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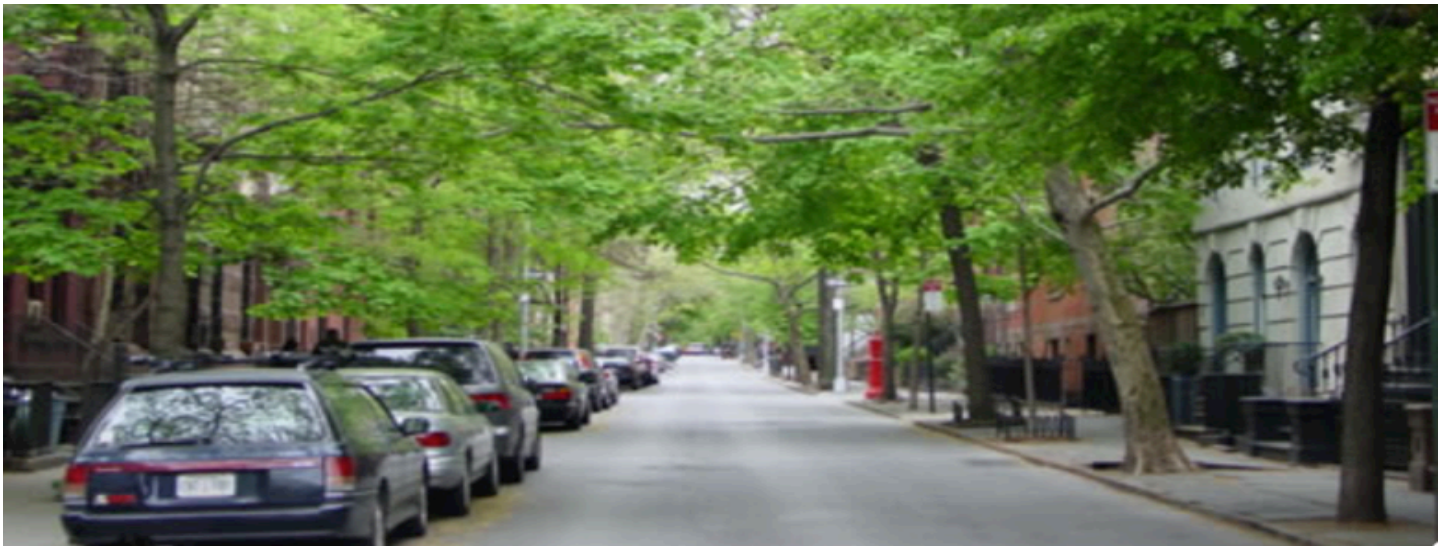
Urban Tree Canopy Assessments: Creating a Nationwide Precedent for Effective Urban Stormwater Management



Trees and forests, including those in cities, have tremendous positive impacts on water quality. Water quality is critically important to human and aquatic health. (Image Credit: Morgan Grove)

If you're like many in the forestry community, you may have heard people give many reasons for wanting to plant trees in city neighborhoods. "They make the neighborhood beautiful", "they clean the air", and "they provide shade" are among some of the more common responses for why trees benefit the local community. Often, paying it forward is a common theme: the idea that planting a tree today can improve lives tomorrow. But how about the idea of paying it forward, spatially? Have you ever heard someone respond by saying "I want to improve water quality for people I haven't even met, who live in rural areas 100 miles away?"

Research by the U.S. Forest Service and partners is showing us just how substantially trees help us to pay it forward, spatially: a tree planted in the city can be a huge benefit for water quality downstream – sometimes, those downstream areas are rural lands adjacent to a river or bay. In fact, investments in urban research, sometimes thought to come at the expense of more rural research and management needs, can yield substantial benefits for both urban and rural areas. So what may have been considered a zero-sum game is now a win-win. What follows is the story of how the Urban Tree Canopy Assessment suite of tools helps us

SUMMARY

The Urban Tree Canopy (UTC) suite of tools consists of high-resolution mapping methodology that integrates green and gray land cover data with critical social, economic, and environmental information to inform sustainability and resilience policy, planning, and management.

The UTC suite of tools came about as a direct result of collaboration among the Chesapeake Bay Forestry Workgroup, the U.S. Forest Service, and other partners. UTC is now used in dozens of cities, and has been used to create and inform tree planting and other goals that improve quality of life for millions of people.

to better understand what, where, and how to prioritize urban tree investment, to create substantial water quality benefits for all communities, whether urban or rural.

