

PROGRESS REPORT
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Project Name: Development of a Green Infrastructure Technology that Links Trees and Engineered Soil to Minimize Runoff from Pavement

Contact Person/Principal Investigator

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Grant Modifications: no significant changes

Date of Expiration: September 30, 2007

Funding: Federal Share: \$ 302,750 plus **Grantee Share:** \$ 346,163 = **Total Project:** \$648,913

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Project abstract (as defined by initial proposal and contract):

Degradation of our waterways by urban runoff is a national concern. We propose to develop a green infrastructure that uses trees and structural soil, a new technology that permits root growth under pavement, in an innovative application that will minimize runoff. Unlike other plant-based systems, ours does not require additional space and can be implemented in ordinary situations. We will evaluate the impact of our system on runoff reduction, present results to allow engineers and developers to implement this technology, provide data to advance storm water management calculations, and improve public awareness of the contribution of trees to water quality.

Project objectives:

- evaluate characteristics of structural soils
- map/model range of possible performance of structural soils in our green technology system
- evaluate trees for removal of water from structural soil reservoir with greenhouse/container studies
- collect and analyze runoff and pass through filter cells
- assess effect of structural soil on water quality
- design mechanism(s) for delivering water to underpavement reservoir
- design/coordinate plans for paved areas at 3 national sites
- install 3 national field sites including trees
- install and maintain monitoring equipment
- collect and analyze runoff/storage data for a series of storm events
- collect and analyze tree growth characteristics at field sites
- Install signs at field sites for use as demonstration sites
- quantify reductions in runoff achieved by the system
- publish papers/present research as part of technology transfer
- publish report
- create on-line manual
- create CD with report, manual and slide presentation
- disseminate results through listservs and societies and personal communication

Objectives met successfully to date:

- **evaluate characteristics of structural soils**
- **map/model range of possible performance of structural soils in our green technology system**
- **design mechanism(s) for delivering water to underpavement reservoir**

Additional objectives in progress:

- **collect and analyze runoff and pass through filter cells.** Lab results have been retested and a data summary is expected before our next quarterly report.
- **design/coordinate plans for paved areas at 3 national sites.** All three national sites have been actively developing agreements with partners to solidify plans for installing the runoff mitigation system.
 - **Cornell University:** Partnering with the City of Ithaca, a 12-car parking lot has been constructed; half with our system combined with porous asphalt and half with traditional construction. Additionally, thirty 8' by 8' test plots located at Cornell University growing facilities. These thirty plots are grouped by 3 different base types: CU Structural Soil®, Carolina Stalite Structural Soil, and traditional medium-duty asphalt comprised of 8" of crusher-run and 6" of No.2 stone as a control. Each of the structural soils has three covers: porous asphalt, zoysia grass, and tall fescue grass, while the control has each of these surface covers plus a traditional asphalt surface. For statistical purposes, each surface and base combination is repeated three times producing the total of 30 plots. These experimental plots will also be used for demonstration/educational purposes.
 - **Virginia Tech:** Two-car parking lot has been installed at the Urban Horticulture Center at Virginia Tech with removable "pavement" system for evaluating as both a perviously and imperviously paved site. Twelve, 1" caliper *Acer rubrum* have been planted on periphery and in internal island. Site design has been developed and

is currently out to bid to local contractors. One bid has been received to date. Area contractors have more work than they can handle, so the Society of Friends is offering flexible scheduling options to try and attract more bids. We have met with numerous contractors in order to help solicit bids, but no additional bids have been forthcoming at this point.

- **U.C. Davis:** Investigators have been consulting with landscape designers to find a suitable site for installation of a site.
- **Install 3 national field sites including trees**
 - Ithaca, NY: two sites installed, paved, and planted (see above).
 - Blacksburg, VA: Two-car parking lot is installed.
 - Davis, CA: Parking lot retrofit project is out to bid.



