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Chesapeake Forest Restoration Strategy

Acknowledgments

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This revision of the Chesapeake Forest Restoration Strategy was a collaborative effort. State forestry agencies in all seven jurisdictions provided the impetus and continued support needed. Our advisory team members played a key role in developing and refining the content (listed on page 6). The following individuals also directly contributed content to the Strategy: Tracey Coulter (Pennsylvania Bureau of Forestry), Lindsey Curtin (U.S. Forest Service), Scott Eggerud (Office of Surface Mining Reclamation and Enforcement), Louis Iverson (U.S. Forest Service), Kate Livengood (The Nature Conservancy), Kate McFarland (USDA National Agroforestry Center), and Matthew Peters (U.S. Forest Service).

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We thank all these partners for making this Strategy a reality.

Links to Websites

All website hyperlinks are underlined in blue. The full URLs for all hyperlinks are listed in chronological order on pages 39 to 40.

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Cover

Top Left: The Wicomico River (top) and Whites Neck Creek (bottom) flow toward the Potomac River in Charles County, Maryland. (Courtesy photo by Will Parson, Chesapeake Bay Program)

Top Right: Forest tour at Enniskillen Farm in Maryland. (Courtesy photo by Skyler Ballard, Chesapeake Bay Program)

Bottom Left: Ryan Davis (Alliance for the Chesapeake Bay) during tree planting instruction with the Huntingdon State Correctional Institution in Huntingdon, PA. (Courtesy photo by Will Parson, Chesapeake Bay Program)

Bottom Right: Urban trees along the waterfront at Nationals Park in Washington, DC. (Courtesy photo by Will Parson, Chesapeake Bay Program)

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Steve Algeier from University of Maryland Extension discusses invasive plant control. (Courtesy photo by Alliance for the Chesapeake Bay)

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Executive Summary

The Chesapeake Bay watershed is the largest estuary in North America and a National Treasure that encompasses 64,000 square miles, including some of the densest human populations in the country. The watershed is agriculturally productive with more than 83,000 farms. Forests, however, cover 60% of the watershed and extend from the Appalachian Mountains to the Coastal Plains. Private landowners own the majority (80%) of the watershed's forests, many of which are associated with a farm. These private, rural landowners are a key partner in restoring the Chesapeake ecosystem. The watershed is also rich with forested public land, including portions of two national forests and numerous State forests.

Forests are the most beneficial land cover for reducing nutrient and sediment pollution and for restoring the functions and services of Chesapeake ecosystems. Forests can also capture more than 85% of airborne nitrogen that falls on them, keeping this nitrogen from entering waterways. Many forests in the Chesapeake Bay watershed have been lost or fragmented as a result of rapid development and, at the same time, forest health is often compromised. Through forest restoration, as forests and tree canopy are re-established and forest health is improved, the landscape moves to an improved ecological condition. These activities benefit both Chesapeake Bay watershed ecosystems and the human communities that rely on them.

To give greater recognition and emphasis to the imperative to collaboratively restore forests across the watershed, the States within the watershed and the U.S. Department of Agriculture, Forest Service decided to update the 2012 Chesapeake Forest Restoration Strategy using shared stewardship as a framework. This Strategy lays out broad priorities and actions that will guide our forestry partnership efforts in the years ahead.

This update of the 2012 Chesapeake Forest Restoration Strategy reflects key advancements made by the Chesapeake Bay Program partnership. These include more accurate data derived from high-resolution imagery, new goals adopted in the 2014 Chesapeake Watershed Agreement, and 2019 Watershed Implementation Planning documents from each of the States.

The Strategy is organized according to three overarching landscape types: urban, agriculture, and natural. While the original Strategy provided information about restoring forests in urban and agricultural landscapes, this update adds strategies for restoring ecosystem health and function to existing forests within natural landscapes. Each section has a similar format and culminates with key restoration actions appropriate to each landscape. A new section on climate change applies to all landscape types, which includes new considerations and actions for improving forest resiliency. The concluding section of the Strategy reviews overarching needs and identifies unifying approaches and tools for forest restoration.

Forest restoration is the foundation for meeting a number of key outcomes and actions set forth in the 2014 Chesapeake Watershed Agreement, such as improving habitat, water quality, and climate resiliency. The Watershed Agreement sets specific targets for increasing riparian forest buffers and tree canopy, which are also reflected in each State's Watershed Implementation Plan. This Forest Restoration Strategy addresses these targeted forest restoration practices and identifies additional forest restoration needs for improving overall forest health and resilience:

- Supporting community-based tree planting initiatives in urban areas.
- Strategically incorporating agroforestry practices into farms to provide economic and environmental benefits.
- Restoring forests, including early successional forest habitat, to improve their health and address stressors such as pests and invasive species.
- Designing and implementing climate-resilient forest restoration projects that will help communities adapt to the impacts of climate change.

To better meet these forest restoration needs across the Chesapeake Bay watershed, the following key, overarching strategic actions were identified:

- Expand the restoration workforce and supply chain to build capacity for sustainable, large-scale forest restoration projects.
- Seek private capital investments to accelerate forest restoration economies.
- Train and educate leaders at all levels so they can better support forest restoration through funding, policies, and mutually supportive decisions.
- Expand outreach and education on forest restoration.
- Work to meet the specific actions identified in the Chesapeake Forest Restoration Strategy for urban and community, agricultural, and natural landscapes, which include supporting the development of diverse markets for forest products.

We celebrate the progress we have made to date restoring forests through the Chesapeake Bay Partnership. We will continue to collaboratively restore forests as outlined in this Strategy for the benefit of both the ecosystems and the people of the Chesapeake Bay watershed.

Section 1 - Introduction

Forests are the predominant natural land cover in the populous Chesapeake Bay watershed, home to the largest estuary in the United States. From its headwaters in the Appalachian Mountains to the Atlantic Ocean, the Chesapeake Bay watershed supports over 3,600 species of animals and plants across multiple physiographic regions (Chesapeake Bay Program 2020) (figure 1.1). This same biodiverse landscape houses over 18 million people who depend on the region's forests for clean air and water, for economic returns, and for recreation and beauty.

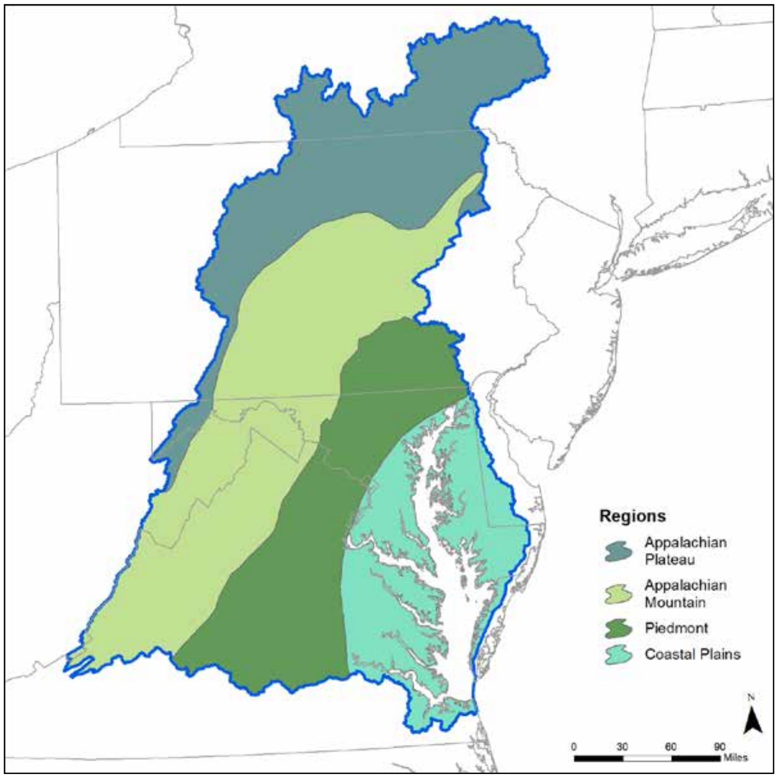


Figure 1.1.—Physiographic regions in the Chesapeake Bay Watershed. (U.S. Forest Service map by Matthew Peters)

Mostly held in private ownership, the 64,000 square miles of the bay watershed encompasses parts of six States and all of the District of Columbia—including rural areas and dense urban populations. The watershed is also agriculturally productive, and many forests are associated with a farm. To maintain the beauty, health, and integrity of Chesapeake ecosystems, our human habitat must increasingly accommodate natural resource needs.

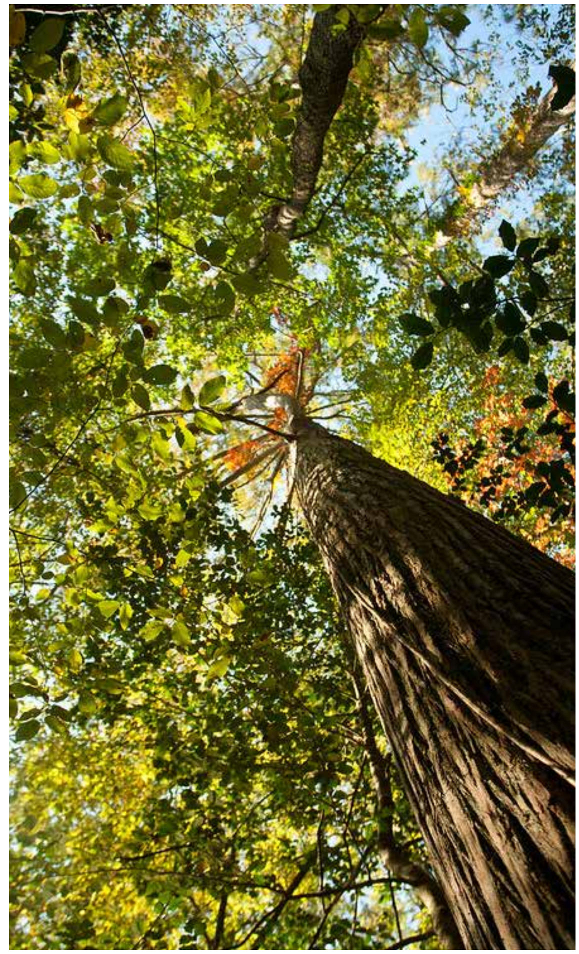
Unfortunately, many forests in the Chesapeake Bay watershed have been lost or fragmented as a result of rapid development, which often compromises forest health. Forest restoration benefits both Chesapeake Bay watershed ecosystems and the human communities that rely on them. Because the Chesapeake Bay has the highest land-to-water ratio of any coastal waterbody in the world (14:1), it is particularly sensitive to land management. Urbanization and climate uncertainties only enhance the need for the many services provided by healthy forests. **In a region with many people, the pressures to remove forests are prominent, but so is the need to restore forests to the landscape**.

What is Forest Restoration?

Forests are the most beneficial land cover for both water quality and bringing back the functions and services of Chesapeake ecosystems. Forest restoration can help mitigate the loss of forests and should be applied widely in concert with other conservation efforts to support well-managed agriculture and well-designed communities. For this report, forest restoration broadly means to move the landscape to an improved ecological condition through re-establishing forests and tree canopy as well as improving forest health through enhanced forest management. Moving the landscape to an improved ecological condition includes restoring diverse forest habitat across multiple age and size classes, including early-successional scrub/shrub habitats, to provide important habitat for a number of declining avian species. **The goal of this Strategy is to highlight the importance of forest restoration and find actions and points of leverage that allow for an increase in forest area and health across the landscape**.

Partnership goals for forest restoration call for the re-establishment of forests in lands that are devoid of trees—known as *afforestation* where forest was not recently present (such as on farms and developed land)—and *reforestation* where there was recently forest. The 2014 Chesapeake Bay Agreement has afforestation goals but does not have a specific goal for reforestation; however, some of the State Watershed Plans and other authorities may. To support other goals in the 2014 Agreement (habitat and clean water goals, for example), there is also a need to restore existing forests to improve ecosystem function and services. Some natural areas, including early successional habitats, have trees or shrubs that are overrun with invasive species, damaged by disease, or have an understory that is unable to regenerate. Other areas may be impaired due to unplanned or poorly planned forest harvesting activities. Degraded forests require active management before they can provide quality habitat or other ecosystem services.

Reversing Forest Loss in the Chesapeake



Tree canopy. (Courtesy photo by Alliance for the Chesapeake Bay)

Established forests are the most valuable forests on the landscape. It takes decades to fully restore a forest, so conserving forests is one of the most cost-effective practices for the Chesapeake Bay. For this reason, the Bay Program partnership established a goal to protect an additional 695,000 acres of forest land of highest value for maintaining water quality by 2025. One analysis in the Rappahannock basin of Virginia found that retaining forests would save $125 million in avoided water quality practices (Healthy Watersheds Project Team 2015). While forest conservation is not the focus of this Strategy, the Chesapeake Conservation Partnership outlines important strategies for land and forest conservation.

The history of forest loss in the watershed highlights the importance of forest conservation and restoration. Before European settlement, the Chesapeake watershed was almost completely forested (Brush 2001). Chesapeake forests were extensively cleared for coal, agriculture, and timber in the 19th century. Many were allowed to regrow during the industrial revolution, and there were some prescient actions to protect forests around that time. For example, the 1911 Weeks Act allowed the Federal government to purchase 6 million acres of private land in the Eastern U.S. (U.S. Forest Service 2011). Some of this land became national forest in the headwaters of the Chesapeake watershed. However, in the 1990s and early 2000s, forests were lost to development at a rate of 100 acres/day in the Chesapeake Bay watershed (The Conservation Fund 2006). In 2013, high-resolution mapping showed that forests covered only 58% of the watershed.

Habitat loss has taken a great toll on the many species that need forests for clean water, food, shelter, breeding – in essence, for survival. Forest lost to development is especially alarming because it is often permanent. High-resolution data reveals that recent forest loss is common in relatively small pieces, but taken together, the toll is large, even in places with goals to increase tree canopy. In one assessment, Prince Georges County, Maryland, had a net loss of 7,155 acres of tree canopy from 2014 to 2018 (Claggett and Soobitsky 2019).

The remaining **forest in the watershed is increasingly impacted by fragmentation and parcelization** as declining forest product markets, development pressure, and high property taxes impact forest landowners. Parcelization divides forest patches into multiple ownerships, making management more difficult and increasing the likelihood that forests will be converted to development. Fragmentation divides larger tracts of forest into patches, which are forested areas that are too small to provide the full benefits of forests but still provide some wildlife habitat benefits. However, fragmentation impacts songbirds like the cerulean warbler and other vulnerable species that require large blocks or “hubs” of forest interior habitat. Forest patches are also more vulnerable to invasive species and extreme weather events and are less likely to be managed and maintained. According to a recent USGS analysis of 2013 high-resolution land use data, 60% of forested areas across the watershed are less than ½ acre. In a patchwork landscape of human disturbances, animals need forested corridors connecting larger “islands” of forest and wetland habitat. Maintaining and restoring corridors will become increasingly important as species migrate to find new suitable habitat in the face of climate change.

Restoring Forest Health

Later-successional forests are often more valuable than new forests in terms of the ecosystem services they provide, such as timber and carbon storage. Because forests have dominated the landscape for thousands of years, perhaps their most important service is providing essential habitat for a diversity of species, including species of conservation concern, like the wood turtle and certain neotropical migratory bird and salamander species. However, multiple interacting human and climate-induced stressors can have a compounding negative impact on the benefits that forests can provide. For example, many poorly managed forest patches are increasingly affected by stressors like invasive species and overabundant deer, which negatively impact the growth of native trees and shrubs as well as the benefits forests can provide to people and wildlife.

A Call for Resources

While planting trees is a cost-effective means to restore many functions back to the Chesapeake ecosystem, substantial resources are still needed. Materials and labor are important during initial planting stages, but intensive maintenance may be needed after planting with annual maintenance continuing for 10 or more years. Restoration of existing forests can also involve substantial resources. Intensive multi-year vegetation removal, tree planting, and ongoing maintenance may be required to restore these forests. This is not a job for any one agency or funding source; rather, coordinating restoration activities at scale will be a layered approach involving many new and existing partners and resources.

Shared Stewardship

For decades, Federal, State, and local partners in the Chesapeake Bay watershed have been working together through the Chesapeake Bay Program partnership to improve water quality and other ecosystem services through forest restoration. This collaboration provides an ideal framework to prioritize where forest restoration is most needed, outline pathways to implement targeted forest restoration to achieve watershed-wide goals, and ensure that the critical voices of Tribal partners and underrepresented communities continue to be reflected in our journey.

The shared stewardship approach reflected in this Strategy complements the priorities identified in individual State Forest Action Plans. Given the diversity of forests and communities within the watershed, integrating the broad recommendations of this Strategy with State Forest Action Plans will help ensure that forest restoration is implemented in a way that addresses local management concerns.