City Stream, Country Stream

Like many of our U.S. Forest Service urban research investments and tools, the origins of the Urban Tree Canopy Assessment suite of tools started with a conversation among scientists and managers. In Maryland and surrounding states, the health of the Chesapeake Bay is an issue of great importance. The Chesapeake Forestry Workgroup coordinates, develops, and implements plans and projects which focus on the contributions of forest lands to improving ecosystem health and economic vitality. The group includes state representatives and many partner organizations and has been led by the U.S. Forest Service Northeastern Area since 1992. In the early 90s, the group identified that forest buffers were critical to the health of the Bay. Typically, enhancing forest buffers involves planting trees along streams that flow through farms to increase capture and improve filtration of nutrient-laden water runoff, thus improving the water that flows into the Chesapeake Bay. In urban areas, however, urban streams have been highly modified — they exist underground, in pipes, and in deeply-incised channels, and barely resemble their rural counterparts. A conversation among scientists and managers revealed that it may not be scientifically correct to assume that urban riparian areas function in the same way as rural ones. Perhaps, they considered, streams in very different contexts — running through a large forested area vs. running near a small patch of trees near the side of a road in Baltimore — not only look different, but function differently as well?

Aerial map of the Chesapeake Bay, showing the six state (plus Distict of Columbia) area that constitutes the Chesapeake Bay Watershed. (Image credit: Chesapeake Bay Program.)

To answer this question, scientists with the Baltimore Ecosystem Study, a foundational partner of the U.S. Forest Service in Baltimore, began to compare the function of urban versus rural streams. A forested area near a rural stream will act as a nitrogen "sink," trapping and absorbing excess nitrogen and preventing it from entering the waterway. Nitrogen is essential for plant and animal growth, but an excess of this nutrient in waterways can cause adverse health and ecological effects. In rural contexts, the forest acts as a beneficial sponge, absorbing and protecting the waterway from an overabundance of nutrients. When the scientists examined urban riparian areas, however, they discovered that these areas had the potential to function as sources, not sinks, of nitrogen. This had to do with the modified hydrologic connectivity of the watersheds. Streams in cities have been highly modified. Many urban streams are piped underground to allow roads, buildings, and parking lots to be built, or they experience such extreme influxes of stormwater running off of impermeable surfaces that they become highly channelized, leading to "hydrologic drought" in urban riparian soils. This occurs because the deeply eroded and channelized streams create a lower water table; tree roots, concentrated near the soil surface, do not reach the water table to effectively filter nutrients and soil processes that remove nitrogen no longer occur when the water table is inaccessible (see Fig 1). Ultimately, these circumstances reduce the ability of urban riparian areas to harvest and retain nitrogen, and to survive. Therefore, excess nitrogen may run into waterways and create serious problems for aquatic organisms, ecosystems, and human health.