Parking Lot Experimental and Demonstration Site in Davis, California

- **Install and maintain monitoring equipment**
 - Observation wells, minirhizotrons, temperature data loggers, and runoff collection equipment have been installed at the Virginia Tech two-car parking lot.
 - Observation wells, leaf transpiration instrumentation and other monitoring equipment have been installed at the Cornell demonstration parking lot.
 - Monitoring equipment location is indicated on the above map (Measurement systems) at the U.C. Davis site and will be installed when retrofitting is complete.
- **Install signs at field sites for use as demonstration sites**
 - At Ithaca, NY demonstration parking lot, interpretive signs and educational materials are in place. At Blacksburg site, these materials are under development.
- **Evaluate trees for removal of water from structural soil reservoir with greenhouse/container studies.**
 - Virginia Tech: At Virginia Tech, Drs. Day and Harris have been working with graduate student Julia Bartens to collect final data and destructively harvest trees in these experiments. Expected completion of data collection is October 15, 2006. Data analysis is underway.
 - Cornell University: Field and greenhouse studies as previously described are mostly complete and data are being analyzed. Monitoring at demonstration/test sites will continue for the long term.

- **Publish papers/present research as part of technology transfer.** This is a cumulative list of work to date. In addition, we have set up a “Scholar” web site at Virginia Tech to make information sharing and collaboration among investigators easier. This is a password-protected site where data and ideas can be shared pre-publication.
 - Virginia Tech
 - Smith, Genevieve. Presented a paper and oral presentation at the ASCE meeting in Blacksburg, Virginia. Her presentations took first and second prize respectively.
 - Pavlis, Michael, Julia Bartens, and John M. Homyk. Current Research in Urban Forestry and Arboriculture at Virginia Tech. Student Poster Session. International Society of Arboriculture 81st Annual Conference. Nashville, Tennessee. Aug. 6-10, 2005.
 - Dove, J., G. Smith, S. Day, and J.R. Harris. Development of a Sustainable Infrastructure Technology: Linking Trees and Engineered Soil to Minimize Runoff. (Poster Session) NSF Workshop National Cross-Disciplinary Workshop in Engineering and Geoscience: Process-Driven Risk Assessment and Sustainable Mitigation Strategies. September 11-14, 2005, Vanderbilt University, Nashville, Tennessee.
(<http://sitemason.vanderbilt.edu/ees/nsfworkshop>)
 - Day, S. In Search of Space: Landscape Design and How it Affects Tree Growth in Urban Sites. Community Tree Conference 2006—Growing Green: Strategies for Success. University of Massachusetts, Amherst, MA. March 23, 2006. This research was highlighted in this talk for Urban Foresters and Arborists in Massachusetts.
 - “Research Approaches in Urban Forestry” LAR 4304 Topics in Landscape Architecture (Research Workshop). March 16, 2006. Guest lecture presented by S. Day to Landscape Architect and Urban Planning graduate students.
 - Day, S. D. Stormwater Management with Trees and Structural Soil. Invited Speaker, Trees: The Oldest New Thing in Storm Water Management, Arkansas Urban Forestry Council 15th Annual Conference. Fayetteville, AR. April 19-20, 2006.
 - Day, S. D. Looking Ahead—Urban Forests and Natural Resource Protection. Keynote Speaker, Trees: the Oldest New Thing in Storm Water Management, Arkansas Urban Forestry Council 15th Annual Conference. Fayetteville, AR. April 19-20, 2006.
 - Bartens, J., S. D. Day, and R. Harris. Trees and structural soil as a stormwater management system in urban settings: Tree development and contribution. Urban Forestry: bridging cultures, disciplines, old attitudes & new demands. 9th European Forum on Urban Forestry. May 22-27, 2006, Florence, Italy. (Abstract and Oral Presentation)
 - Cornell University
 - Northeast ASHS Conference Soils Symposium " Managing Urban and Compacted Soils" January 2006
 - Fayetteville, NY Urban Tree Management workshop January, 2006
 - Auburn , NY Cooperative Extension workshop. 'Trees in Tough Sites' and 'The Use of Structural Soil in the Urban Environment.' February, 2006
 - Longwood Garden, March 2006. "Techniques for dealing with compacted soils in the landscape."