Restoring Chesapeake Forests through Partnerships

Many partners are working to restore the Chesapeake Bay ecosystem and its vital forests, and this Strategy lays out broad priorities and actions that will guide our forestry partnership efforts in the years ahead. The process of collaboration started with the following organizations and individuals who helped guide the development of the Strategy:

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Benefits of Forests

Ecosystem services is a term commonly used to describe the benefits nature provides to people, often free of cost. Trees are nature's multitaskers, providing numerous, far-reaching, and long-term ecosystem service benefits. For example, a recent analysis from the watershed found that riparian forest buffers provide higher total levels of co-benefits for other ecosystem services and Bay Program goals than other water quality Best Management Practices (Tetra-Tech 2017). Forests provide four types of ecosystem services defined by the Millennium Ecosystem Assessment (2005) (figure 1.2).

More detail on the ecosystem service benefits forests provide can be found within specific landscape types throughout this Strategy. These ecosystem services provided by trees directly benefit people in a number of ways:

- Diversifying rural livelihoods
- Increasing income (from improved food/timber production)
- Increasing property values
- Improving public health
- Providing a buffer to climate change impacts
- Protecting infrastructure from flooding

Forest restoration activities also directly benefit communities. Engaging the public in forest restoration can provide a hands-on form of environmental education that helps cultivate an environmental stewardship ethic and generate a sense of pride within communities. Further, realizing our forest restoration goals at scale will not only require knowledgeable foresters, but leagues of restoration workers in both rural and urban areas that can help with project planning, implementation, and maintenance. By supporting local businesses and entrepreneurs while generating jobs, forest restoration can grow local restoration economies.

These are some of the broad, cross-cutting reasons to facilitate forest restoration; more specific reasons are included in the priority areas of this Strategy.

Responding to Drivers for Forest Restoration

Chesapeake Executive Council Directives and Agreements in 1996, 2000, 2003, 2006, 2007, and 2014 set goals for forest cover, including riparian forest buffer restoration, forest conservation, and urban tree canopy expansion. The most recent Directive signed by the Executive Council is the 2014 Watershed Agreement, which had the following vision:

> *"The Chesapeake Bay Program partners envision an environmentally and economically sustainable Chesapeake Bay watershed with clean water, abundant life, conserved lands and access to the water, a vibrant cultural heritage and a diversity of engaged citizens and stakeholders."*

Provisioning services	• Water supply • Timber production • Food production • Biomass for energy production
Regulating services	• Water filtration • Flood mitigation • Temperature regulation • Air quality • Carbon storage • Erosion control
Supporting services	• Soil fertility • Wildlife habitat • Pollination
Cultural services	• Recreation • Scenic beauty • Tourism

Figure 1.2.—Ecosystem services provided by forests.

The Restoration Economy

Ecosystem markets connect the restoration and conservation of healthy ecosystems with funding from the people or organizations that benefit from the services these ecosystems provide. Ecosystem markets have expanded rapidly in the United States in recent decades. An estimated $383 million per year moves through watershed markets and $58 million per year moves through forest and land-use carbon markets (Bennett and others 2016). Increasing investments in ecosystem markets have supported a growing restoration economy. BenDor and others (2015) found that nationwide, the restoration economy directly employs 126,000 people and helps support 95,000 additional jobs. Restoration businesses have spread throughout the country and are often located in rural areas that may be more negatively affected by economic downturns. Restoration jobs include both white-collar jobs that involve planning, designing, and engineering restoration projects as well as "green-collar" jobs that support site preparation, construction, and maintenance. Furthermore, restoration activities directly support other local businesses, including plant nurseries and heavy equipment companies.

The goals specific to forest restoration include these:

Riparian forest buffers: "Continually increase the capacity of forest buffers to provide water quality and habitat benefits throughout the watershed. Restore 900 miles per year of riparian forest buffer and conserve existing buffers until at least 70 percent of riparian areas throughout the watershed are forested" (figure 1.3). States also established ambitious targets for forest buffers in their Watershed Implementation Plans proposing an additional 148,000 acres of forest buffers by 2025 to improve water quality. According to high-resolution land use data, almost 70% (201,600 miles) of the watershed's streambanks and shorelines are in a natural condition (including non-forested, grass, or wetland areas). However, there are still at least 1.4 million acres where riparian forest buffers could be established (Chesapeake Progress 2020).

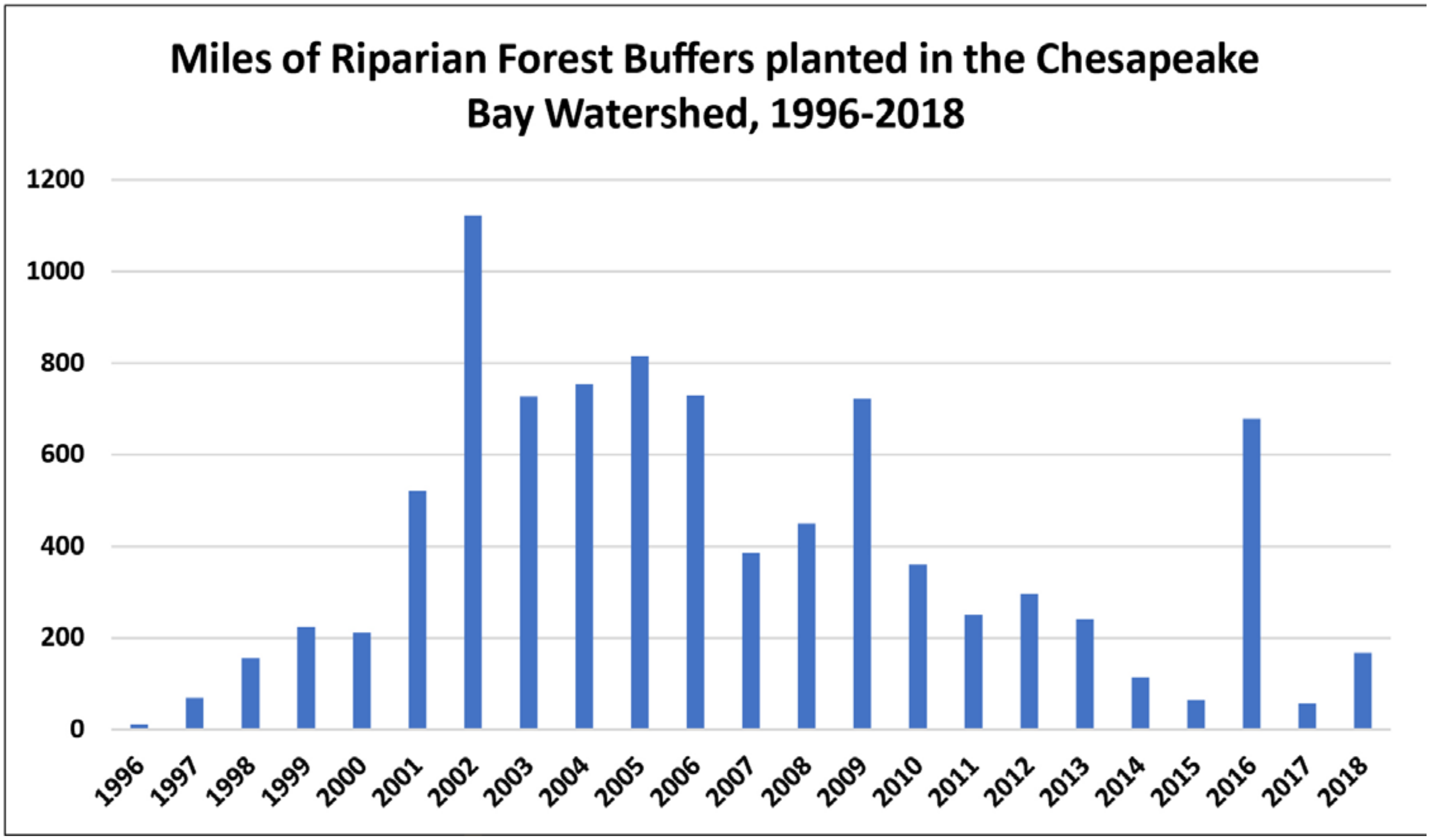

Figure 1.3.—Annual riparian forest buffer accomplishments from 1996 to 2018.

Urban tree canopy: "Continually increase urban tree canopy capacity to provide air quality, water quality, and habitat benefits throughout the watershed. Expand urban tree canopy by 2,400 acres by 2025." The first watershed-wide, baseline urban tree canopy assessment was completed for 2013. A new high-resolution dataset is currently being produced using 2018 data, which, when complete, will enable an assessment of progress towards meeting this goal.

In addition to these specific goals, forest restoration is the foundation for meeting a number of other key outcomes and actions set forth in the 2014 Chesapeake Watershed Agreement, including fish habitat, brook trout, stream health, water quality, healthy watersheds, citizen stewardship, and climate resiliency.

TMDL

The largest driver for restoration for the past 30 years of the Bay Program has been poor water quality. In 2010, the Environmental Protection Agency (EPA) listed the main stem of the Chesapeake Bay as impaired for non-point source pollutants (nitrogen, phosphorus, and sediment). A regulated blueprint to improve water quality, the Chesapeake Bay Total Maximum Daily Load (TMDL), limits the load of pollutants that can enter waterways throughout the watershed. Riparian forest buffer plantings and other tree plantings are Best Management Practices (BMPs) that count toward the TMDL's required pollution reductions, with riparian forest buffers being one of the most cost-effective BMPs. One acre of riparian forest buffer can remove up to 171 pounds of total nitrogen, 33.6 pounds of total phosphorus, and 17,612 pounds of suspended sediment annually (Chesapeake Bay Watershed Data Dashboard n.d.).

Overview of the Strategy Sections

There are different ways to prioritize areas for forest restoration. This Strategy takes a broad look at the watershed and landscape areas that offer ripe opportunity for action.

Urban and Community Landscapes — Increasing tree cover in towns and cities is a priority because of the numerous environmental and social benefits to people. Grassroots community involvement can spur tree-planting initiatives in developed areas and unique partnerships to plant trees for different but mutually beneficial reasons. Developed areas accounted for 13.5% of the watershed in 2018.

Agricultural Landscapes — Trees can produce economic and environmental benefits on farms through strategic practices such as riparian forest buffers, windbreaks, alley cropping, silvopasture, and forest farming. Partnership actions focus on increasing awareness and implementation of agroforestry practices. Agricultural landscapes accounted for 20.1% of the watershed in 2018.

Natural Landscapes — Many wildlife species in the watershed depend on forests. Restoration activities can target practices like invasive species removal and tree thinning that improve the quality of forested habitats and the ecosystem services they provide. The watershed also includes natural, shrub-scrub areas that can provide important early successional habitat or opportunities for restoration. For example, previously mined lands dominated by non-native grasses can be restored to high-value hardwood trees. Natural landscapes accounted for 66.4% of the watershed in 2018.

In this updated Strategy, we have added a section on the implications of **climate change** for forest restoration. We discuss the projected changes in climate for Chesapeake forests, highlight the important role forest restoration can play in mitigating and adapting to climate change, and outline important considerations for designing climate-resilient forest restoration projects.

The Strategy's **conclusion** emphasizes integrating forest restoration efforts across these priority areas, highlighting key tools, partnership actions, and financing strategies that can support implementation. Regional and local partnership initiatives can target areas of overlapping priorities, leveraging resources from multiple programs to achieve forest restoration goals.

Section 2 - Restoration in Urban and Community Landscapes

Why

Considering the many benefits trees provide to people, it is important that they grow where people are—in our towns and cities. Increasing tree cover in communities is one of the most sustainable and cost-effective practices to improve both societal well-being and the environment. Trees provide innumerable benefits to communities, and our understanding of the relationship between trees and human health is growing rapidly. Some of the benefits of trees in communities are highlighted in figure 2.1.

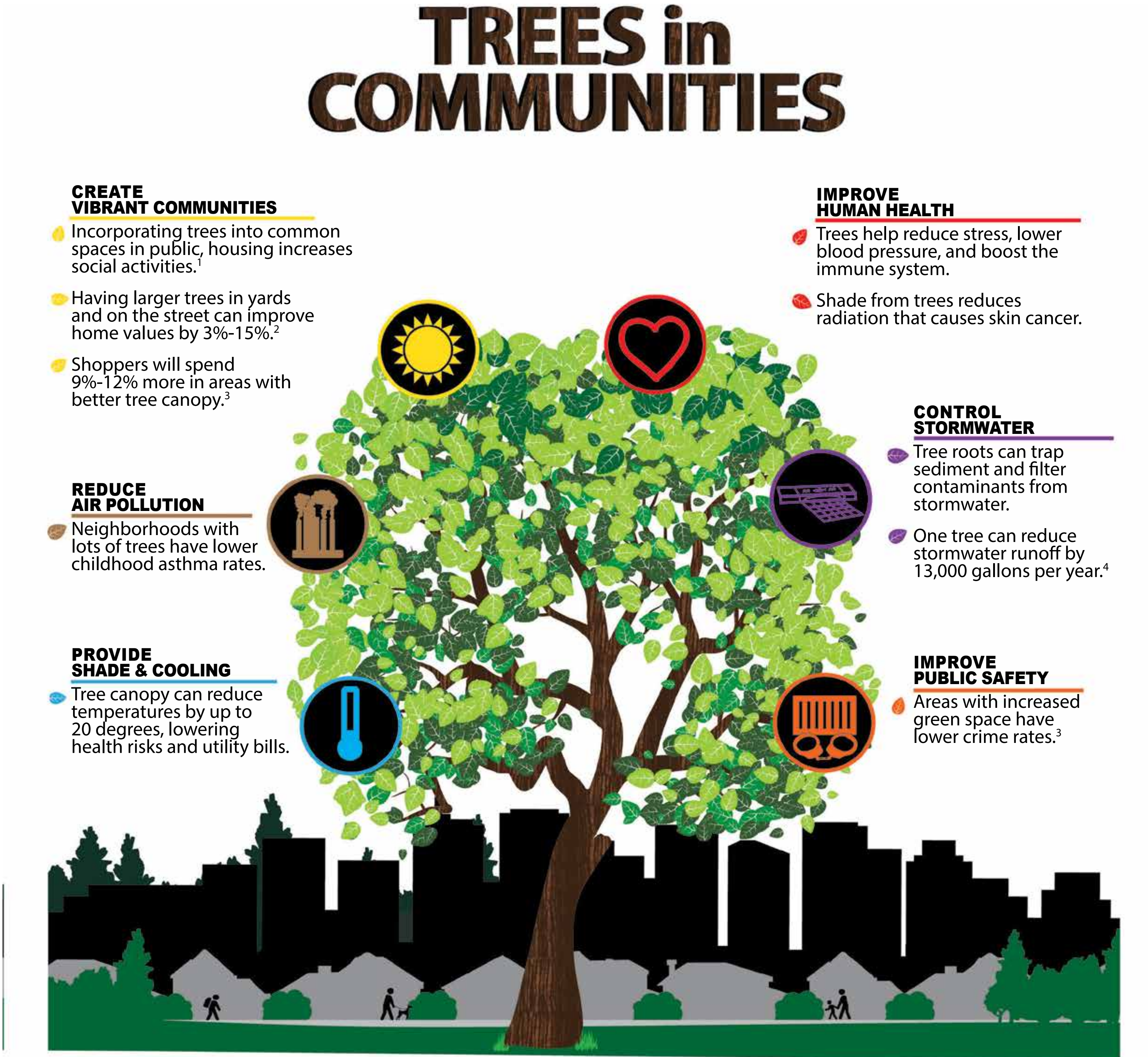

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Figure 2.1.—Benefits of trees in communities. (U.S. Forest Service illustration by Cheryl Holbrook)

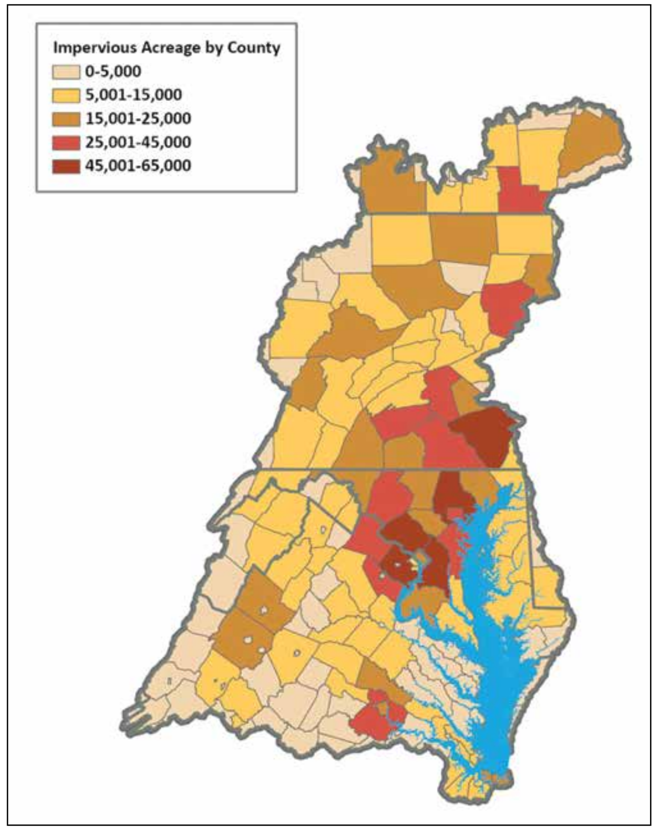
Where

Given the holistic benefits community trees provide to people, *every* community in the Chesapeake watershed stands to gain from a strategic focus on conserving and expanding its tree canopy. Figure 2.2 shows the distribution of turf grass cover and impervious surfaces in the watershed as a broad-scale representation of the extensive area that could be enhanced through tree planting. Fortunately, Chesapeake communities now have access to a variety of tools and datasets that can reveal at a hyperlocal scale where tree planting opportunities exist. At least 33 communities and 7 counties have set urban tree canopy (UTC) goals based on high-resolution tree canopy assessments.