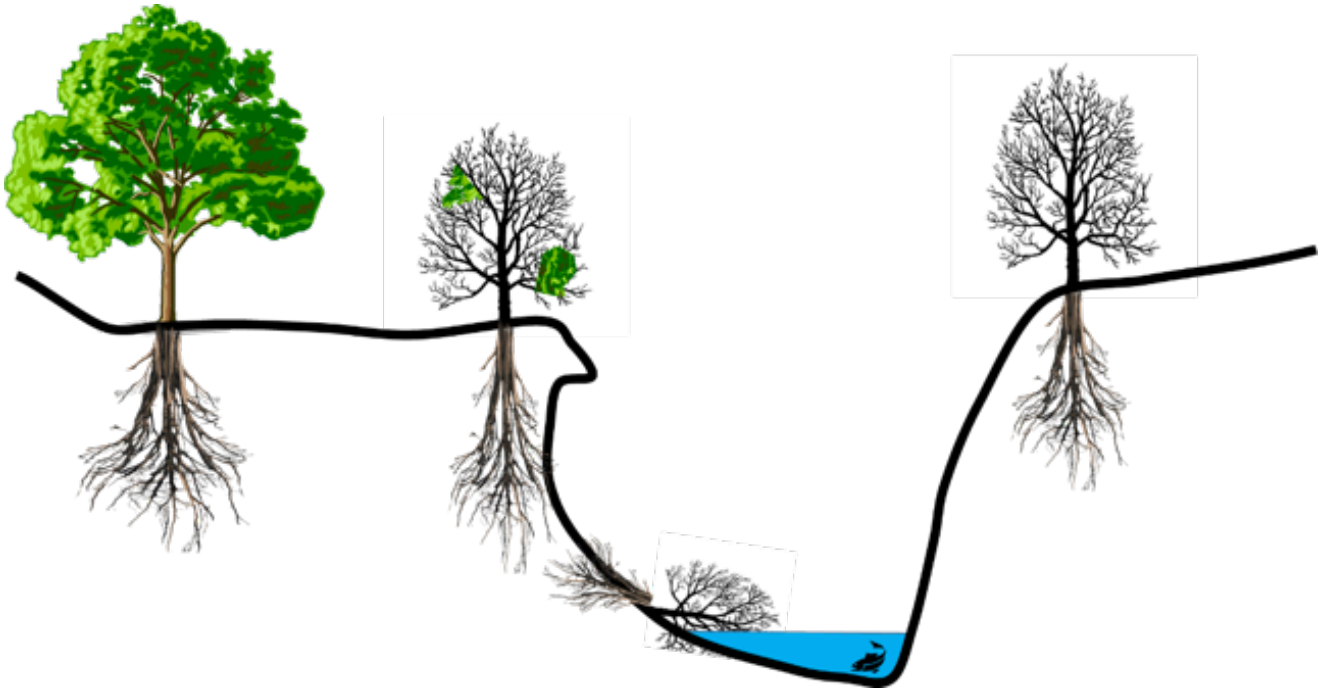


Figure 1. In urban areas, an abundance of impermeable surface means that little stormwater is absorbed into the ground, and instead runs off into streams in large and intense pulses. This leads to streambank erosion and highly incised streams. The surrounding water table, which is connected to the stream's baseflow, drops significantly as the bottom of the stream cuts into the earth. Trees and soil ecosystems are literally left "high and dry" – they are cut off from the water table and no longer absorb or transform nitrogen. These modified urban riparian areas may no longer function as strong nitrogen sinks. (Image credit: Ken Belt).

Better Living through Urban Tree Canopy Cover

Confirming that urban riparian areas function dramatically differently from rural ones demonstrated that planting trees in these areas was not going to solve the water quality problem. The Forestry Workgroup concluded that urban forest restoration, rather than targeting riparian areas, would yield improved results for water quality. What began as a tree planting goal (e.g., plant a certain number of trees by a certain date) turned into a goal to increase total tree canopy cover. This would work to encourage both restoration and conservation of the tree canopy. The idea was that increasing tree canopy across a town or city would create important hydrologic and nutrient cycling benefits to the Bay, because previous research had demonstrated how urban trees reduce stormwater runoff and reduce the flow of stormwater through interception, evaporation, and transpiration. Since stormwater can be a vector that carries litter, pollution (such as oil and gas residues from the street), pesticides, and nutrients (such as fertilizers), reducing large pulses to the Bay would help water quality.

As the Forestry Workgroup discussed how to expand tree cover over cities, including Baltimore and suburban areas, they realized that they needed to know how much tree canopy they had already, where it was located, and where else they could plant trees. While some satellite data existed to show urban tree cover at a very coarse (30 m) resolution, the kind of high-resolution data that the managers needed to answer their questions, garner resources, and prioritize tree planting investments did not exist. U.S. Forest Service scientists and partners, including Morgan Grove, Jarlath O'Neil-Dunne, and Dexter Locke, realized what a critical information gap this was, and how important high-resolution spatial data was to informing both the policy and practices that could make a difference for Chesapeake Bay water quality. From these conversations, the Urban Tree Canopy (UTC) suite of tools was born. The UTC suite is a high-resolution mapping methodology that integrates green and gray land cover data with critical social, economic, and environmental information to inform sustainability and resilience policy, planning, and management. UTC mapping resolutions yield approximately 1,000 times as much information as the previous 30 m resolution data and a UTC assessment can accurately map trees as petite as 8 feet tall – this represents a major advancement in mapping technology, and the information it provides allows for much more detailed, accurate, and advanced decision-making (see Fig 2).