- Owego, NY State Nursery and Landscape Assoc. "New trees for the urban landscape" and "Update on CU-Structural Soil."
- Bassuk, N.L. and P. Trowbridge. Tree Friendly Technologies for Stormwater Management. American Public Works Association National meeting. Kansas City, September 10-12, 2006.
- University of California at Davis
 - McPherson, Greg. Quantifying Benefits of Green Infrastructure and Storm Water Management. Workshop Session. Right-of-Way Re-engineering Workshop, May 24, 2006. This workshop convened about a dozen experts from public agencies and the land development industry for one day to identify problems associated with current approaches, promising new systems and solutions, and research/demonstration needs
 - Xiao, Qingfu and E. Greg McPherson. Pollutant Removal and Runoff Storage by Three Structural Soils. Abstract for the 4th Biennial CALFED Science Conference 2006: Making Sense of Complexity: Science for a Changing Environment, October 23-25, 2006, Sacramento Convention Center, 1400 J Street, Sacramento, California.
- Additional Presentations highlighting aspects of our project (Jason Grabosky, Rutgers Univ.—Cook College)
 - New Jersey ASLA chapter annual meeting audience approx. 200, January 30.
 - Taj Mahal casino, Atlantic City NJ Long Island Arborists annual meeting, audience approx. 120, February 11.
 - SUNY Farmingdale North Central Texas Urban Forestry Workshop audience approx. 150 February 16.
 - Colleyville, TX Ecology and Evolution graduate program seminar series. audience approx 50 March 2.
- City of Ithaca, NY (Cornell University Partner)
 - Hillman, Andy. CU Structural Soils—Lessons from the field. 2005 Annual Meeting of the Mid-Atlantic Chapter of the International Society of Arboriculture. September 26-28, Morgantown, West Virginia.
- Demonstration Site Tours (Blacksburg, VA)
 - Town of Blacksburg Public Works and Parks and Recreation-6/06 (4 people)
 - Master Gardener College 2006-6/06 (20 people)
- Demonstration Site Tours (Ithaca, NY)
 - New York State Department of Conservation seminar on porous asphalt and structural soil 5/06 (~25 people)



Dr. Bassuk Addresses Crowd at NYSDEC Seminar on Porous Pavement and Structural Soil.

Objectives not yet met:

- evaluate trees for removal of water from structural soil reservoir with greenhouse/container studies *in progress—see above*
- collect and analyze runoff and pass through filter cells (water quality analysis) *in progress—see above*
- assess effect of structural soil on water quality *in progress—see above*
- design/coordinate plans for paved areas at 3 national sites *in progress—see above*
- install 3 national field sites including trees *in progress—see above*
- install and maintain monitoring equipment *in progress—see above*
- collect and analyze runoff/storage data for a series of storm events *in progress—see above*
- collect and analyze tree growth characteristics at field sites *in progress—see above*
- install signs at field sites for use as demonstration sites *in progress—see above*
- quantify reductions in runoff achieved by the system *in progress—see above*
- publish papers/present research as part of technology transfer *in progress—see above*
- publish report
- create on-line manual
- create CD with report, manual and slide presentation
- disseminate results through listservs and societies and personal communication *in progress—see above*

How will this project increase the knowledge we have about urban forestry? How will the public benefit?

This project looks to develop a green infrastructure technology to protect water quality from contaminants in urban runoff. Although the benefits of trees in runoff reduction are well known, we now have, through structural soils, a unique opportunity to integrate the function of on-site storm water management directly with trees. We propose to develop and evaluate a storm water management system that would direct water to a reservoir of structural soil under pavement. Storm water will then be taken up by tree roots and dissipated through transpiration or slowly drain into the water table below. Because structural soils are engineered to support vigorous tree growth as well as to be load-bearing, trees are an integral part of the system as they first intercept water to slow accumulation rates, and then remove water from the reservoir with their root systems. This project will give us understanding about how urban forest trees can directly and measurably reduce or eliminate runoff and the associated nonpoint source pollution from urban sites on a localized scale. When this system is developed, and implemented on a broad scale, the public will benefit from an improved environment—dangers from nonpoint source pollution can be reduced, land will be less likely to be devoted to detention ponds and their associated problems. Water quality will improve. The public will further benefit from a greater population of healthy trees, providing shade, beauty, and all the economic and social benefits shown to accompany them. All developers and municipalities would be delighted to have a beautiful, compact, shaded parking lot with plenty of parking spaces but no runoff—or a shady broad avenue with arching trees and little or no runoff. These ideals seem impossibly distant from the average shopping mall today. We would like to work towards closing that gap by using trees as a functioning part of an engineered storm water management system that does not require additional, valuable land area. Additionally, this project includes many opportunities for public education about trees. Specifically, this project presents a means to show the general public an effective, direct role for trees in green infrastructure.

