Trees and Urban Stormwater Management: A Good Partnership!

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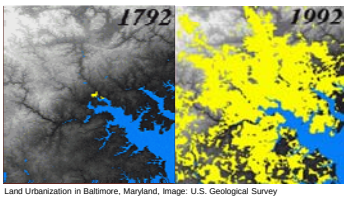
URBAN FORESTRY AT VIRGINIA TECH



Land Urbanization in Baltimore, Maryland, Image: U.S. Geological Survey


Urban runoff with pollutants

Urbanization continues at a rapid pace. Stormwater management is increasingly difficult and expensive.

Structural Soil is a matrix of stone and soil that meets engineering specifications for load bearing, yet holds enough moisture and has enough void spaces to allow froot growth. Using structural soils under pavement therefore allows trees to thrive in places where they would normally languish.

Stormwater management requires detention areas so that water does not flow directly into natural aquatic systems. These detention areas require a lot of increasingly scarce and expensive space. Can stormwater effectively be detained underground in the voids of structural soil in which tree roots are growing until it infiltrates below or is transpired by the trees? A 24-inch deep layer of structural can hold 5-7 inches of rain. Can we have viable stormwater detention and thriving trees as part of the same system?

This detention pond required use of most of a city park.

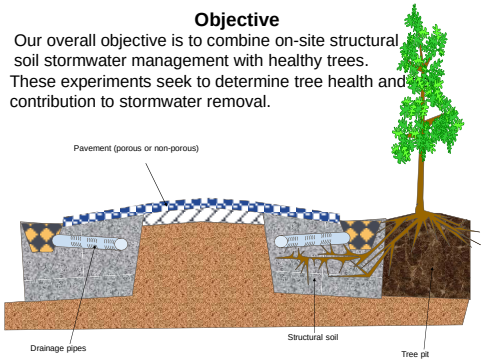
Trees help keep a lot of rainfall from becoming stormwater by storing rain on the tree's canopy until it evaporates. Water is also channeled to the ground below by stem flow. Once in the root zone, it infiltrates deep in the soil or is transpired.

Introduction

Trees in urban settings frequently suffer, decline and die prematurely as a result of the limited rooting volume imposed by intentional or unintentional soil compaction. One solution is the use of "structural soils", such as that developed at Cornell University in Ithaca, NY, which meet engineering specifications for load bearing yet still provide large voids that can be penetrated by roots. Another challenge in urban settings is stormwater management. An increase in paved surfaces have resulted in a huge increase in stormwater runoff, and thus pollution of water bodies. Legal mandates for retention in areas where available land is very limited and expensive have created a critical need for novel solutions.

Objective

Our overall objective is to combine on-site structural soil stormwater management with healthy trees. These experiments seek to determine tree health and contribution to stormwater removal.



Drawing of a parking lot with structural soil and trees, which could be used as a stormwater management system

General Experimental Procedure

Tree Response to Periodic Flooding (Experiment 1): Trees were exposed to fluctuating water tables that simulated different infiltration rates into the ground below.

Infiltration (Experiments 2 and 3): Trees were planted in containers with compacted clay loam soil around and/or below rootballs.

Results

- Trees thrived in fluctuating water tables, but roots were more shallow in the slow drainage treatment. Trees grew best and transpired the most water in the moderately drained treatment.
- Roots grew through the geotextile into all layers of compacted soil. In the most restrictive cases, the presence of trees increased infiltration up to 27X.
- Differences in tree response to Cornel Structural Soil vs. the mix made from Carolina Stalite were minor.

Summary and Significance to Industry

→Three experiments were conducted that test the efficacy of trees as a vital component of a novel stormwater management system for urban areas.

→Such a system will provide a pleasing, tree-shaded urban landscape while significantly contributing to stormwater management.

→In this system, stormwater is directed and stored under pavement into a special substrate, structural soil.

→ Our data suggest that trees will be able to thrive in such systems, especially where drainage is not severely retarded. Trees may help water drain into the soil below the system.

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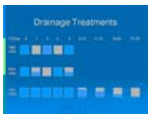
Periodic Flooding (experiment 1):

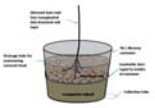


Questions:
1) Can trees survive periodic flooding such as are likely to occur in structural soil stormwater systems?
2) How is root development affected?
3) How is transpiration affected?

Species:
Green Ash (*Fraxinus pennsylvanica*) and Swamp White Oak (*Quercus bicolor*)

Methodology:
Trees were planted into 25-gallon containers filled with structural soil and subjected to simulated fast, medium, and slow drainage regimes for two growing seasons. Cornell University Structural Soil (uses native gravel) and a mix utilizing Carolina StaLite (a proprietary heat-expanded rock) were evaluated. Tree growth and rooting depth were recorded at the end of the experiment. Transpiration and sap flow were recorded periodically.

Infiltration (experiments 2 and 3):



Questions:
1) Will roots penetrate through geotextile (required to be placed below structural soil) and into compacted soil below?
2) Does root penetration aid infiltration?

Species:
Experiment 1: Black Oak (*Quercus velutina*) and Red Maple (*Acer rubrum*)
Experiment 2: Green Ash (*Fraxinus pennsylvanica*)

Methodology:
Experiment 2: Bare-root seedlings were planted into cylinders of pine bark that was surrounded by compacted soil in 7-gallon containers. Infiltration was measured periodically by saturating the soil and pouring a measured amount of water into the cylinder.

Experiment 3: Bare-root trees were planted into 25-gallon containers filled with CU structural soil on top and compacted soil below. Geotextile separated the layers. Saturated hydraulic conductivity of the soil was measured by the "constant head" technique two years later.