Informing Policy and Practice

The UTC Assessment has helped to inform the City of Baltimore's policy goal of achieving 40% tree canopy cover (from 27% currently), and in turn has

fostered tree planting and prioritization practices that will enable success. For example, one of the major findings in Baltimore is that a) most of the land is private residential, b) most of the canopy is on private residential, and c) most of the opportunities for additional greening are also on private residential land. Knowing this helps managers target planting efforts accordingly by engaging the right partners. In other words, we know that improving water quality requires working on land, and working on land requires working with people. Knowing where the greatest opportunities lie helps managers target planting efforts accordingly by engaging the right people and partners. And as more trees are planted in parking lots, along streets, in parks, and in yards, water quality begins to improve. These trees can also have positive impacts on quality of life, property values, crime rates, quality of life, localized temperature (by ameliorating urban heat island effect), biodiversity, and more.

Since the first UTC assessment was developed for the City of Baltimore, these data are now being produced and used at state and regional levels, including for the entire multi-state Chesapeake Bay watershed. The State of Maryland has adopted the UTC assessments as its standard for all urban and rural lands and requires the state's Department of Natural Resources to conduct an assessment of forest and land cover change for the entire state and to submit a report to the state legislature. To date, 87 UTC assessments have been conducted in the United States and Canada, covering approximately 37,800 square miles, 1,900 communities, and 40 million people (2013 Census). These data are integrated with municipal data systems for local decisionmaking in general and other assessment tools in particular, such as the Forest Service's iTree suite of software tools to model ecosystem service values and EPA's EnviroAtlas system for assessing the health impacts of trees and other vegetation in urban areas.

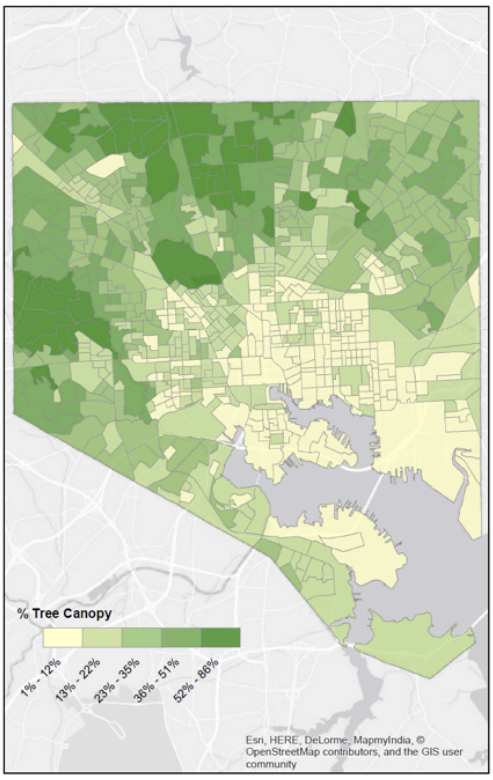


Fig 2. Map showing tree canopy cover in the city of Baltimore. The UTC suite of tools, which enable the creation of maps such as this, came about as a direct result of the collaboration among the Chesapeake Forestry Workgroup, the U.S. Forest Service, and other partners. (Image Credit: US Forest Service)

Tree Planting as a Creditable Best Management Practice

The policies and practices enabled by the work of the Chesapeake Forestry Workgroup and the UTC suite of tools have been so effective that they have resulted in regulation changes. From 2014-2016, the science behind the Expanded Urban Tree Canopy practice was reviewed and, in September 2016, an updated credit was adopted by the Chesapeake Bay Program. Under the updated credit, cities receive TMD6 credits (as well as institutional and financial backing) for tree planting and urban tree canopy enhancement. This not only improves water quality in the Bay, it improves lives and well-being in Baltimore and beyond. Now, those planting trees in Baltimore (or other cities) can feel good knowing that their investments help not only their community, but also communities many miles away, since rural areas adjacent to the Bay benefit by improved water quality enabled by uniquely urban research investments. The scientists and practitioners with the U.S. Forest Service and the Chesapeake Forestry Workgroup are working with partners so that the lessons learned and positive outcomes for water quality and urban forest investments that were enabled by the UTC suite of tools can be used to improve stormwater management and water quality nationwide.