The Chesapeake region has benefited from being the laboratory for ever-refined UTC assessments using the latest high-resolution land cover mapping methodologies. What started as single-city assessments has grown into a robust watershed-wide dataset (circa 2013) that communities can freely download and analyze to identify areas without tree canopy. Chesapeake Bay partners have committed to updating these land cover data every 5 years, providing the most accurate tracking we've had to date on where gains and losses of tree canopy are happening across the landscape (see Baltimore case study, page 13).

At the community scale, these land cover assessments become most meaningful when analyzed in conjunction with local datasets. Most community assessments have found that most of the existing tree canopy and plantable space occurs on private properties, outside the direct authority of local governments. Using a Geographic Information System (GIS) to overlay parcel ownership data, land use and zoning designations, and other relevant planning data illuminates where tree canopy and plantable space intersect with various types of public and private property. This data-driven approach can help identify appropriate strategies for reaching diverse property types (schools, parks, parking areas, residential yards, etc.). Adding datasets of other local partners can illustrate where trees can support other community priorities such as stormwater, public health, and revitalization. In this way, diverse groups of community partners can work together to prioritize and focus tree canopy efforts in places of greatest potential and impact.

In many communities across the country, tree canopy is not distributed evenly across the community, and areas of low canopy often overlap with low-income neighborhoods and/or communities of color where other environmental and socioeconomic stressors are concentrated. Focusing investment in these areas, in partnership with impacted residents, can help improve equity to ensure all residents are receiving the benefits of trees. Another way to maximize benefits to children and other community members is planting shade trees in schools, parks, places of worship, and other community spaces that desperately need them.



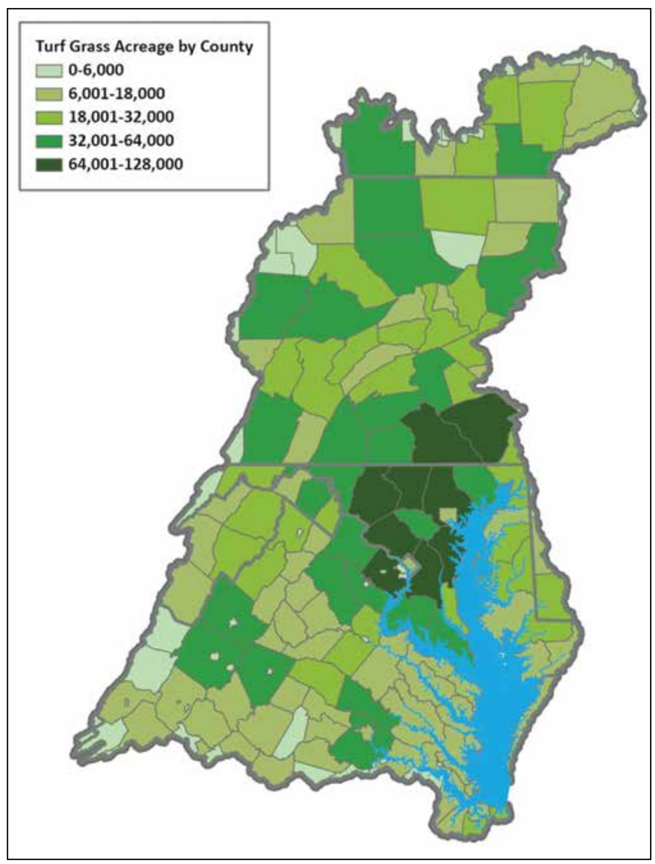


Figure 2.2.—Impervious acreage and turfgrass acreage by county, based on 2013 high-resolution land use data. (Courtesy data and maps by Peter Claggett (USGS) and Nora Jackson (Chesapeake Research Consortium))

Tree planting can be incorporated into restoration and revitalization projects focused on the many types of contaminated sites that occur across the watershed. These contaminated lands include brownfields, Superfund (Comprehensive Environmental Response, Compensation, and Liability Act) remedial and removal sites, Resource Conservation and Recovery Act Corrective Action sites, and State Superfund sites. A high percentage of contaminated lands are either adjacent to or very close to wetlands, creeks, streams, or rivers. Planting trees on these properties can directly and positively influence the quantity and quality of stormwater runoff that enters waterways. Rehabilitated properties are commonly used for residential, commercial, and industrial developments as well as recreational areas and restored natural habitats.

How

Achieving an urban tree canopy (UTC) goal in a given locality requires a holistic approach that addresses tree conservation, planting, and maintenance needs (figure 2.3). At the local level, this means developing a sound urban forest management plan, including short- and long-term actions needed to sustainably support each component of the equation.

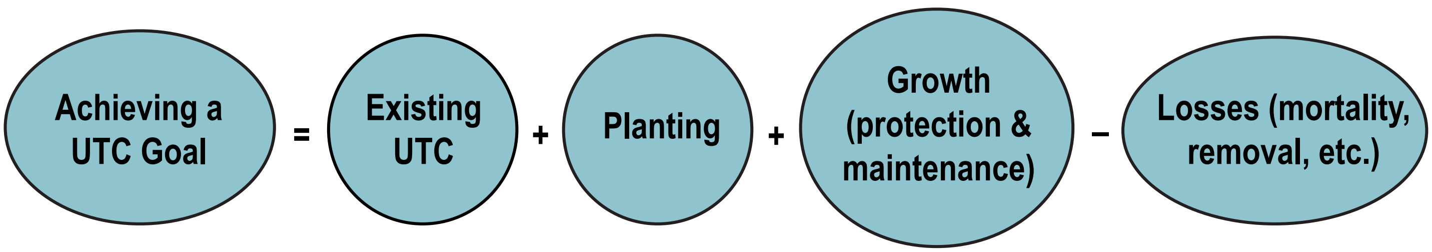


Figure 2.3.—Equation for calculating Urban Tree Canopy (UTC) change. (Luley and Bond 2002)

Conserve First

Many communities across the country are losing more tree canopy than they are gaining due to a variety of factors such as development, pests and diseases, lack of maintenance, storms, and other stressors, as well as natural mortality. Keeping as many healthy, mature shade trees on the landscape as possible should be a central strategy since they provide vastly greater environmental and public health benefits relative to younger or smaller stature trees. State and local policies can be powerful tools to conserve trees as much as possible during development; in the Chesapeake watershed, Maryland and DC have been leaders in this arena.

Plant Abundantly on Public and Private Lands

Robust tree planting and maintenance programs are needed to mitigate losses and ultimately expand tree canopy cover over time. Trees are an essential part of a community's infrastructure and should be well integrated into stormwater programs and capital improvement projects. Successful planting requires any needed site preparation, for example, ensuring adequate soil volume and quality to maximize canopy growth over time. Tree planting can help communities meet water quality goals tied to permits for Municipal Separate Storm Sewer Systems (MS4) permits and the Chesapeake Bay TMDL, with three specific BMPs that have been approved by EPA and State regulatory agencies for credit:

Urban tree planting – canopy expansion: This BMP includes all the dispersed tree plantings on public or private property, such as along streets, in parks, at schools, or in residential areas. For the purposes of Chesapeake TMDL crediting, 300 trees planted are credited as 1 acre of new urban tree canopy, and the understory is assumed to be turf or impervious.

Urban forest planting: This BMP includes tree planting projects designed to create forest-like conditions, with a natural understory and minimal mowing to aid forest establishment. The plantings are tracked in acres, and as a forested land cover, receive a much higher level of water quality credit. Programs that convert lawn area to forest cover, such as Baltimore County's longstanding Rural Residential Reforestation Program, are eligible for this credit (see case study, page 13).

Urban forest buffers: This BMP includes tree plantings along waterways in any developed areas (i.e. turf cover, non-agricultural land use), with a minimum 35-foot buffer width (smaller widths are also reportable but for less pollution reduction credit). While well-developed agricultural cost-share programs exist for riparian buffers on farmland, programs for urban forest buffers are less common. The Maryland Forest Service has provided a "backyard buffer" program to homeowners for a number of years, a model that could be replicated in other parts of the watershed. New York's Trees for Tributaries program has been used to establish urban forest buffers on private and some public properties. The Virginia Department of Forestry is currently piloting a new forest buffer program for non-agricultural lands using Tree Stewards and other volunteers with specialized training. One opportunity to get more urban forest buffers planted is to couple buffer planting with urban stream restoration projects, which are frequently used to meet MS4 and Chesapeake TMDL requirements (figure 2.4).

Figure 2.4.—The U.S. National Arboretum and the DC Department of Energy and Environment joined forces to restore Springhouse Run, a channelized urban stream running through the grounds that had been degraded since the 1800s. Arboretum staff, interns, and volunteers collected seed from local populations of more than 75 species of native plants and trees and grew more than 30,000 plants for the project. (Courtesy of National Arboretum)

Restore Contaminated Lands

Contaminated sites throughout the watershed can benefit from restoration efforts ranging from enhanced landscaping strategies to total reforestation of large and small parcels. Trees and shrubs can be integrated into redevelopment plans for recreational, residential, commercial, and even industrial facilities. At Naval Station Norfolk, for example, a landfill adjacent to the Chesapeake Bay was capped as part of the site closure and new parking areas were integrated into the design of the cap. To address negative impacts potentially associated with runoff from the site and the new parking areas, the design incorporated vegetated bioswales with native trees and shrubs to capture and passively treat parking lot runoff and reduce the heat island effects associated with the parking area. Trees are also being used in some projects to clean up contamination through a process known as phytoremediation. Gray alder, black locust, and other species can remove metals such as cadmium, copper, and zinc from soils and keep them from migrating to surface waters or to other plants and animals.

Invest in Maintenance

With tree planting as a primary strategy to help maintain and increase canopy cover, the importance of adequate maintenance cannot be overstated. While finding money to plant trees may be relatively easy, maintenance needs are more difficult to cover and require a long-term mindset for sustainability. Trees that are not planted and maintained properly – especially in the first few years of establishment – will not survive to generate the needed tree canopy. Failed projects create a strong visual impression in the community and may make it difficult to garner future investments and support. With a changing climate adding to the stressors, tree planting programs should be strategically designed to address all watering and maintenance actions needed to sustain and grow the canopy into its full potential.

Respond Proactively to Tree Losses

While removals of healthy trees should be avoided as much as possible, some tree losses are inevitable, especially given climate-related increases in storm damage, pests and diseases, drought, and other stressors. State forestry agencies have developed proactive responses, such as deployment of Urban Forest Strike Teams, to help communities assess and recover from severe storm damage to trees. When damaged or unhealthy trees must be removed, urban wood utilization programs help communities reduce wood waste (and disposal costs) and generate productive materials that give these trees a second "life." An emerging and vibrant urban wood economy is growing yearly by utilizing trees at the end of their biological lives; innovative partnerships in Baltimore, DC, and Virginia can serve as a model.

Financial and Technical Assistance

Each State forestry agency (including DC) has an Urban & Community Forestry Program, delivered in partnership with the U.S. Forest Service, that provides the primary source of technical and financial assistance to support community tree management and planting.

The Chesapeake Tree Canopy Network is the online resource hub for our region, hosting information about funding, partners, tools and best practices, outreach materials, and "Community Spotlight" stories of model programs around the watershed.

To address local funding challenges, the University of Maryland Environmental Finance Center and the Alliance for the Chesapeake Bay developed the comprehensive "Financing Urban Tree Canopy Programs: Guidebook for Local Governments in the Chesapeake Bay Watershed."

The Center for Watershed Protection's guide "Making your Community Forest-Friendly: A Worksheet for Review of Municipal Codes and Ordinances" helps communities assess their local policies to determine options for strengthening them to support tree canopy goals.

The Chesapeake region's high-resolution land cover data has been imported into i-Tree Landscape, a free online tool that allows users to estimate benefits of their canopy in terms of air pollution, carbon capture, and stormwater reduction. Putting a dollar value on these ecosystem services can help make the case to local leaders, funders, and the general public for increased investment and tree-canopy friendly policies.

To support the restoration of contaminated lands, the EPA and State partners have a variety of technical and financial assistance opportunities, including EPA's Greener Cleanup initiative, which encourages ecological restoration for habitat, recreational, and carbon storage benefits.

Actions

Provide training and technical assistance to help build community capacity to implement tree canopy goals.
- Use the latest high-resolution tree canopy data and change analyses of tree canopy losses and gains to strengthen local strategies.
- Develop more robust, sustainable financing approaches, such as innovative public-private and cross-sector partnerships, that are needed to significantly scale up community tree planting and maintenance.
- Strengthen local policies and programs to both conserve and expand tree canopy.

Encourage development and use of local Urban Forest Management Plans to holistically and strategically address all tree canopy elements, including assessment, conservation, planting, maintenance, management, and wood utilization.
- Connect communities with urban wood utilization networks to add to the holistic urban forest management approach.
- Encourage communities to develop a disaster response plan; for example, use Urban Forest Strike Team resources to assist with canopy loss data collections.

Bolster cross-sector collaboration and outreach to increase support for tree canopy efforts.
- Work with stormwater managers to promote and track tree planting as a cost-effective, core strategy for meeting local TMDL targets and MS4 stormwater requirements.
- Facilitate connections between communities and professional urban planners, arborists, and tree steward groups.
- Develop and implement a Communication Strategy, with outreach campaigns targeted to key audiences, to raise awareness of tree canopy co-benefits (public health, stormwater, climate resilience, etc.) and promote more local action.

Continue building resources and strategies to support equity and environmental justice in community tree canopy initiatives, including support for urban forestry workforce development programs.

Transfer successful urban forest planting (turf to trees) and urban riparian buffer program models and lessons learned to more localities throughout the watershed.
- Share successful case studies through our partnership websites.
- Continue to incorporate presentations on innovative tree canopy programs at watershed conferences, forums, and training sessions.

Case Studies

Using Data to Drive Strategies in Baltimore

Baltimore has long been at the cutting edge of using the latest data and technological innovations to guide tree canopy goals and strategies, thanks to longstanding collaboration amongst researchers, the city, and a host of community partners. Baltimore's first urban tree canopy assessment prompted the city to set an ambitious goal of 40% canopy by 2037. Researchers with the Baltimore Field Station, part of the USDA's Network of Urban Field Stations, assisted the city in conducting a comprehensive prioritization process, overlaying data layers on community priorities such as stormwater, public health, equity, and more to identify common high-priority areas and target planting activities accordingly. Several organizations within the city's TreeBaltimore partnership have used the data to guide plantings, community engagement, and workforce development efforts in low-canopy, low-income neighborhoods to achieve a more equitable distribution of canopy benefits.

Tracking tree canopy change over time at the city scale is a complicated task, but recently Baltimore served as the test case for new sophisticated methodologies to accurately analyze canopy gains and losses. The University of Vermont Spatial Analysis Lab completed a change analysis for Baltimore. They found that overall canopy showed a net increase of 1% between 2007 and 2015 (O'Neil-Dunne 2017), a positive trend in light of nationwide research showing canopy declining in the vast majority of cities. More importantly, the analysis revealed that while 4% of canopy growth occurred as a result of tree planting and growth, this was offset by 3% canopy loss from forces such as storms, the impact of pests, and the removal of trees for new development. This finding highlights the critical need for strategies to conserve existing tree cover, as exemplified by Baltimore Green Space's efforts to protect and restore the health of small forest patches throughout the city.

Turf to Trees, Lawn to Woodland

Beginning in 2005, Baltimore County saw an opportunity to turn excess turf in low-density residential neighborhoods into forests to improve water quality and provide habitat and other environmental benefits. As a result, the Rural Residential Reforestation program began one of the first "turf to trees" programs in the region. An important part of the turf to trees conservation strategy focused on reducing barriers, such as cost, to landowner participation in watershed restoration projects. The educational, technical, and financial incentives provided to landowners helped them to mow less and become better stewards of their land. In the current version of the program, Baltimore County has converted over 150 acres of private lawn to forest as an important strategy to meet the county's MS4 permit and Chesapeake TMDL targets.