What specific quantifiable results will be produced?

- Development of a successful tree-based, green infrastructure system for storm water management
- Research findings from the numerous experiments associated with this project including quantifying the reductions in runoff and effects on water quality and quantifying growth of trees in our system
- Tools and information distribution to turn those findings into action including tracking website “hits”
- Test plots serving as public demonstration sites with signage where allowable
- A CD that includes a report, how-to manual, and a slide presentation
- Publication of full scientific findings in peer-reviewed journals
- Articles published in professional magazines/journals
- Talks and presentations at conferences
- Ongoing cataloging of the implementation of this technology around the country in years to come via monitoring structural soil installations.

How will the results be disseminated to the public?

We will use multiple channels of communication to reach as wide an audience as possible. Because land-use planning and development involves professionals from a variety of disciplines, we will emphasize reaching out to each of these, rather than limiting ourselves to urban forestry professionals. First, findings will be published in a peer-reviewed journal and widely presented at both regional and national green industry and research meetings to reach landscape architects, arborists, municipalities, developers, engineers and researchers. These include state Urban Forestry Council workshops and annual meetings; annual meetings and magazines of the American Society of Landscape Architects, the International Arboriculture Society and many others; the Transportation Research Board, and the American Society of Civil Engineers; trade shows such as New England Grows and the Professional Horticulture Conference of Virginia, the Society of Municipal Arborists meetings, the annual meeting of the American Society for Horticultural Science, Metropolitan Tree Improvement Alliance (METRIA) meetings, the National Urban Forestry Conference, and other venues where our collaborators are frequent presenters. Finally, the CD described will be sent (free of charge) to all 50 State Urban Forestry Coordinators and appropriate Extension personnel. Resources will be posted on the internet for no-cost downloading through Virginia Tech’s Forestry Department. Hydrologic modeling information will be provided to engineers and developers of GIS software such as CITYgreen for possible integration into storm water management calculations. We will also communicate the availability of online material via listservs for these professions such as Treelink’s “urbnrnet”. Finally, research test areas will serve as demonstration sites for the public and the municipalities that team with us on this project will communicate its success through their outreach programs.

Has the project met the projected timeline of accomplishments? Is the project on schedule? Is the project ahead of schedule? Is the project behind schedule? If a no-cost time extension has been requested for this project, why is (was) it needed?

The project is mostly on schedule at this point. One point of possible delay is the off-campus demonstration site in Blacksburg, Virginia. The site design has been developed for some time and is currently out to bid to local contractors. One bid has been received to date and this bid is very high. Area contractors have more work than they can handle, so the Society of Friends is offering flexible scheduling and uncoupled bidding options to try and attract more bids. Although there is a housing market slump nationally, we are not experiencing its effects in Blacksburg and contractors continue to

be overbooked. We continue to make all possible efforts to get this project successfully bid and completed, but it is possible that we will have to find other means to accomplish our objective.

List the active partners (key individuals or organizations) involved in the project to-date:

The most active participants at this point are bolded below.

Dr. Nina Bassuk, Cornell University: Director of the Urban Horticulture Institute at Cornell

Ms. Julia Bartens, Graduate Student, Virginia Tech

Dr. Laurence Costello, University of California at Davis

Dr. Susan Day, Virginia Tech

Dr. Joseph Dove, Virginia Tech

Dr. Jason Grabosky, Rutgers University

Dr. Marte S. Gutierrez, Virginia Tech

Mr. Ted Haffner, Graduate Student, Cornell University

Dr. J. Roger Harris, Virginia Tech

Dr. E. Gregory McPherson, USDA Forest Service (Cooperator, federal employee)

Dr. Peter Trowbridge, Cornell University

Dr. Qingfu Xiao, University of California at Davis

Andy Hillman, City Forester, Ithaca, New York

Blacksburg Society of Friends

Comments considered of importance but not covered above: Please note that many objectives are “in progress”. Many of these are essentially complete, but we will continue to add to them and refine them until the end of the grant period.

This report was prepared by:

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Date: September 21, 2006