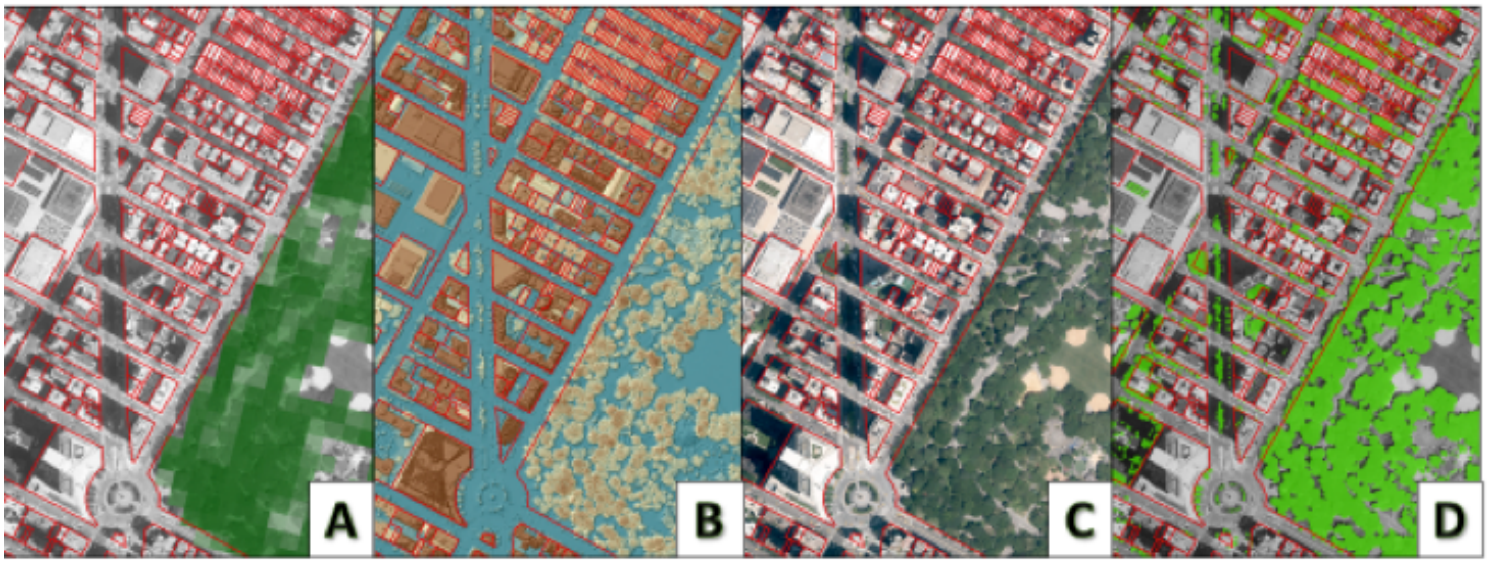


Figure 3. This image shows A) National Landcover Database (NLCD) tree canopy cover, available at 30 m resolution. Using B) LiDAR and C) Parcel data yields D) an Urban Tree Canopy (UTC) assessment which accurately accounts for tree canopy (or lack thereof) in each parcel and shows trees as petite as 8 feet tall. (Image credit: Jarlath O'Neil Dunne)

KEY FINDINGS

• Water quality is critically important to human and aquatic health, and improving water quality requires working on land. Specifically, trees and forests have tremendous positive impacts on water quality.

• Not all land is the same: Urban ecosystems are heavily modified and we cannot assume that they function in ways similar or identical to rural ecosystems. Studies have demonstrated that trees in urban riparian areas are not as effective at reducing nitrogen and other pollutants.

• Impervious surfaces—found in abundance in urban and suburban areas - negatively impact water quality. Green infrastructure and trees can reduce impervious surface area, mitigate stormwater runoff, and improve water quality in local streams and waterways as well as larger downstream areas (e.g. the Chesapeake Bay).

• Working on land requires working with people, especially in an urban context. The UTC suite of tools can help identify opportunities for increasing canopy; because the data is spatially explicit, managers can better determine with whom they must work to reach their goals.

MANAGEMENT IMPLICATIONS

• A more effective strategy for decreasing stormwater runoff and improving water quality in urban areas involves planting trees throughout the city rather than targeting urban riparian areas. Trees help reduce stormwater runoff via interception, evaporation, transpiration, and nutrient uptake. Trees planted throughout the city can effectively slow stormwater surges and remove nitrogen better than their counterparts in compromised urban riparian zones.