Baltimore County's example has helped catalyze other residential reforestation programs in Maryland, including Frederick County's Creek Releaf program, which planted over 160 acres of forest from 2017 to 2018. Recently, Pennsylvania committed to start a new Lawn Conversion program to help meet its Chesapeake TMDL requirements, with a goal of converting 5,000 acres of turf to forest and 5,000 acres to meadow habitat by 2025. With support from a National Fish and Wildlife Foundation grant, the Alliance for the Chesapeake Bay is working with Pennsylvania partners to launch this program and already has more than 70 acres of reforestation completed or planned.

Partnering to Grow Tree Canopy in Community Spaces

Opportunities abound across the watershed to improve human health and quality of life through planting trees in community spaces. The Delaware Forest Service created a Community Tree Canopy online tool that makes it easy for communities to see their current canopy and areas that can be improved by planting trees. In addition to municipal tree canopy, the tool provides tree canopy information for homeowner associations, which make up much of the landscape in Delaware. Each year, the Delaware Forest Service partners with the Delaware Urban and Community Forestry Council to provide grants and technical assistance for tree planting and management activities to municipalities, homeowner associations, non-profit groups, and schools (figure 2.5). Since 2010, over 7,300 trees have been planted just by homeowner associations.

Figure 2.5.—Kesha Braunskill, Delaware Urban & Community Forestry Coordinator, leads a tree planting with schoolchildren. (Courtesy photo by Delaware Forest Service)

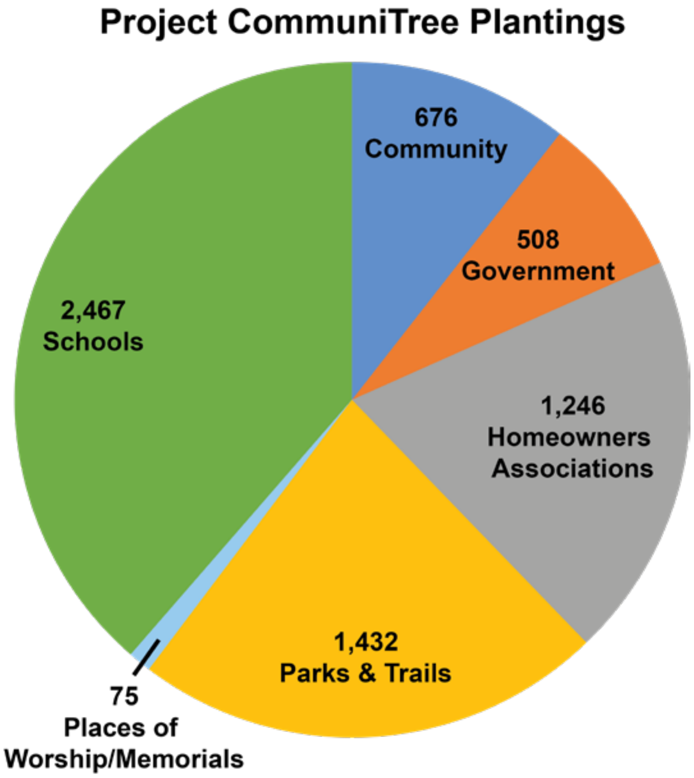


Figure 2.6.—Project CommuniTree tree plantings from 2012 to 2019 by property type.

In West Virginia, the WV Carla Hardy Project CommuniTree partnership has been successful working with a wide variety of community groups to get trees planted at school grounds, places of worship, community parks, and homeowner association properties. The Cacapon Institute completed a tree canopy assessment of over 100 public schools in the eight counties of the West Virginia Potomac Basin. Using 2013 land cover data, they found extensive areas of turf potentially available for tree planting; one third of the schools had less than 5% tree canopy cover. Each spring and fall, community groups take the lead in organizing and implementing volunteer tree planting projects, and they commit to maintaining the trees after planting to ensure successful establishment. Through the program, the groups apply to receive Project CommuniTree kits that include trees in a variety of species and stock sizes, tree tubes or cages to protect them from deer, and mulch to foster good root growth. Over 7,000 trees have been planted through the partnership (figure 2.6). Building on this success, a new program has been launched to provide cost-share tree plantings on private properties.

Urban Forestry in Washington, DC

The Washington, DC, Department of Transportation (DDOT) cares for all of the city's public trees. In the past decade, their Urban Forestry Division (UFD) has been focused on achieving a complete collection of healthy and thriving public street trees. To achieve this goal, UFD has applied a data-driven approach that leverages not only citizen-generated service requests, but also information from UFD's public tree inventory and results from multiple land cover assessments that identify available planting areas. As potential planting areas are inspected and new planting locations identified, UFD has been systematically planting trees, typically more than 8,000 annually. Each of these newly planted trees is watered regularly following installation. As a result of these efforts, more than 60,000 new trees have been planted in the past 10 years, increasing the citywide stocking level from 90% in 2010 to greater than 97% in 2020. These plantings – combined with partners' planting activities, tree preservation policies, and a comprehensive maintenance program – have helped the District move closer to its 40% canopy goal. The three citywide high-resolution land cover assessments that UFD has completed since 2006 show a promising increase from 35% in 2006 to 38.7%, as of 2015.

These planting activities, combined with a comprehensive maintenance program, have resulted in a high-quality public urban forest, which delivers multiple benefits to residents and visitors across the city. Interestingly, as the number of open spaces declines across the city, the number of requests from the public to plant new trees has actually increased. This increase in demand for urban forests is evidence that the public's awareness of the value and importance of trees in their city is increasing.

Section 3 - Restoration in Agricultural Landscapes

Why

Farms and forests play a vital role in the economic, social, and ecological landscape of the Chesapeake Bay watershed. Approximately 20 percent of the watershed—8.4 million acres—is in agricultural land use (figure 3.1). The watershed also includes nearly 2.8 million acres of woodlands on farms, based on data from the 2017 Census of Agriculture. The future viability of these working lands is threatened by high rates of land conversion and development. Retaining sustainable and resilient rural communities and economies must be at the heart of watershed restoration efforts. Environmental stewardship practices on farms are critical for reducing nutrients and sediment runoff to local waterways. Although agriculture accounted for only 20% of the watershed's land area in 2018, it was responsible for 45% of nitrogen loads to the waterways in the Chesapeake Bay (Chesapeake Progress 2020).

This Strategy section focuses on **using trees in strategic and innovative ways** to benefit farms and the Chesapeake Bay (figures 3.2 and 3.3). By incorporating trees into agricultural landscapes, farmers can bolster the economic and environmental sustainability of their farming enterprise. Rather than asking farmers to take land out of production, agroforestry allows farmers to incorporate trees into regenerative systems, creating positive social, environmental, and economic outcomes.

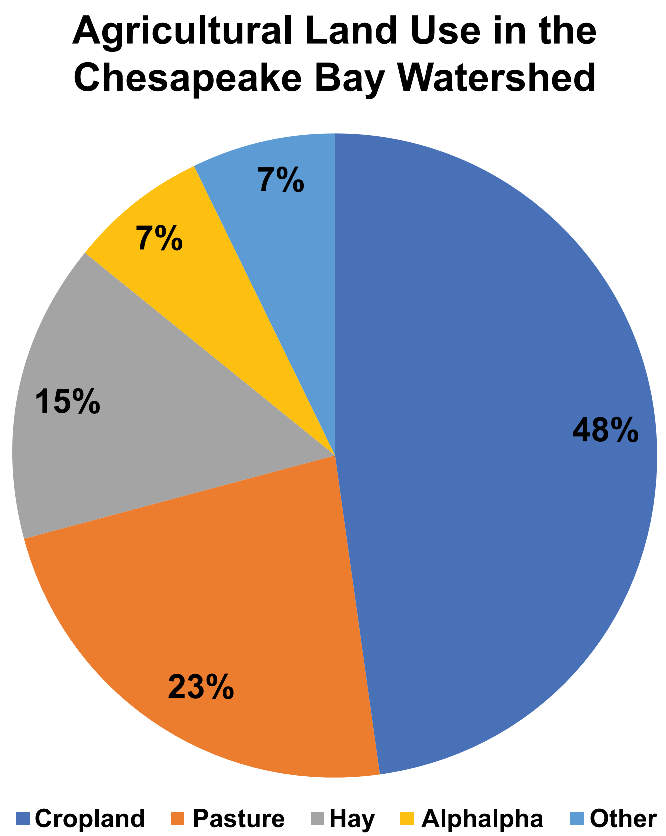


Figure 3.1.—Agricultural land use in the watershed. The "other" category includes nurseries, animal operations, and open space. (Courtesy graphic by Chesapeake Bay Program)

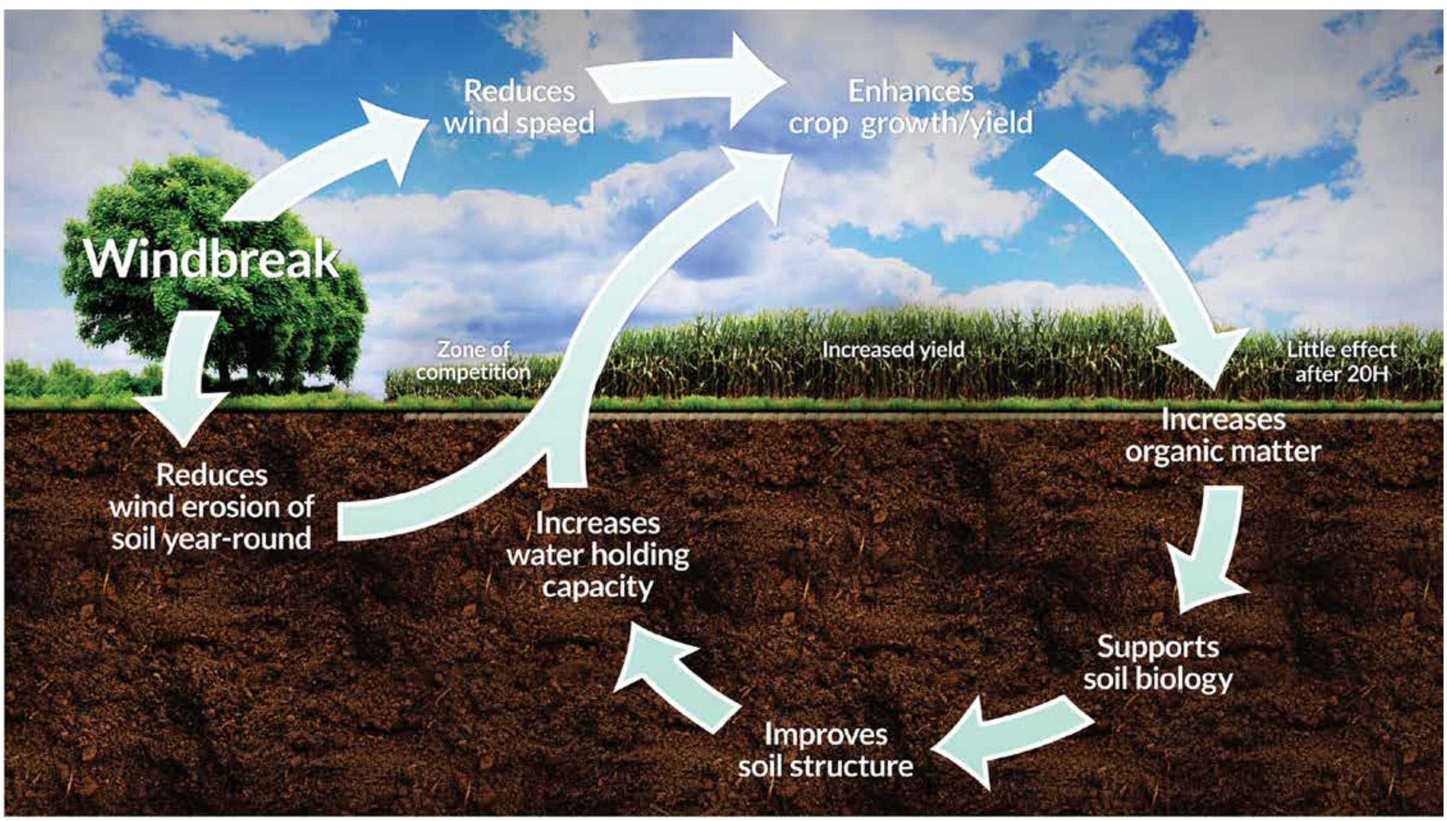
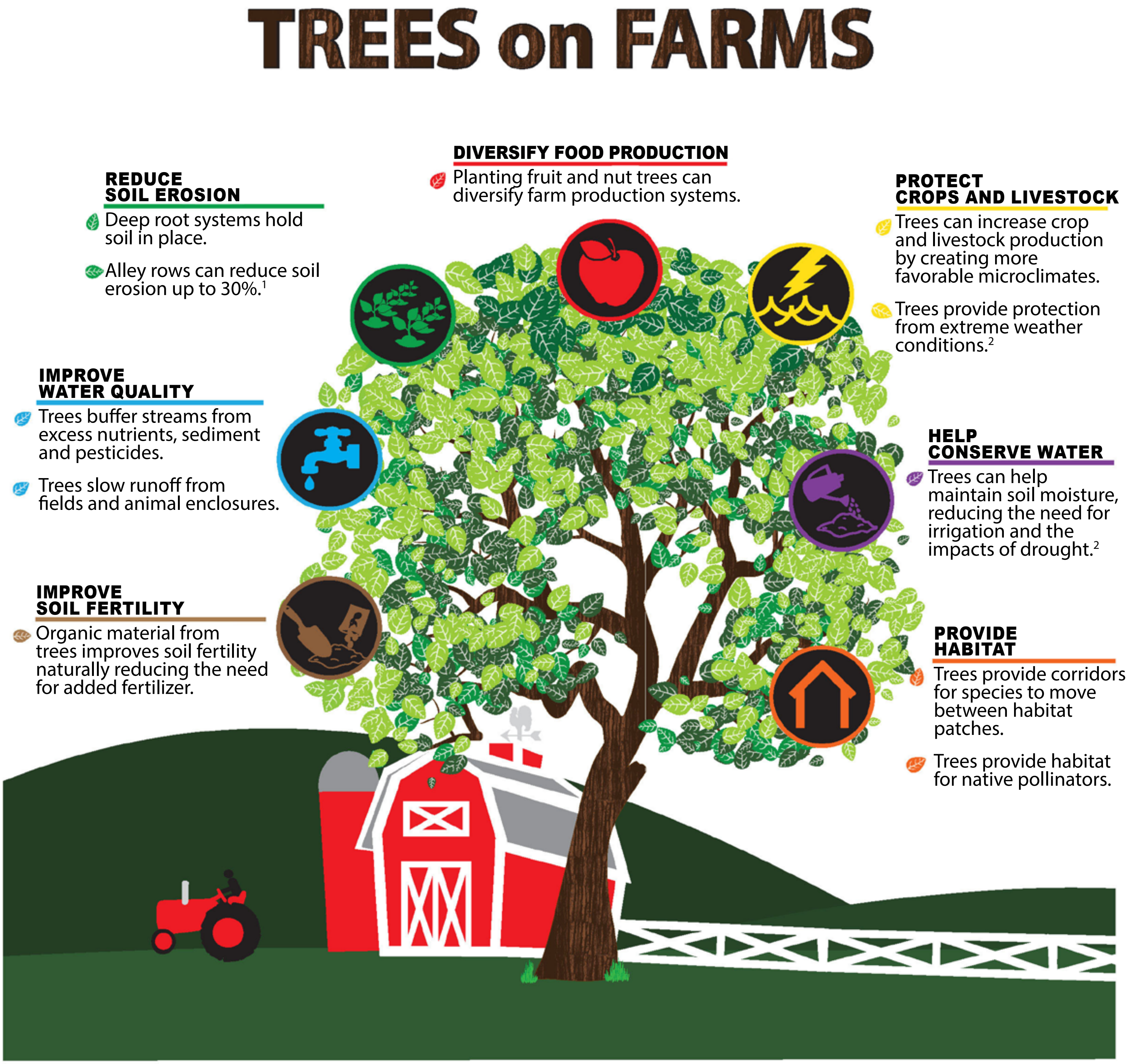


Figure 3.2.—Benefits of windbreaks for soils. (Courtesy graphic by National Agroforestry Center)



[1] Udawatta, R.P.; Garrett, H.E.; Kallenbach, R. 2011. Agroforestry buffers for nonpoint source pollution reductions from agricultural watersheds Journal of Environmental Quality. 40(3): 800–806.

