Trees and Structural Soil as a Stormwater Management System in Urban Settings

URBAN FORESTRY AT VIRGINIA TECH

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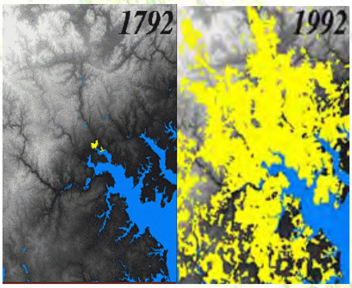
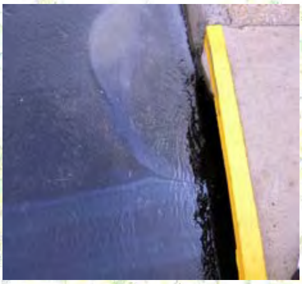


Land Urbanization in Baltimore, Maryland, Image: U.S. Geological Survey

Introduction

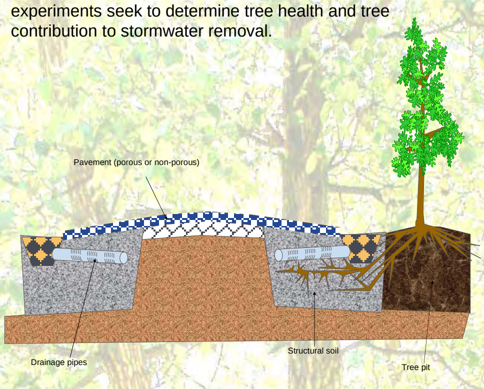
Trees in urban settings frequently suffer, decline and die prematurely as a result of the limited rooting volume imposed by intentional or unintentional soil compaction. One solution is the use of "structural soils", such as that developed at Cornell University in Ithaca, NY, which meet engineering specifications 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, whereas legal mandates for retention in areas where available land is very limited and expensive have created a critical need for novel solutions.



Urban Runoff with pollutants

Objective

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



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

Experiment 1: Tree development and water uptake in fluctuating water tables

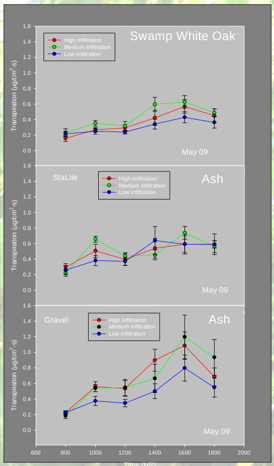
Material and Methods

In a stormwater management system using structural soil, trees are exposed to fluctuating water tables. To determine whether or not trees thrive in such a system, we exposed two species, ***Fraxinus pennsylvanica*** **(green ash) and** ***Quercus bicolor (swamp white oak)***, to **fluctuating water** tables that mimicked slow, medium, and high infiltration rates. In spring 2005, bare-root trees were planted in 25-gal containers filled with two common types of structural soil (Carolina Stalite and Cornell Structural Soil). A system of outside tubes allowed for a controlled lowering of water tables (fig. 3). **Tree development** in these fluctuating water tables and **water uptake** will continue to be monitored since these factors **influence the capacity of the stormwater management system**. During the summer of 2006 we are measuring sap flow, transpiration rate, and tree development below and above ground.

Trees in structural soil in containers with tubes to lower water table

Results and Discussion

Except for green ash grown in Stalite, trees show the lowest transpiration rate for the lowest infiltration rate regime and the highest transpiration rate for the medium infiltration rate regime. The high water tables in the low infiltration treatment apparently had a negative effect on transpiration rate due to low aeration. An unexplained lower transpiration rate is evident for green ash in Stalite vs. CSS. This generally lower transpiration rate will be closely monitored to see if it is transitory. The data suggest that swamp white oak is adapted to medium infiltration rates, reflecting the ecology of this flood plain species.



Experimental Procedure

Experiment 1: Trees were exposed to fluctuating water tables and tree development and water uptake were measured.

Experiment 2: Trees were planted in containers with clay loam surrounding the root ball with different compaction levels. Infiltration rate was measured to see whether root growth into the clay loam has influence.

Results

- Trees thrive in fluctuating water tables
- There are differences in development and water uptake when trees are exposed to fluctuating water tables
- Results suggest an effect of root growth into subsoil on the infiltration rate

Summary and Significance to Industry

→Two experiments were conducted that test the efficacy of trees as a vital component of a novel storm-water management system for urban areas

→ Such a system will provide a pleasing, tree-shaded urban landscape while aiding in stormwater management

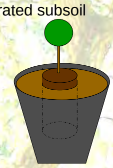
→ In this system, stormwater is directed and stored under pavement into a special substrate, structural soil

→Data suggest that trees will be able to thrive in systems where drainage is not severely retarded and that trees may help water drain into the soil below the system if roots are able to penetrate the subsoil

Experiment 2: Contribution of roots to stormwater infiltration into subsoil below system

Material and Methods

The capacity of a stormwater management system utilizing structural soil and trees depends upon stormwater infiltration into the subsoil below. In the spring of 2006, two tree species, ***Quercus velutina*** (black oak) and ***Acer rubrum*** (red maple), plus a no-tree variant, were planted in pine bark into a cylinder in the middle of 7 gal containers. **Clay loam surrounded the root ball** so that all new roots would reach the clay loam (fig. 4). Five replications of three compaction levels were employed. Infiltration rate was periodically measured as trees grew during summer 2006 by timing the infiltration of 1L of water from the original rootball into the surrounding saturated subsoil

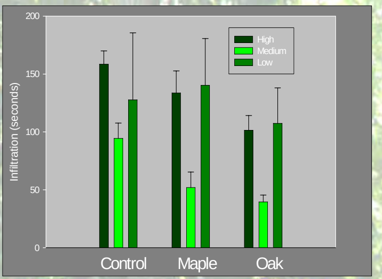


Drawing of the basic set-up

Set-up of experiment showing the pools in which we saturated the soil and the sleeves in which the water was filled to measure the infiltration rate

Results and Discussion

Both tree species show increased infiltration rates for both compaction levels compared to the no tree variant. This suggests, that the tree roots grew into the subsoil and increased the infiltration rate due to root channels. Black oak showed a greater influence than red maple, perhaps due to a difference in root structure and/or prior weakening of red maple from thrips and mites. The time of infiltration was shorter for the compacted variants than for the non-compacted control. This can be caused by an interface within the compacted clay loam due to our method of compacting in layers.



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