• The Urban Tree Canopy (UTC) suite of tools has enabled Baltimore and many other cities (including New York, Philadelphia, Los Angeles, Denver, and Detroit) to create policy and implement practices to achieve greater urban tree cover. A UTC assessment has been completed for the entire multi-state Chesapeake Bay Watershed and has become a significant tool to help plan, implement, and monitor enhancements in tree canopy and translate those enhancements into water quality improvements.

• Increasing urban tree canopy throughout cities creates a host of benefits beyond water quality, including reducing the heat island effect, improving well-being and neighborhood satisfaction, increasing biodiversity and, in some cases, reducing crime.

•Uniquely urban research investments can yield new knowledge that helps us to manage urban areas and rural areas more effectively, to the benefit of both urban and rural populations.

FURTHER READING

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• Urban Tree Canopy Assessment information page. US Forest Service, Northern Research Station. Available at: https://www.nrs.fs.fed.us/urban/utc/

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• Chesapeake Tree Canopy Strategy (2015) accessible at http://www.chesapeakebay.net/managementstrategies/strategy/tree_canopy

• Urban Tree Canopy BMP Expert Panel Report http://www.chesapeakebay.net/publications/title/urban_tree_canopy_bmp_expert_panel_recommendations

SCIENTIST PROFILES

Sally Claggett is a program coordinator with the U.S. Forest Service's Northeastern Area and has served as liaison to the Chesapeake Bay Program since 2002. In this capacity, she has worked with forestry and water quality partners to better integrate forestry as a solution to non-point source pollution. Prior to her work at the Chesapeake Bay Program, Sally was a botanist on National Forests in the Pacific Northwest. She holds a BS in Environmental Biology from the University of Colorado, and a MS in Ecology from the University of Oregon.

Mike Galvin is a project manager with the Baltimore Urban Field Station and also serves as Director of the consulting group for SavATree. He helps to apply and extend the results of the Urban Tree Canopy Assessments to the surrounding region. Mike has close to 30 years of experience in the forestry and arboriculture communities, which includes 13 years with the Maryland Department of Natural Resources.

Morgan Grove is a research forester with the U.S. Forest Service's Northern Research Station at the Baltimore Urban Field Station and the lead social scientist for the Baltimore Ecosystem Study, a long-term ecological research project funded by the National Science Foundation. He was the first social scientist from the Forest Service to receive the President's Early Career Award for Scientists and Engineers. Morgan has several degrees from Yale University: a doctorate in social ecology, a master's degree in community forestry, and bachelor's degrees in urban planning and environmental studies.

Dexter Locke is a PhD candidate at the graduate school of geography at Clark University. He has worked with the U.S. Forest Service for over 5 years, spending time at the New York City, Philadelphia, and Baltimore Urban Field Stations. Dexter has a B.S. in natural resource planning from the University of Vermont, a MESc in environmental science from the Yale School of Forestry and Environmental Studies, and an MA in Geography from Clark.

Julie Mawhorter serves as Mid-Atlantic Urban and Community Forestry Coordinator at the U.S. Forest Service, Northeastern Area. As part of this role, she coordinates the development and implementation of partnership activities under the 2015 Chesapeake Tree Canopy Strategy. Prior to joining the Forest Service in 2010, Julie completed a PhD in Natural Resources Policy and Masters in Public Administration at the University of Tennessee.

Jarlath O'Neil-Dunne is a faculty member at the University of Vermont, where he also serves as director of the University's Spatial Analysis Laboratory. He also holds a joint position with the U.S. Forest Service. His research focuses on the application of geospatial technology to a broad range of natural resource related issues. Jarlath has certificates in hyperspectral image exploitation and joint GIS operations from the National Geospatial Intelligence College, a master's degree in water resources from the University of Vermont, and a bachelor's degree in forestry from the University of New Hampshire.

WRITER'S PROFILE

Sarah Hines is the Development, Communication, and Science Delivery Coordinator for the Northern Research Station's Urban Field Station Network. She holds an A.B. in biological anthropology from Harvard University and an M.S. and M.B.A. from the University of Michigan.

Other people who have been critical to advancing the tools and outcomes described above but are not currently affiliated with the U.S. Forest Service include ***Al Todd, Peter Claggett, Gene Moll,*** *and the many dedicated professionals who serve on the Chesapeake Bay Program Forestry Workgroup.*

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