[2] Dosskey, Michael G.; Brandle, Jim; Bentrup, Gary. 2017. Chapter 2: Reducing threats and enhancing resiliency. In: Schoeneberger, Michele M.; Benrup, Tech. Report WO-96. Washington, DC: U.S. Department of Agriculture, Forest Service. 7-42.

Figure 3.3.—Benefits of trees on farms. (U.S. Forest Service illustration by Cheryl Holbrook)

Where

Agroforestry practices can be applied wherever there are farms. Landowner outreach, technical assistance, and incentives for agroforestry should be focused in areas that have the greatest need and present the greatest opportunity. For instance, counties with a large amount of pasture are prime opportunities for riparian forest buffer and silvopasture outreach and pilot initiatives (figure 3.4). To find hydrologically sensitive areas where riparian forests or forested wetlands will have the biggest impact, high-resolution land use and stream maps are being created by partners at the Chesapeake Bay Program. Together, these data will help target agroforestry activities.

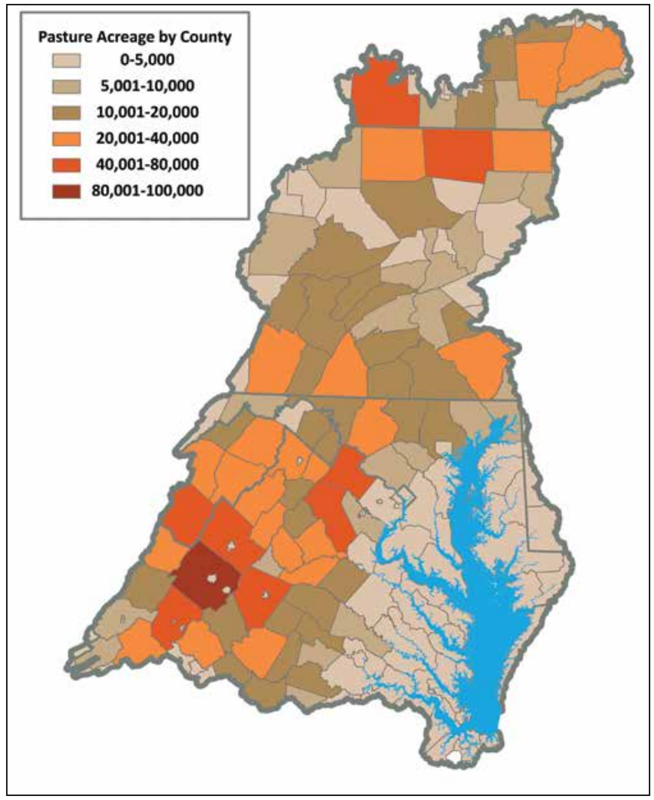
Research suggests that farmers may be more interested in agroforestry if these practices are also supported by their neighbors, family, and peers (Trozzo and others 2014). The 2017 Census of Agriculture included a question asking whether farms are using agroforestry practices. Using this data, we now have a better idea of where there are a relatively large number of farms using agroforestry (figure 3.4) and where there is more likely to be a solid base of support, knowledge, and infrastructure for implementing additional agroforestry activities. At the other end of the spectrum, areas where there is very little agroforestry activity can be targeted for workshops or similar outreach to start to build awareness of these practices.

In addition to water quality, restoration of habitat is another driver for agroforestry (see Upper Susquehanna Coalition case study, page 20). On average, stream temperatures have increased 1 degree Fahrenheit between 1960 and 2014 (Chesapeake Progress 2020), and these trends are likely to increase with climate change. Riparian forest buffers provide cooling shade, shelter, and food for aquatic wildlife. This is especially important for at-risk species like the Eastern brook trout, which require cool water. The Eastern Brook Trout Joint Venture has a mapping tool (EBTJV 2017) that can identify stream segments where brook trout populations are likely present, but where the stream lacks forest cover and may therefore benefit from riparian buffer planting.

How

Agroforestry Strategies

Riparian Forest Buffers act as the last line of defense, protecting streams and ultimately the Chesapeake Bay from polluted runoff. While their importance is well recognized, there are still approximately 1.4 million acres where riparian forest buffers could be planted (Chesapeake Progress 2020). The 2018 Farm Bill has some promising provisions to help support the creation and maintenance of new riparian forest buffers, but additional sources of funding are greatly needed to increase riparian forest buffer planting.



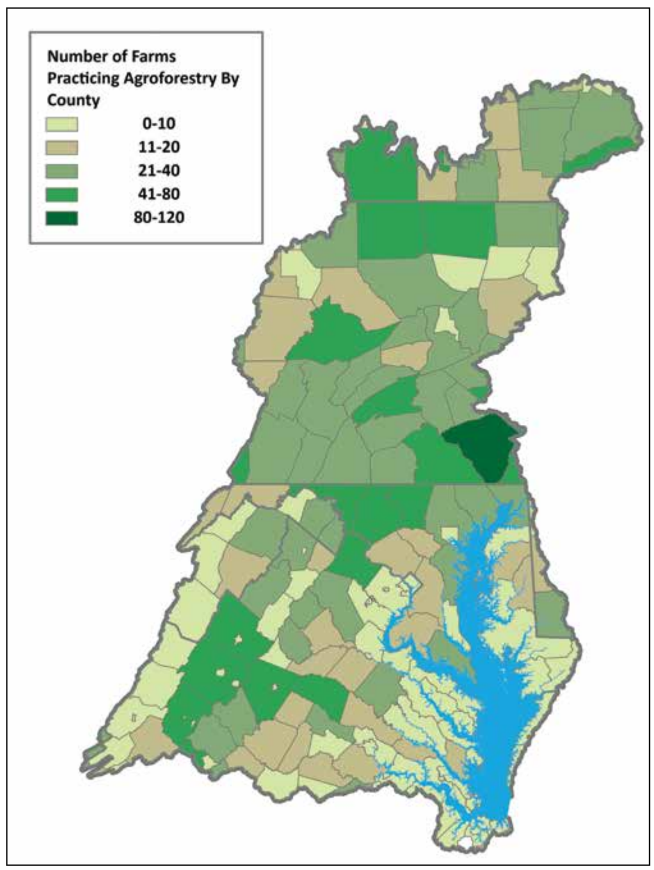


Figure 3.4.—Top: Pasture acreage by county based on 2013 high-resolution land use data. Bottom: Number of farms practicing agroforestry by county. (Courtesy graphics by Chesapeake Bay Program and 2017 Census of Agriculture. Courtesy map by Nora Jackson, Chesapeake Research Consortium)

In addition to their water quality and habitat benefits, with proper planning and management, riparian forest buffers can produce income, for example by generating compatible products like biomass, fruit, nuts, and even timber in areas further from the stream. These multifunctional forest buffers may be attractive to certain farmers who want to diversify production and have a positive impact not only on water quality, but also long-term profitability. The National Agroforestry Center has developed tools, including the Non-Timber Forest Product Calculator and Buffer$, to help estimate the costs and potential income that can be generated from multifunctional forest buffers. Pennsylvania, which has a large amount of agricultural land, is also working on multiple fronts to promote multifunctional forest buffers (see case study, page 20).

The design and placement of riparian forest buffers ideally should consider the broader landscape and hydrologic processes. In rural areas, riparian buffers work best in conjunction with other on-farm conservation practices such as contour grass strips, residue management, and other tree planting. This "whole-farm" approach to managing polluted runoff acknowledges that upstream agroforestry practices can reduce the burden imposed on buffers. With good upland management practices, riparian buffers are more likely to have their desired water quality impact. Although these approaches can improve the benefits buffers provide, it is still worth planting buffers whenever a landowner is willing to do so. The following agroforestry practices are examples of upslope agroforestry practices:

Windbreaks/Shelterbelts are rows of trees and/or shrubs that mitigate the negative impacts of wind, snow, or other environmental conditions. Windbreaks and shelterbelts protect crops and livestock, reduce snowplow costs, and provide shelter for homes (reducing heating costs and snow drifting, among other benefits). Additional benefits include capture of pesticide spray drift; reduced emissions and odor from intensive livestock production systems; carbon sequestration; and marketable products such as timber, biofuels, and fruit.

Alley Cropping is using rows of trees or shrubs to create alleys within which one or more agricultural or horticultural crops are grown. Alley cropping produces beneficial microclimates for sheltering crops and can increase or sustain site productivity while diversifying production. Using woody species in alley cropping can increase nitrogen availability through nitrogen fixation; produce energy through woody biofuels; and provide income through seed, fruit, nut, and fiber production. A common example of alley cropping in the Chesapeake Bay region is the integration of annual crops, such as pumpkins or sweet corn, with orchard tree crops. Alley crops can also be grazed.

Silvopasture is the integration of trees with livestock and forage production. The tree protection provided by silvopasture reduces heat and cold stress on livestock and provides forage while increasing the amount of carbon stored in woody biomass and in soils. Silvopasture may also improve biodiversity by providing habitat and food for wildlife species. In some cases where farmers have established riparian forest buffers, silvopasture can be integrated with rotational grazing to extend riparian buffer zones.

Forest Farming/Multistory Cropping is the cultivation of edible, floral, medicinal, and craft crops underneath a forest canopy. Common income-generating understory crops include ginseng, goldenseal, and other valuable medicinal herbs as well as edible ramps and mushrooms. Forest farming can increase the economic viability of forest land by providing annual or short-term income as timber matures. It also provides an incentive for forest landowners to address issues such as forest health, overstocked stands, invasive species, lack of forest regeneration, and excessive deer browse (see Appalachian Beginning Forest Farmer Coalition case study, page 20).

Woodlot Management is the sustainable management of forested areas on farms, which can provide a number of benefits for farmers, including providing marketable timber and biomass for heat and energy, and improving habitat for wildlife and game species. Many of the practices outlined in the "Forest Restoration in Natural Landscapes" chapter of this Strategy can also be used to improve forest health and ecosystem function in woodlots.

Biochar Production and Utilization: Biochar, a carbon-rich soil amendment that is created through careful burning of woody biomass, may provide a valuable commodity for otherwise unutilized wood. Energy production is a biproduct of making biochar. When applied, biochar can improve soil fertility, soil carbon storage, crop yields, soil structure, and water-holding capacity.

Financial and Technical Assistance

Technical assistance for installing agroforestry practices is available from the Natural Resources Conservation Service, State forestry agencies and consulting foresters, land-grant university extension departments, and local Soil and Water Conservation Districts.

USDA Farm Service Agency administers the Conservation Reserve Enhancement Program (CREP), which provides cost-share and rental payments to establish riparian forest buffers, among other practices.

USDA Natural Resources Conservation Service (NRCS) provides financial assistance to establish agroforestry practices through Farm Bill programs with the support of Soil and Water Conservation Districts and other conservation partners. These programs include the Environmental Quality Incentives Program, Conservation Stewardship Program, Regional Conservation Partnership Program, and Working Lands for Wildlife. NRCS priorities for the Chesapeake Bay include improving soil health, restoring and improving fish and wildlife habitat, training conservation professionals, and using partnerships to increase capacity (USDA Natural Resources Conservation Service 2018). As many of these priorities align with the activities and actions outlined in this Strategy, there are significant opportunities to partner with NRCS to advance forest restoration in agricultural landscapes.

The **National Fish and Wildlife Foundation (NFWF)** provides grant funding through their Chesapeake Bay Stewardship Fund to State and local agencies, universities, and non-governmental organizations. This funding helps support implementation and education around practices that will restore water quality, including riparian forest buffers.

Sustainable Agriculture Research and Education (SARE) has been an important funder of agroforestry research and education, especially in the Chesapeake Bay region.

Northeast/Mid-Atlantic Agroforestry Working Group (NEMA) is a consortium of technical service providers, agency staff, researchers, practitioners, and experts focused on educating, promoting, and implementing agroforestry systems in the region. The group is open to anyone interested in agroforestry and hosts workshops, webinars, and regular conference calls.

USDA National Agroforestry Center works with State, Federal, non-profit, and private partners throughout the region to accelerate the adoption of agroforestry.

Actions

Increase capacity for forest buffer implementation to accelerate the pace and scale of buffer establishment.

- Work with Chesapeake Bay Program leadership to support riparian forest buffer programs that complement CREP and reduce requirements and out-of-pocket costs for landowners.
- Develop strategies to encourage private capital investments in riparian forest buffers and other agroforestry practices.
- Develop programs that provide buffer maintenance for landowners.
- Increase the workforce for tree maintenance by providing training opportunities through schools, prisons, and programs like AmeriCorps.
- Support programs that leverage funding for riparian forest buffers to implement other on-farm water quality and soil health improvement practices (i.e. “buffer bonus” programs).

Improve technical assistance to farmers.

- Engage foresters on delivering agroforestry practices to agricultural landowners.
- Work with agricultural technical service providers and foresters to provide cross-training in forestry and agroforestry practices.

Improve access to markets for agroforestry products.

- Develop marketing strategies for agroforestry products through farmers markets, Grow Local, and Farm/Forest to Table networks.
- Increase funding to support development of cooperatives for aggregation and processing of agroforestry products.
- Identify and prioritize agroforestry products that are easily grown and for which there is a scalable market.

Support the implementation of agroforestry practices that are profitable for farmers.

- Focus on flexible, multiple-use buffers that balance profitability with water quality improvements.
- Layer multiple agroforestry practices to provide multiple income streams to offset costs.
- Provide flexibility in tree selection to avoid shading out productive lands.
- Explore opportunities where natural regeneration, with appropriate management, could be a cost-effective approach for establishing forest buffers.
- Generate examples of business operations plans from existing profitable operations.
- Promote using or selling biochar from agriculture and woodlots.

Cultivate and strengthen agroforestry partnerships.

- Support partnerships that can provide efficient technical and financial assistance in implementing NRCS and other agroforestry programs.
- Increase visibility of buffers and agroforestry across jurisdictions among agricultural landowners and the general public through demonstration projects.
- Highlight habitat benefits from agroforestry, for example, by starting a Save the Hedgerows campaign.

CASE STUDIES

Pennsylvania Multifunctional Riparian Forest Buffer Program

Pennsylvania is promoting multifunctional riparian forest buffers to stimulate more landowner interest in planting buffers by providing additional flexibility in buffer design, including species planted. By incorporating species that generate marketable products, such as fruit and nut trees, multifunctional buffers may be more attractive to landowners as they can increase and diversify income streams. For example, switchgrass can be incorporated into buffers for biomass production or elderberries can be planted and used to make value-added elderberry syrup. Farmers that have planted multifunctional buffers in Pennsylvania have also cited their benefits in stabilizing soils, providing shade and forage for cattle, improving forage growth through nitrogen fixation, and providing habitat for native songbirds.

PENNVEST and Pennsylvania DCNR awarded $3 million in grant funding to support the planting of multifunctional forest buffers. Some of these buffers will serve as demonstration sites, for example, to show potential profits from multifunctional buffers. The largest grant recipient from this program was the Pennsylvania Association of Conservation Districts, who is using this money to provide grants to conservation districts to work with landowners to install multifunctional buffers.

Upper Susquehanna Coalition

Soil and Water Conservation Districts in the Upper Susquehanna were early adopters of riparian forest buffers in response to habitat concerns, especially for the embattled Eastern brook trout. The Upper Susquehanna Coalition (USC), a partnership that includes parts of 22 Soil and Water Conservation Districts that encompass the entire Chesapeake Bay headwaters within New York and Pennsylvania, is leading the charge for buffers in a direction guided by data. Like many groups around the watershed, the USC uses highly accurate modeling tools to determine where riparian forests are most needed to have the greatest impact on water quality or habitat.

