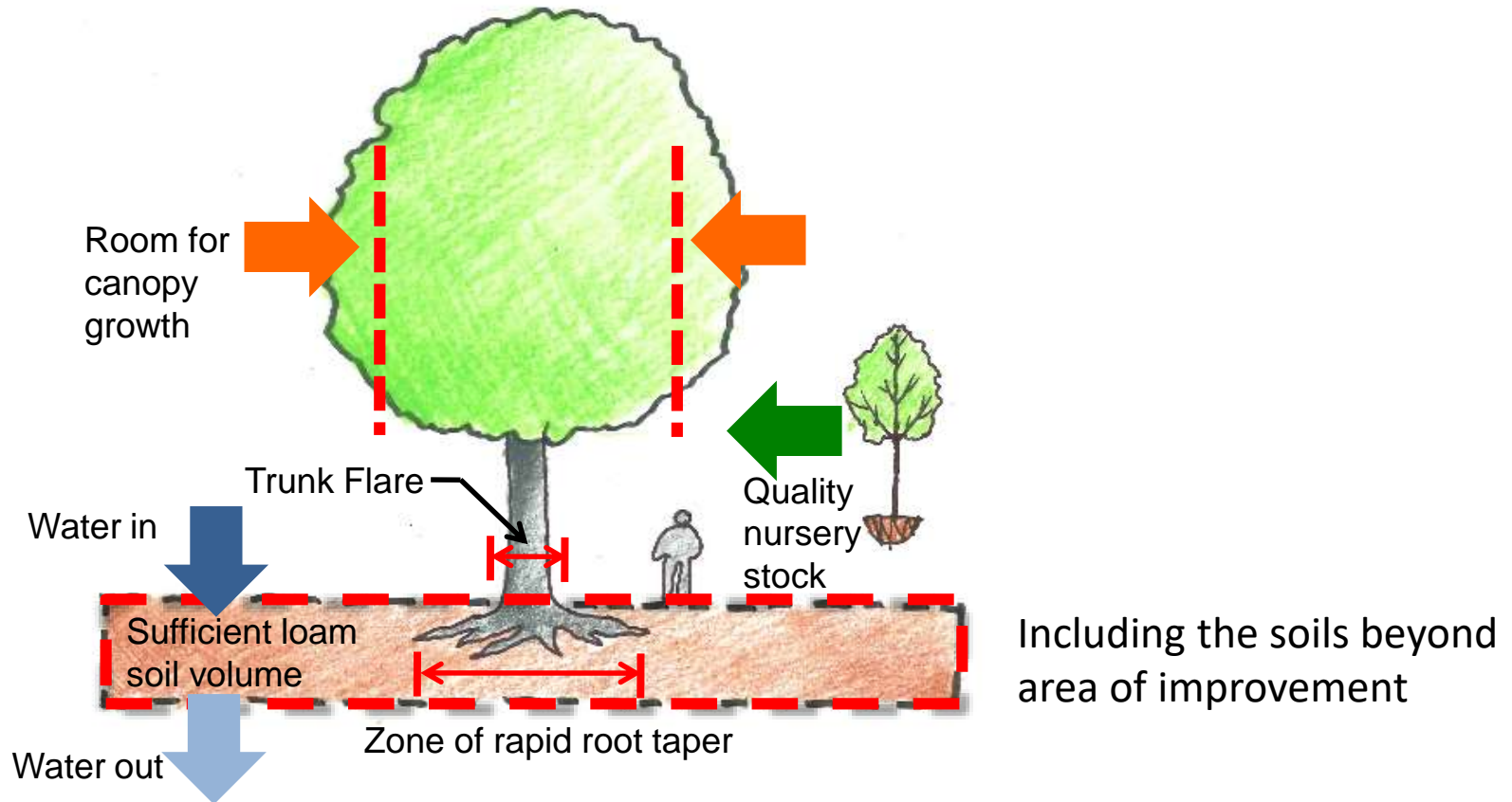


20%  
EFFICIENT

**Effective Rooting Space**

## Recommendation - Design improvements

Designers must pay more attention to all the parts of the tree in pavement problem. The choice of a soil approach is only one small part of a very complex design problem.





2016

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**More Research Needed!**

ASLA Tree and Soil Research Blog

<https://treeandsoilresearch.asla.org>



**Support the Tree Fund**