

# Tree Performance in a Gravel Bed Bioretention System

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## Abstract

Stormwater runoff is an issue in urban areas as impervious surfaces increase. Various retention systems that incorporate trees have been developed but are expensive and require large amounts of space and cause their implementation to be difficult. We are investigating a system that is simple and mitigates the effects of stormwater runoff while increasing the urban tree canopy. Our full-scale prototype of this system has been constructed adjacent to a parking lot on Virginia Tech's campus in Blacksburg, VA. It consists of a rectangular prism of a clay loam soil surrounded by a gravel moat filled with gravel. The system mitigates stormwater runoff by utilizing water uptake from three London planetrees planted in the soil prism. The gravel bed is intended to support an expansive root system that can absorb and transpire captured runoff while utilizing the soil for nutrients and anchorage. Adjacent to the gravel bed are three control trees of the same species, planted in the undisturbed native soil. The purpose of this study is to evaluate and compare tree performance and characterize the hydrology of the gravel bed. We are monitoring crown and root growth, photosynthesis, conductance rates, plant-water relations, and rainfall. The trees in the system have generally outperformed the control since being planted in May 2020.

## Background

- Stormwater is a problem that is increasing with urbanization.
- Mitigating stormwater with green infrastructure can be very effective if planned correctly.
- Green infrastructure is the utilization of plants and nature-based solutions in urban area (Sprouls, 2020).
- Increasing urban tree canopy cover reduces stormwater due to interception and transpiration (Figure 1).
- Trees are excellent for bioretention systems because their large size above and below ground (Scharenbroch, 2016).
- Tree root systems filter stormwater runoff before it enters MS4 systems and thereafter the Chesapeake Bay.
- The goal of the project summarized here is to demonstrate and evaluate a low-cost, low-tech bioretention system that captures runoff and creates tree canopy near impervious areas.

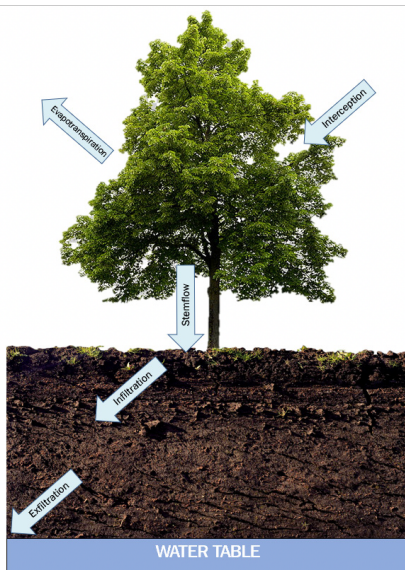


Figure 1. Tree mediated processes that positively influence the urban water cycle.

## Methods

- A series of measurements were performed on both sets of trees to determine their performance during the summer of 2021. This was second growing season since the trees were transplanted in May of 2020.
- The tree species that was chosen for this system was *Platanus x acerifolia* 'Morton Circle.'
- Tree canopy comparison was done using UrbanCrowns photographic analysis software (Figure 5).
- Weekly stomatal conductance measurements were taken with the LI-COR 600 (Figure 6).

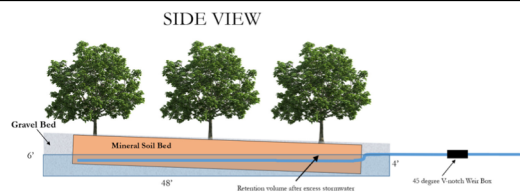


Figure 2. Side view schematic of the gravel bed bioretention system as it was constructed on the Virginia Tech campus.



Figure 3. Gravel bed bioretention system in June 2021, one year after construction and tree planting.

## Conclusion

- The system has been functioning as intended for the 1.5 years since construction.
- The gravel bed trees put out statistically significant larger and more dense crowns than the control trees.
- Their stomatal conductance followed similar trends with the control trees averaging slightly higher than the gravel trees.
- The larger canopy size could be because the gravel bed trees have easy access to water.
- Preliminary results indicated this system holds promise as being a low-cost, low-tech bioretention system
- Monitoring of the gravel bed trees is to be continued for further analysis.

## Results

- Significant differences were found in crown size and density during July of 2021.
- The gravel trees had statistically significant higher values than the control trees for multiple variables (Figure 5).
- The gravel trees had larger, and more dense crowns than the control trees based on multiple evaluations.
- The stomatal conductance levels of the control trees and gravel trees followed very similar trends (Figure 6).
- The conductance was significantly different for only a couple weeks over the course of this past growing season.

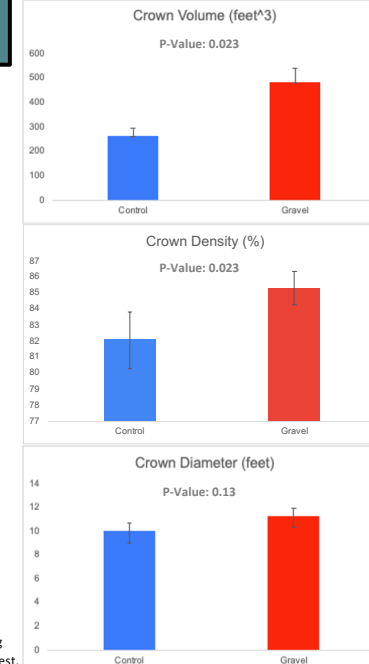


Figure 5. Comparison of crown attributes in control (n=3) vs gravel bed trees (n=3) during 2021 growing season. Comparison of means using two-sample t-test.

## Stomatal Conductance

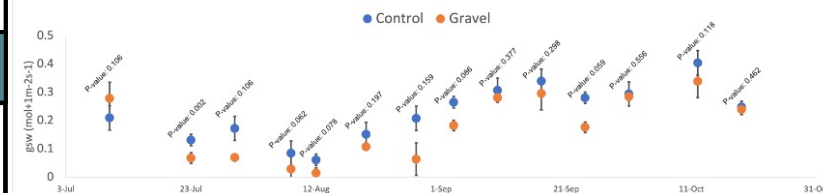


Figure 6. Comparison of stomatal conductance (mol+1m-2s-1) in control trees (n=3) vs gravel bed trees (n=3) during 2021 growing season. Comparison of means using two-sample t-test.

## Work Cited

- Scharenbroch, B. C., Morgenroth, J., & Maule, B. (2016). Tree species suitability to bioswales and impact on the urban water budget. *Journal of Environmental Quality*, 45(1), 199-206.
- Sprouls, Jason M. (2020). Growing Trees in a Gravel Bed Stormwater Retention System as a Novel Approach to Stormwater Management in Urban Sites [Published master's thesis]. Virginia Polytechnic Institute and State University.