Tree planting in Tompkins County. (Courtesy photo by Finger Lakes Land Trust)

Black cohosh harvest. (Courtesy photo by Priya Jaishanker, Licensed by Creative Commons)

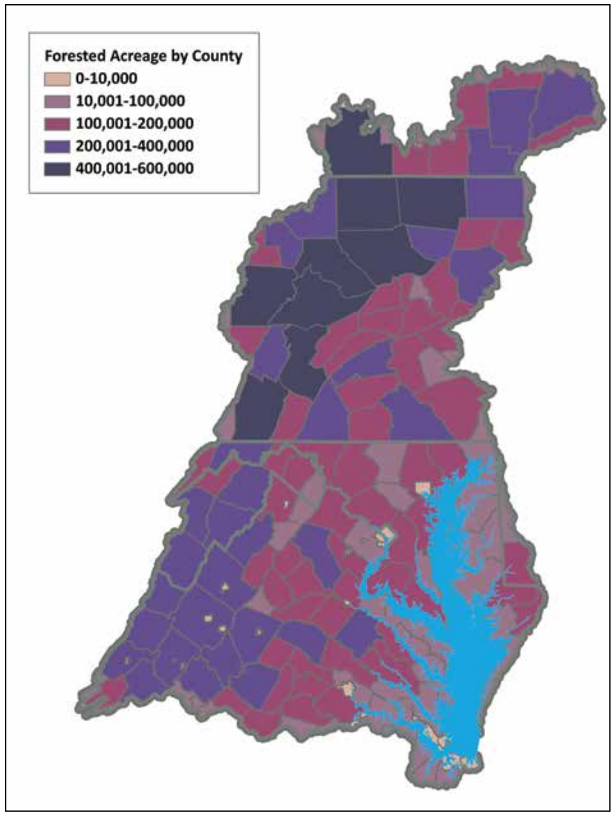
Lately, they have partnered with local land trusts to restore buffers on protected lands. In 2019, the USC worked with Finger Lakes Land Trust to reestablish a streamside forest and restore wetlands along West Branch of Owego Creek, a premiere trout stream. More than a dozen different species were planted, including trees such as sycamore, basswood, and red maple along with shrubs such as arrow wood, buttonbush, and spicebush, while Japanese knotweed was removed. Their current work with Otsego Land Trust features restoration of 1 mile of Butternut Creek and surrounding wetlands, where there are endangered yellow lampmussels, an active eastern hellbender recovery program, and newly introduced American eel populations. American eel were released at the property in 2019, with plans for more releases in 2020. USC is emblematic of how riparian forest buffers can be strategically implemented to benefit wildlife.

Appalachian Beginning Forest Farmer Coalition

Demand for forest medicinal plants in the U.S. has grown to $1 billion annually, with increasing interest in sustainable and organic products. Appalachian forests provide suitable habitat for 15 medicinal plants suitable for forest farming, including ginseng, goldenseal, and wild yam. The Appalachian Beginning Forest Farmer Coalition was funded under the National Institute of Food and Agriculture's Beginning Farmer and Rancher Development Program to help facilitate forest farming of these and other medicinal crops. The Coalition is a network that includes universities, non-governmental organizations, government agencies, and forest landowners who are all working to support the expansion of forest farming across Appalachia. Members of the Coalition have access to training and technical assistance for cultivating, harvesting, and marketing forest botanicals, including value-added products. The Coalition is also training extension and State agency personnel to increase the availability of technical assistance.

To further support forest farmers, partners at Appalachian Sustainable Development and Appalachian Harvest are working to create a "herb hub" that will enable forest farmers to share processing infrastructure and aggregate their products for herbal buyers. They are also providing cost-share support for forest farmers to achieve Forest Grown Verification, which may help increase access to high-value niche forest botanical markets.

Section 4 - Restoration in Natural Landscapes



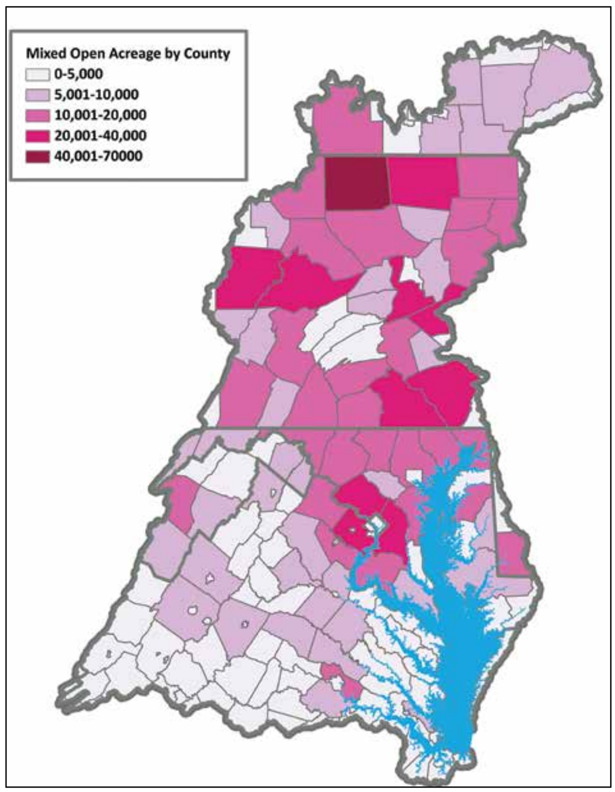


Figure 4.1.—Forested and mixed-open acreage by county based on 2013 high-resolution land use data. (Courtesy data and maps by Peter Claggett (USGS) and Nora Jackson (Chesapeake Research Consortium))

Why Forest health in the Chesapeake region has been steadily declining. Whether it's fire suppression, lack of regeneration due to overabundant deer, forest pests, unsustainable harvest, or increasing of greenhouse gases, **forests are challenged to provide habitat and the services upon which we depend**. In these natural landscapes, which include both forested and mixed open or shrub-scrub lands, restoration activities often take the form of forest management (figure 4.1). Because forests have changed over time with the climate, this section focuses on restoring ecological functionality, resilience, and ecosystem services to natural landscapes, rather than restoring forests to their past condition.

Forest Restoration for Habitat

Biodiversity is the foundation for forest resiliency and therefore a primary driver of restoration. A number of recent reports have demonstrated that biodiversity across multiple species groups is in steep decline worldwide (Rosenberg and others 2019, Sanchez-Bayo and Wyckhuys 2019). This loss of species threatens to destabilize ecosystems and the benefits they provide. As human population growth and development continue in the Chesapeake, **forest habitat must be conserved, managed, and restored in priority areas** to minimize further losses in fish and wildlife populations.

The quality of forested habitats in the watershed is threatened by multiple stressors. One of the greatest threats is development and fragmentation, which create an opening for invasive species. Invasive vines such as English Ivy, Oriental Bittersweet, and Kudzu can climb trees and pull them down while outcompeting other native species. Vines are also empowered by increased CO_2 in the atmosphere (Mohan and others 2006). Other invasive species, like Tree of Heaven, can be seeded by wind after a disturbance and outcompete native species, while producing compounds that inhibit the growth of other plants.

Over the past century, diseases such as chestnut blight, Dutch elm disease, and now emerald ash borer, have caused ecological catastrophes in our native forests. For example, the emerald ash borer effectively kills 99% of ash trees within 4 years of infestation. Another "emerging" invasive – Spotted Lanternfly – has appeared in southern Pennsylvania, Maryland, and recently Virginia. This new introduction could have significant impacts on forests and agriculture. Sometimes there are actions that can mitigate the diseases, but often many decades of genetic work may be needed to allow for the return of these dominant forest species.

Other stressors on Chesapeake forests include deer browse and altered fire regimes. An overabundance of white-tailed deer has generated intense browsing pressure, which prevents young trees from getting established. Selective deer browsing also significantly impacts species composition. In terms of the fire regime, fire suppression has degraded forest habitat and changed species composition.

The restoration of mine lands presents another opportunity to improve habitat. In the short term, mine land restoration can benefit early successional songbird species, such as the golden-winged warbler, that require young forest habitat. In the longer term, mine land restoration can benefit species that require large blocks of later-successional forest by expanding forest cores and reducing overall forest fragmentation. Mine land reforestation offers an opportunity to restore rare forest types and species, such as red spruce, and manage for game species habitat.

Forest Restoration for Ecosystem Services

Healthy, well-managed forests generate many ecosystem services that directly benefit people. Using restoration to improve the health of our existing forests can therefore help improve the benefits we receive from forests (figure 4.2, facing page).

Where The majority of the Chesapeake Bay watershed's forests are held in private ownership, which means private landowners are a key partner in restoring the health of existing forests. While forest restoration can be used wherever forest health has been degraded, it can also be targeted to improve forests that provide the greatest value to people or to bolster networks of wildlife habitat. Because of the paucity of interior forest habitat in the Mid-Atlantic, increasing and improving this habitat will directly benefit bird species such as wood thrush, Kentucky warbler, hooded warbler, and yellow-throated vireo. Restoring corridors along waterways and ridgelines that are critical habitat pathways for wildlife may also be needed. State Wildlife Action Plans, revised in 2015 by State wildlife agencies, are a key tool for identifying habitat priorities for wildlife species of concern.

We can design forest restoration to improve **diversity in age, structure, and species composition** of forest stands to meet the unique needs of different wildlife species across the landscape. Some key species in decline, like the cerulean warbler, wood turtle, and Delmarva fox squirrel, require later-successional forest habitat. Others, such as American woodcock and golden-winged warbler, rely on young or early successional forest habitat (Larkin and others 2017), which has declined due to fire suppression and other land use changes.

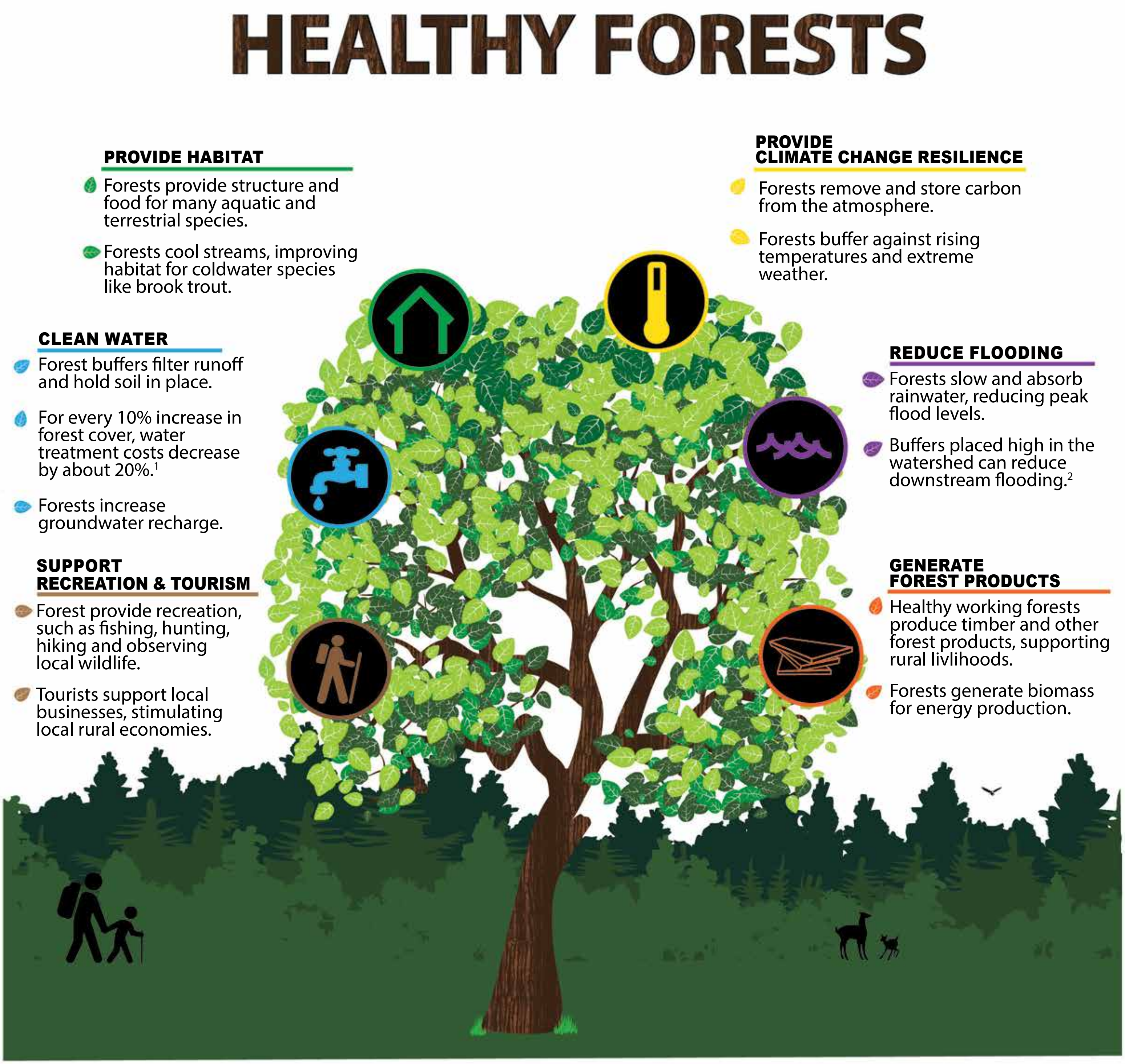
How **Forest management.** Forest management plans can help guide landowners in selecting restoration strategies that will help them improve the ecosystem services and habitat their forest provides over the long term. However, these plans need to be much more widely adopted and implemented to achieve these goals at a landscape scale. Because implementing the activities in forest management plans can be costly, one approach to minimize costs may be to help smaller landowners coordinate their management activities. By aggregating smaller forest landowners into larger networks, these networks may be able to attract contractors that can implement management activities at affordable rates.

A well-planned timber harvest can help maintain forest health, so restoration goals can often be achieved while generating forest products. Thinning can provide important benefits for forest health by freeing up space, nutrients, and light, which allows the remaining trees to grow larger. This can in turn increase carbon sequestration and carbon storage within forests. Management practices should also address local species of concern. For example, for cerulean warblers, harvesting regimes can work to mimic natural disturbances to enhance habitat (Wood and others 2013). Likewise, to improve early successional habitat for golden-winged warblers, managers can leave residual trees and snags for foraging and use thinning to create their preferred edge habitats with gradual vegetation transitions.

Abate biological stressors. Forest restoration is a long-term process. Foremost is the need to slow fragmentation, which can be addressed by land use and natural resource conservation policies. In the meantime, many biological stressors that impact forest health can be managed. For example, controlling invasive species, pests, disease outbreaks, and deer populations can help minimize changes to natural species compositions and support forest regeneration. There is a wide range of control techniques that can be tailored to specific sites and to specific invasive species, pests, and diseases with the support of technical service providers or private consultants. For example, invasive species control can involve mechanical removal, various herbicide treatments, or biological control. While targeted herbicide applications can be very effective in some cases, they may not be appropriate in sensitive sites, for example, where herbicide could contaminate local water supplies or damage nearby rare plants.

Consider fire. In landscapes with a history of fire suppression, prescribed fire can be an important strategy for restoring health to forested ecosystems (see George Washington and Jefferson National Forests case study, page 26). In situations where prescribed fire is not possible, strategic harvesting can be used to mimic natural fire regimes by creating forest openings and controlling undesirable species.

Improve markets. Local markets for forest products can be an economic driver for restoration activities by providing revenue from the biomass removed during thinning. Providing strong markets for renewable forest products not only helps avoid forest loss, but also supports resilient rural economies by ensuring forests remain profitable for landowners. In addition to timber markets, improving markets for other forest products, such as biochar and biomass for energy production, can support rural economic development.



[1] Ernst, C. 2004. Protecting the Source: Land Conservation and the Future of America's Drinking Water. The Trust for Public Land, American Water Works Association. https://www.tpl.org/protecting-source.

[2] Dixon, S.J., Sear, D.A., Odoni, N.A., Sykes, T., & Lane, S.N. 2016. The effects of river restoration on catchment scale flood hydrology. Earth Surface Processes and Landforms. 41(7): 997-1008.

Figure 4.2.—Benefits of healthy forests. (U.S. Forest Service illustration by Cheryl Holbrook)

However, the forest products market has been struggling, due to overall market decline and the closure of local mills. One new approach that is being evaluated in the watershed is to develop centralized woodyards that would buy pulpwood from smaller forest landowners to aggregate for shipping using a dedicated truck fleet. Another emerging potential income source for forest landowners comes from emerging ecosystem markets for services like carbon, improved water quality, and habitat for species of concern.

Forest certification. Sustainable forestry certification programs, such as those provided by the American Tree Farm System, Forest Stewardship Council, and the Sustainable Forestry Initiative, can provide important guidance on forest restoration and management. Certification often requires implementing practices designed to safeguard water resources and habitat while improving carbon sequestration capacity. In turn, certification can enable forest owners to maintain market access. However, these certification programs may not be beneficial for smaller, private forest landowners since certification can be expensive and may not improve financial returns.

Stack of harvested trees. (Courtesy photo by Chesapeake Bay Program)

Mine lands restoration. Established in 2004, the Appalachian Regional Reforestation Initiative (ARRI) promotes mine land reforestation through a broad coalition that includes the Office of Surface Mining Reclamation and Enforcement (OSMRE), State coal regulatory authorities, Federal and State natural resource agencies, academia, industry, and non-governmental organizations. ARRI has drawn from decades of research to develop the Forestry Reclamation Approach, which often involves "ripping" soil to mitigate compaction and blend surface materials to quickly and effectively restore high-value forest habitat on reclaimed mine lands and legacy sites (see Round Knob case study, page 27).

The techniques and funding used to reforest mine lands vary depending on the type of mine land, which generally fits into one of three categories: active mining operations, abandoned mine lands, and legacy sites. On *active* operations, coal operators are responsible for reclamation and tree planting. *Abandoned Mine Lands (AML)* were not reclaimed and generally abandoned prior to the passage of the Surface Mine Control and Reclamation Act of 1977 (SMCRA). AML sites often produce Acid Mine Drainage and have unnatural features such as dangerous highwalls, open pits, and open underground portals, which can negatively impact human health and safety, wildlife, and water quality. Fees from active mining operations fund reclamation and tree planting on AML sites. *Legacy sites* are mining operations that were permitted, usually post SMCRA, which emphasized issues such as stability and water quality. SMCRA encouraged the "tracking in" of surface materials and establishing heavy ground covers, resulting in soil compaction and increased competition. These techniques often killed or slowed the growth of native vegetation, arresting natural succession for decades or longer, with non-native invasive species often covering these sites. Funding for legacy reforestation projects is generally limited, but can come from Federal forest restoration programs, mine land-specific programs, non-profits, and other organizations.

Financial and Technical Assistance

The **U.S. Forest Service** provides technical support to help State and private forest landowners manage their forests through multiple programs:

- Through the Forest Stewardship Program, the Forest Service works with State forestry agencies, cooperative extension, and conservation districts to provide private landowners with the information and tools they need to manage their forests.
- The Forest Health Protection group provides technical assistance and expertise to help manage invasive plant species, insect pests, and pathogens.

The **USDA Natural Resources Conservation Service** administers multiple financial and technical assistance programs for forest lands in cooperation with State forestry agencies:

- The Environmental Quality Incentives Program (EQIP) provides a cost-share for developing and implementing forest management plans. This includes forest stand improvement activities designed to sustain forest health and productivity, improve habitat, and increase carbon storage, among other objectives.
- The Conservation Stewardship Program (CSP) provides annual land use payments based on the environmental benefits generated by conservation activities on private forest lands. This includes a variety of forest stand improvement activities, including thinning and creating or improving wildlife habitat.

- Working Lands for Wildlife provides technical and financial assistance for implementing forest management practices that will benefit wildlife.

Other grant and cost-share programs that provide financial assistance are available at the State and regional level.

Forests for the Bay is a website resource for landowners in the Chesapeake Bay watershed and has a woodland planning tool that assists landowners in assessing their natural resources and developing management plans.

My Land Plan is an American Forest Foundation tool for developing woodland management plans. Because a forest management plan is required for sustainable forestry certification programs, and these plans can be expensive and time consuming to develop, this tool was designed to help reduce barriers to certification for small woodland owners.

State Forest Action Plans, originally developed by State forestry agencies in 2010 with new versions to be released in 2021, provide guidance on State forest management priorities.

The Center for Invasive Species and Ecosystem Health has catalogues of invasive plant, insect, and disease species; a repository of publications on these species and control techniques; and invasive species distribution maps, among other resources.

Technical assistance for forest management is available from NRCS, State forestry agencies, land grant university extension departments, and private forestry consultants.

Actions

Improve enabling conditions and increase private forest landowner access to financial and technical assistance for forest management planning and practices.

- Develop ways to aggregate smaller forest properties for management using existing landscape or neighborhood networks and identify or train contractors that can help manage these smaller acreages.
- Build a larger network of technical service providers through cross-training sessions with others doing landowner assistance (for example, providers offering conservation easements or agricultural BMPs).
- Work with NRCS to streamline existing programs and consider a Regional Conservation Partnership Program to fund forest management practices included in forest plans and to support landscape-level forest management planning efforts, especially where greater stand diversity is warranted.
- Encourage States, philanthropic entities, nongovernmental agencies, and localities to develop grants and programs to assist landowners with land management opportunities and removal of barriers.
- Leverage other environmental stewardship efforts such as land conservation, invasive species outreach, source water protection, and environmental planning to advance forest management activities.
- Explore opportunities for improving State tax policies to incentivize forest management and conservation.
- Work to facilitate prescribed burns on private lands, for example, by providing training sessions and funding.

Develop markets and support local economies for diverse forest products.

- Explore opportunities for aggregating and marketing timber from smaller forest owners and accessing diverse forest products markets (including carbon markets).
- Demonstrate wood availability, including lower-value timber, using U.S. Forest Service Forest Inventory and Analysis data to economic development groups to support the development of local wood economies.
- Remove barriers for bringing timber to market where possible, for example, by working to improve road systems while minimizing water quality impacts.
- Identify viable non-timber forest products to produce and sell in the region.
- Assess the utility of lowering barriers to forest certification for small landowners.

Ensure protected lands receive management.

- Work with land trusts and other conservation easement programs to include forest management in the terms of the easement.
- Provide education to conservation easement holders (local, State, and regional) on the importance of using forest management to maintain and improve forest health.

Continue to promote forest restoration on mine lands in the watershed.

- Align mine land restoration efforts with other conservation priorities and prioritize sites for reforestation based on partner objectives.
- Increase funding for restoring legacy mine sites.
- Support the Appalachian Regional Reforestation Initiative's outreach and collaboration efforts with active mining operations, State mining agencies, and abandoned mine lands programs to encourage forest reclamation.

Case Studies

Restoring Ecosystems with Prescribed Fire on the George Washington and Jefferson National Forests

Provided by Lindsey Curtin, Fire Ecologist, George Washington and Jefferson National Forests

The George Washington and Jefferson National Forests rely on the use of prescribed fire to restore and maintain healthy, diverse ecosystems. Importantly, prescribed fire mitigates the harmful effects of large wildfires by reducing available fuels when weather conditions are favorable and fire behavior is less intense. Prescribed fires create a mosaic of habitats many plant and animal species depend on, such as young forests and open woodlands, and stimulate the growth of shrubs that provide bountiful food for wildlife. Oak and yellow pine species rely on fire to increase light to the forest floor and reduce competition from fast-growing competitors, like red maple. Soils benefit from nutrient cycling without experiencing harmful erosion that can cause sedimentation in streams and rivers.

Top: Open woodland habitat restored using prescribed fire on the Eastern Divide Ranger District.

Bottom: Fire backing through the Gauley Ridge Prescribed Burn in November 2014. (U.S. Forest Service photos by Lindsey Curtin)

Fire managers on the Forests may treat up to 35,000 acres of land with prescribed fire annually, as weather conditions and funding allow. Prescribed burn blocks are identified by proximity to the wildland-urban interface (where wildfires are most dangerous and destructive) and by using GIS modeling techniques developed in collaboration with The Nature Conservancy (TNC) to highlight areas dominated by fire-adapted and fire-dependent vegetation. Fire-effects monitoring is conducted across the Forests in addition to lands managed by TNC, the Virginia Department of Conservation and Recreation Natural Heritage Program, and the Virginia Department of Game and Inland Fisheries to ensure prescribed burn objectives are met after treatment and to improve the success of future treatments. More information is available through the Central Appalachian Fire Learning Network.

Family Forest Stewardship in Maryland

Provided by Kate Livengood, Family Forest Outreach Specialist, The Nature Conservancy

In January of 2018, with the support of the National Fish and Wildlife Foundation's Central Appalachia Habitat Stewardship Program, the Nature Conservancy (TNC) launched a Family Forest Stewardship Project in western Maryland in partnership with the Maryland Forest Service, Maryland Wildlife and Heritage Service, NRCS, and the American Forests Foundation. The project is using targeted social marketing (for example, Tools for Engaging Landowners Effectively) to increase the number of private landowners utilizing existing State and Federal programs to address stressors like invasive species and insect pests. During the first year of the project, project partners distributed a mail survey to 2,000 landowners with 10 or more acres of woodland. The majority of respondents reported interest in wildlife habitat on their land but did not have a forest stewardship plan. In 2019, survey data was used to develop a targeted social marketing campaign. Mailers offered landowners more information on local programs on topics like Forest Stewardship Plans, Estate Planning, and invasive species management.

In coming months, project partners will also use grant funding to accelerate implementation of invasive species management to benefit bird habitat and forest health. They are developing a pilot program that will assist landowners with accessing State cost-share money and contractors for invasive species management. They will hire one contractor to write invasive species management plans for five to eight landowners and carry out the management actions. The program will cover the costs up front, then apply for reimbursement from the State cost-share program, making the process easier for both the landowners and the contractor.

Round Knob Bond Forfeiture Site
From 2004 to 2019, the Appalachian Regional Reforestation Initiative (ARRI) has worked with nearly 200 partner organizations to plant approximately 139.5 million trees on 232,500 acres across Appalachian mine lands. The Round Knob bond forfeiture site project is an excellent example of ARRI partners working together to achieve a common goal. The Round Knob surface mine is an abandoned 35-acre site in Huntingdon County, Pennsylvania, that was producing Acid Mine Drainage (AMD). Water from this site eventually flows to the Susquehanna River and ultimately into the Chesapeake Bay.

To prepare the site for reforestation, biosolids were first applied and disked in to add nutrients and much needed organic matter. Bulldozers then ripped the soil to mitigate compaction and blend the surface materials to ensure the quality of the growth medium for reforestation. A site-specific planting plan was prepared for three distinct cover types. Tree species common to northern red oak forests were planted on most of the site, while red spruce and aspen were planted at higher elevations, and wet-tolerant plants such as sycamore, willow, and dogwood were planted at lower elevations. The trees and shrubs in this area will transpire water and trap excess metals and salts, reducing the strain on the water treatment system used to treat AMD.

ARRI partners pooled resources to reforest the site. The Pennsylvania Environmental Council (PEC), Foundation for Pennsylvania Watersheds, and the Susquehanna River Basin Commission (SRBC) provided funding for the project. The Office of Surface Mining Reclamation and Enforcement (OSMRE) provided technical assistance and the ARRI Core Team members from Pennsylvania coordinated the site preparation and tree planting. Approximately 24,000 native tree and shrub seedlings were planted at this headwater site, creating wildlife habitat while stabilizing the land and addressing water quality concerns. The parties continue to work together on mine land reforestation projects in the Chesapeake Bay watershed.

Restoring Corcoran Woods
The 215-acre Corcoran Woods is owned and managed by the Maryland Park Service and located outside of Annapolis, MD. Over the last several decades, invasive plants have either replaced or degraded almost a quarter of the property's upland and bottomland hardwood forests and threaten to infiltrate the remaining healthy acreage. The Maryland Department of Natural Resources (DNR) Forest Service developed a thorough multiphase forest restoration plan for Corcoran Woods that catalyzed a diverse group from State and local government agencies, environmental non-profit organizations, and private natural resources contractors. The plan delineates parcels within the Corcoran Woods according to their degree of invasive plant infestation, current regeneration, and canopy structure.

The Alliance for the Chesapeake Bay has been working collaboratively with several agencies, including the Maryland DNR Forest Service, Park Service, and Chesapeake & Coastal Service, as well as with local government and State funding sources, to manage project implementation with private contractors. The goal of the multifaceted, multiyear project is to manage and control invasive plants in the most highly infested parcels, which comprise 45 acres, while simultaneously restoring native tree cover in these areas through reforestation plantings. Monitoring and managing the spread of invasive plants in parcels with little infestation is also underway.

Top: Round Knob Reforestation Partners (left to right): Tom Clark, SRBC; Scott Eggerud, OSM/ARRI; Laura England, PEC; Eric Oliver, PA Department of Environmental Protection. (Courtesy photo by Scott Eggerud)

Middle: Round Knob Tree plantings. (Courtesy photo by Scott Eggerud)

Bottom: Forest restoration at Corcoran Woods, Anne Arundel County, Maryland. (Courtesy photo by Will Parson, Chesapeake Bay Program)

Section 5 - Climate Change and Forest Restoration

Projected Impacts of Climate Change on Chesapeake Forests

Climate change is significantly impacting ecosystems around the world, including Chesapeake forests. Although many of the changes in climate will be highly localized, a recent report projected increases in temperature and changes in the amount and timing of precipitation for the Mid-Atlantic (Butler-Leopold and others 2018). Changes in precipitation may include an increased frequency of intense precipitation events, with increased flooding potential in the winter and spring, but decreased precipitation in the summer and fall, potentially resulting in flash droughts. Under a high-emissions scenario, global sea-level rise is projected to increase by up to 4.3 feet, with the Mid-Atlantic likely experiencing higher sea-level rise due to multiple factors, such as ocean circulation patterns and land subsidence. “Sunny day” flooding and storm surges will therefore be increasingly prevalent in coastal areas.

Climate change will interact with other stressors, such as forest fragmentation and altered forest management regimes in ways that are difficult to predict. Based on the changes in climate predicted by climate models, Butler-Leopold and others (2018) used forest impact models and published research to identify some potential impacts of climate change to Mid-Atlantic forests:

- **Changes in species composition:** Some species may lose the capacity to regenerate over the next century, and more southern species may gain suitable habitat in the region.
- **Longer growing seasons:** Higher temperatures are likely to lengthen growing seasons. This may contribute to increased forest productivity, but other stressors, such as pests, pathogens, and moisture stress, may counteract any increases in productivity.
- **Increased flooding impacts:** Although the impacts of flooding on forests will vary depending on local topography, soils, and vegetative cover, the projected increase in rainfall intensity may directly damage tree stems and limbs while scouring soils and vegetation.
- **Increased risk of moisture stress:** Warmer temperatures and the potential for reduced precipitation in the summer and fall may increase the risk that trees will not have adequate water during the growing season.
- **Increased wildfire risk:** Although there have been few studies specific to the Mid-Atlantic, there is some evidence that conditions for wildfire may become more favorable.
- **Increased impacts from insect pests and pathogens and invasive species:** Invasive plants and insect pests and pathogens may benefit from warmer temperatures, longer growing seasons, and more frequent disturbance, and are therefore likely to pose an increasing threat.
- **Increased impacts from rising sea levels:** Sea-level rise will continue, which will increase impacts on coastal forests through land loss, flooding, saltwater intrusion, and storm surge.

Flooding from Hurricane Isabel in Annapolis, MD. (Courtesy photo by Mike Land, Chesapeake Bay Program)

Forest Restoration for Climate Change Mitigation

Forests are an important carbon sink. Forests sequester carbon dioxide (CO_2) from the atmosphere and store it in multiple places within forest ecosystems. In many forests, most of the carbon is stored in above-ground live trees, as soil organic carbon, or on the forest floor. When wood is used for durable solid-wood products, such as timber, mass timber, or furniture, it continues to store carbon. On the other hand, although wood-based bioenergy can provide an important source of renewable energy, when wood is burned, it releases carbon and no longer acts as a carbon sink.

Many of the forest restoration activities described in this Strategy have important climate mitigation benefits. In the U.S., research demonstrates that **reforestation has very high climate change mitigation potential** (307 Tg CO_2e year−1) without sacrificing productive cropland, pasture, or natural grassland (Fargione and others 2018). Beyond large-scale reforestation, implementing agricultural best management practices, such as riparian forest buffers, can increase carbon sequestration. By storing carbon in trees, riparian forest buffers can sequester 3,036 pounds of carbon per acre per year in the Chesapeake watershed (Chesapeake Bay Foundation 2007). Natural forest management also has high climate change mitigation potential, with mitigation gains achieved through extending timber harvesting cycles (Fargione and others 2018). Providing sound forest management strategies, like thinning forests, can increase total long-term carbon storage by improving light availability after harvest (Davis and others 2009), while also improving forest health. Forests with greater structural complexity have higher primary productivity and therefore greater carbon sequestration capacity because diverse forests with multiple leaf traits can better capture light to sequester carbon (Gough and others 2019). Forest restoration efforts designed to improve the diversity and structural complexity of forests may therefore have important carbon sequestration benefits.

It is estimated that watershed wide, **Chesapeake forests are storing 1.9 billion short tons of carbon** both above and below ground, with the majority of that carbon storage occurring on private lands (figure 5.1). There are also multiple ongoing initiatives that will further improve our understanding of the carbon mitigation capacity of Chesapeake forests. For example, the U.S. Climate Alliance, which is a coalition of 25 governors who have committed to contributing to global climate change efforts, has a Natural and Working Land initiative that is evaluating the carbon sequestration implications of forest conservation, restoration, and management. The Family Forest Carbon Program is also piloting a new carbon accounting system for small, privately owned forests to improve access to carbon markets. Finally, the U.S. Forest Service Northern Forest Futures project has created projections to estimate total forest carbon storage under various climate and harvesting scenarios.

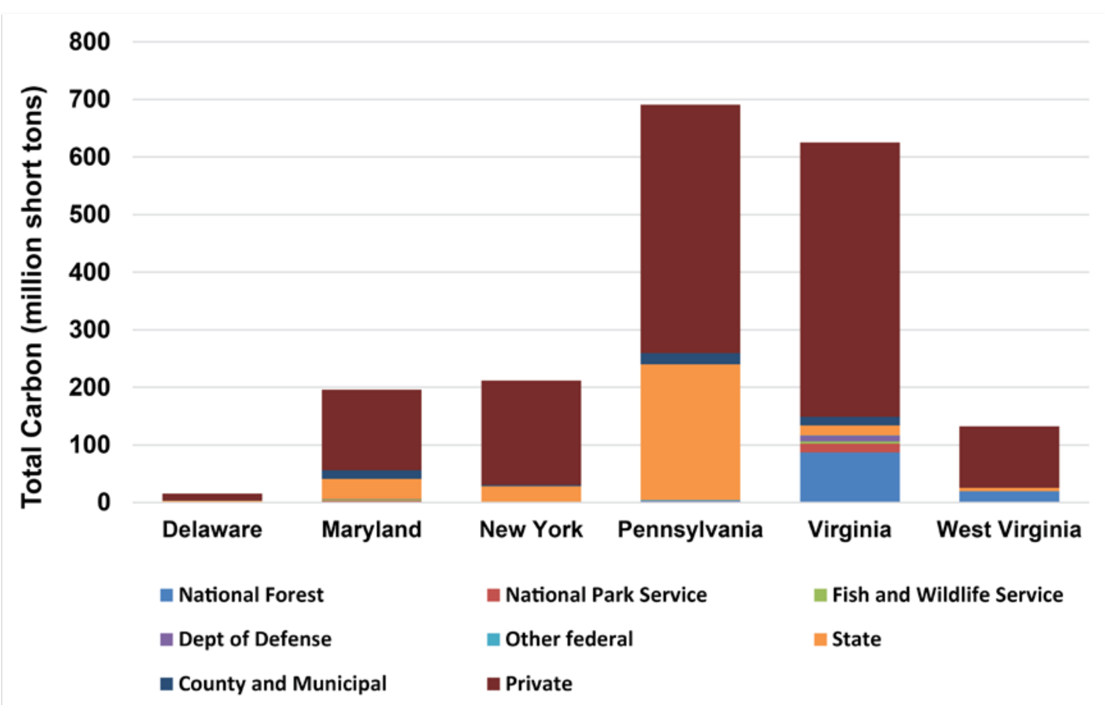


Figure 5.1.—Carbon storage in Chesapeake Bay watershed forests based on U.S. Forest Service Forest Inventory and Analysis data. (U.S. Forest Service analysis by Tonya Lister)

Forest Restoration for Climate Change Adaptation

Many of the forestry BMPs used to improve water quality in the Chesapeake Bay can also help ecosystems and communities adapt to the projected changes in climate. For example, as the temperature warms, planting trees can provide important cooling benefits for people and wildlife alike. In the urban environment, planting trees in areas that currently have low canopy cover may be an especially valuable adaptation strategy to minimize the negative human health impacts that can result from the urban heat island effect (see D.C. case study, page 34).

At the same time, establishing riparian forest buffers can help stream ecosystems adapt to increased temperatures. Many aquatic species, like brook trout, require cool water temperatures. As the climate warms throughout the watershed, planting and maintaining riparian forest buffers to shade streams will help increase available habitat for aquatic species that need cool water. On land, as soils may be more likely to dry out in the summer and fall, planting trees to create shade can help reduce the amount of soil moisture that is lost to evaporation and minimize the stress imposed on forest vegetation.

Forest restoration may also increase our ability to adapt to increased flooding. Because forests have higher rates of infiltration and evapotranspiration than other land cover types (Eisenbies and others 2007), increasing forest cover can reduce the amount of stormflow reaching streams and communities. Hydrologic modeling suggests that restoring riparian forests in middle or upper sub-basins can also reduce downstream flooding by desynchronizing the flood peaks coming from different sub-basins within a watershed (Dixon and others 2016). With high infiltration and evapotranspiration rates, forests can also protect soils from eroding away during floods and minimize stream sedimentation. Strategically restoring forests can therefore help protect communities, infrastructure, and ecosystems from the damaging impacts of flooding, which is likely to become more common.

Climate-smart Forest Restoration

Forest restoration is a valuable strategy for mitigating and adapting to climate change, so it will be increasingly important to consider ways to design and implement climate-smart forest restoration projects. Although designing *resilient* forest restoration projects is a primary focus, *resistant* or *transitional* forest restoration strategies can also be appropriate, as described by the Climate Change Response Framework. While resistant strategies seek to defend against change and disturbance, resilient strategies work to accommodate some degree of change while ensuring a system persists. Transitional strategies intentionally facilitate change within a system and may be especially relevant in coastal areas where sea-level rise is likely to result in significant conversions of forest habitat to marsh.

Species selection is one important consideration for designing climate-smart forest restoration projects. In many cases, native species that are projected to have favorable habitat under future climate scenarios should be selected. However, in some cases, managers may carefully consider using a transitional, assisted migration strategy by planting species that are currently rare or nonexistent in an area but that are projected to do well in the future. The U.S. Forest Service recently developed projections for 125 tree species found in eastern forests to show how they may fare under future climate scenarios (Iverson and others 2019). Using a series of models and a literature review, the projections help evaluate how these species will resist or adapt to a changing climate based on their current abundance, future habitat suitability, and species-specific traits. Models also evaluate species' likelihood to migrate and colonize new habitats over the next 100 years.

Researchers then applied the same modeling procedure to four physiographic regions within the Chesapeake Bay to provide guidance to forest managers regarding how tree species and forest communities may change over the next century. Abridged versions of these projections are provided as online supplemental material, with additional results available upon request. These changes will occur very slowly over the landscape as species that are less well adapted lose their ability to regenerate naturally. However, while some species, like white oak, are projected to do well as the climate changes, other species, like quaking aspen, are unlikely to be able to cope with the changing climate and will become less common over time (table 5.1). At the same time, these models suggest that **some species native to the Southeast are likely to migrate into or expand within the watershed** over the next 100 years, including longleaf pine. As the species composition of forests change, management practices may also need to adapt. For example, prescribed fire may become increasingly important as some areas shift to having more fire-associated species, such as oaks and pines.

Although we can avoid planting species that we know are particularly vulnerable to current stressors, such as emerald ash borer, increasing the diversity of species planted can reduce vulnerability to future pest or pathogen infestations. At the same time, we can consider planting species that are likely to be well adapted to future site conditions. For example, plantings in riparian areas that are likely to flood more often in the future should target species that tolerate these conditions.

Winners	Losers	New species
American hornbeam	Bigtooth aspen	Longleaf pine
Blackgum	Eastern white pine	Sugarberry
Eastern redcedar	Gray birch	Sweetgum
Loblolly pine	Paper birch	
Mockernut hickory	Pawpaw	
Northern red oak	Quaking aspen	
Southern red oak	Red pine	
Sweetgum	Serviceberry	
White oak	Striped maple	
	Swamp white oak	
	Sweet birch	
	Tamarack (native)	

Table 5.1.—Summary of likely climate winners, losers, and new species in at least two physiographic regions in the watershed based on the modeling approach used by Iverson and others (2019). ***Winners*** *have a very good capability to cope with the changing climate under at least one climate scenario, have an increase or no change in available habitat, and have at least medium adaptability.* ***Losers*** *have a very poor capability to adapt with a changing climate and have a large or a very large decrease in available habitat.* ***New species*** *are projected to have new habitat and may migrate into the area within 100 years under both climate scenarios and have at least medium adaptability.*

Sourcing of seeds and seedlings used in restoration projects is another consideration. The Seedlot Selection Tool can be used to identify potential seed source areas for afforestation and reforestation projects based on current or future climate projections for a specific planting location. This approach can improve the resilience of planting stock (see Finzel Swamp case study for an example, page 33). Seed orchards, which track the genetics of each seed, may be another valuable source of seeds within these favorable climate windows. For programs that do not collect or propagate seeds, planting larger individuals or sourcing conservation-grade seedlings from nurseries may improve the resilience of seedlings to climate change. Breeding efforts continue to generate more resistant tree species like ash and elm that could be used to reduce susceptibility to environmental and ecological change.

Other than species selection and genetics, it is important to consider climate-driven changes in seasonality and other environmental conditions in planning for restoration. For example, planting earlier in the year may help ensure trees can get established before soils dry out later in the summer. This may be especially important for urban tree planting where trees are already stressed. Understanding that invasive species may become more competitive under future climate scenarios, projects may also need to budget in additional funding for vegetation maintenance to ensure that seedlings can get established. Likewise, more funding may be needed for pest control as climate change accelerates the life cycle for certain insect pests and may even provide conditions where pests can complete two life cycles within a single season.

Although we have focused here primarily on biophysical considerations for designing climate-smart forest restoration projects, it is also important to recognize that some human communities are more vulnerable to climate change than others. For example, some lower-income neighborhoods and communities of color can have less access to shade and greater heat exposure. There are therefore important environmental justice considerations in designing and siting forest restoration projects. For example, although tree planting may help a community adapt to increased temperatures, **targeting plantings to benefit communities that may be more vulnerable to future climate change impacts, such as lower-income communities and communities of color, could help improve their resilience**.

In the Chesapeake Bay watershed, our long history of working in partnership to address complex water quality issues has left us well equipped to address climate change. Given the uncertainty and urgency with which we must address climate change, we should seek to leverage these existing partnerships to coordinate our forest restoration activities to improve resilience across the watershed.

Financial and Technical Assistance

Northern Institute of Applied Climate Science (NIACS) Climate Change Response Framework facilitates collaboratively responding to climate change that supports climate-informed conservation and forest management through multiple pathways:

- Regional climate vulnerability assessments.
- Adaptation Planning and Practices workshops: Workshops for natural resource managers working to actively improve the response of forests and other ecosystems to the changing climate.

- Adaptation Workbook: An online workbook for considering climate vulnerability in forest management.
- Adaptation demonstration sites: Real-world examples of managers implementing climate adaptation actions to meet management objectives.

The **U.S. Forest Service** has a number of resources available related to forest restoration and climate change:
- The Climate Change Atlas and Mid-Atlantic Forest Atlas projections provide region-specific information regarding the vulnerability of specific tree species to the projected changes in climate.
- The Climate Change Resource Center is a repository of tools and information on forests and climate change.
- The Sustainability and Climate Office provides resources on climate vulnerability and adaptation, and forest carbon, as well as climate tools and data, which includes a climate change and adaptation story map for the Mid-Atlantic.

Nature4Climate U.S. State Carbon Mapper is an interactive mapping tool showing the carbon mitigation potential of various natural climate solutions, including reforestation and avoided forest conversion.

U.S. Climate Resilience toolkit provides climate projections for every county in the U.S., projections for coastal flooding, and decision support tools.

Resilience Adaptation Feasibility Tool (RAFT) is designed to help localities move through a process (at no cost) to evaluate existing resilience, and develop and implement strategies to increase climate resilience, including riparian buffers and tree planting.

EPA's Climate Adaptation Resource Center is an interactive resource designed for local government officials to help account for climate change in decisionmaking.

Climate Smart Land Network provides access to climate experts for guiding management decisions for forest landowners in their network.

EcoAdapt's Climate Adaptation Knowledge Exchange Virtual Library is a repository of climate change adaptation literature across multiple sectors.

Actions

Target forest restoration and management activities to maximize potential climate adaptation benefits in both the short and the long term.
- Promote riparian forest buffer restoration as a key climate adaptation strategy.
- Evaluate where forest corridors will be most important for species migration based on projected changes in forest habitat.
- Target buffer plantings to areas where they can have the greatest impact for at-risk aquatic species that require cool stream temperatures.
- Work closely with the Animal and Plant Health Inspection Service (APHIS) and other invasive species organizations to regularly evaluate and address emerging invasive species threats.
- Work with nurseries to stock native disease-resistant species that are projected to do well under future climate scenarios.

Target restoration to groups vulnerable to climate impacts.
- Address urban heat island impacts by strategically placing shade trees to maximize cooling benefits for populations that are most vulnerable to climate impacts, including low-income communities, communities of color, children, and the elderly.

Provide technical assistance on planning climate-smart forest restoration projects.
- Develop tools to communicate with landowners regarding the best forest restoration practices they can implement for climate change adaptation.
- Hold workshops with technical service providers to keep them well informed on effective climate-smart restoration strategies and on the use of any new tools for communicating with landowners.
- Support the implementation of local codes and ordinances that will support climate-resilient forests.

Improve communication among partners regarding forest climate adaptation strategies.

Address barriers for using forest restoration to mitigate and adapt to climate change.
- Increase available funding for climate change mitigation and adaptation using forest restoration.
- Work with FEMA to identify and minimize unnecessary barriers to planting trees in flood hazard mitigation areas.

Case Studies

Red Spruce Adaptation at Finzel Swamp
Finzel Swamp is in western Maryland at the Central Appalachian headwaters of the watershed and is owned and managed by The Nature Conservancy (TNC). Finzel Swamp is in a frost pocket, which means it captures moisture and cold air, creating habitat for species that are generally more common in northern areas, including red spruce. Although red spruce used to be prominent in the Central Appalachians, as the glaciers retreated, their range contracted to cooler areas, and populations in some areas became isolated on mountaintops. Suitable red spruce habitat is projected to decline due to higher temperatures, lower snowpacks, longer growing seasons, and altered soil moisture patterns. However, there are cooler and wetter frost pockets in the Central Appalachians in places like Finzel Swamp, where it is more likely that suitable habitat for red spruce will persist.

Although TNC has been planting red spruce since the mid-1990s in western Maryland, most seedlings were sourced from a single population in the Monongahela National Forest. TNC is now partnering with the University of Vermont (UVM) to improve adaptive capacity by increasing the genetic diversity of seedlings planted. Genetic research revealed that red spruce populations at Finzel Swamp are very genetically isolated, making them especially vulnerable to the impacts of disease or disturbance. Using survey data of red spruce genetics from across the Central Appalachians, TNC and UVM have identified genetic populations that are best suited for planting at Finzel Swamp, accounting for future climate projections. Seedlings from these populations are currently growing out in preparation for planting in experimental plots in spring 2021. These plantings will be monitored for growth and survivorship to guide future red spruce reforestation efforts at the site. Restoring genetically diverse red spruce populations at Finzel Swamp will contribute to TNC's broader efforts to maintain climate corridors in the Central Appalachians to help ensure that species and genes can shift northwards or to higher elevations as the climate warms.

TNC red spruce plantings in western Maryland. (Courtesy photos by Sev Smith, The Nature Conservancy)

Washington, DC, Heat Planning

Climate projections suggest that DC will experience longer, hotter, and more frequent heat waves with as many as three times the number of dangerously hot days. This is of particular concern due to the urban heat island effect, which has been found to increase temperatures on the ground in certain areas by up to 13 degrees (figure 5.2). The challenges presented by climate change are further complicated by population growth in the District, highlighting the need to identify green infrastructure solutions that can provide cooling benefits while also maintaining an increased population density.

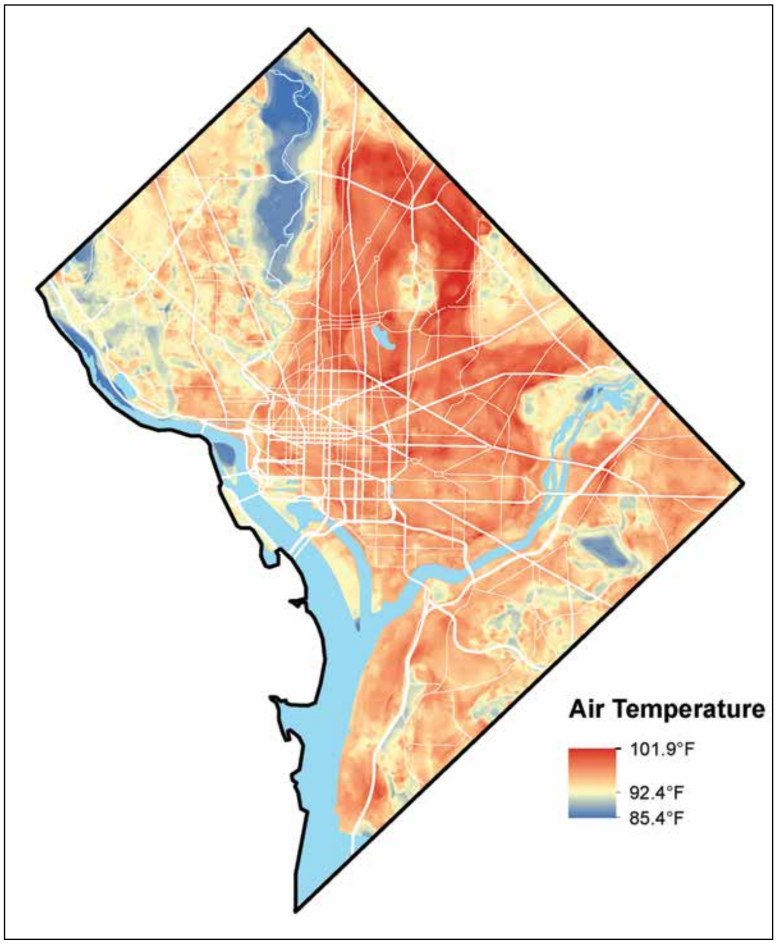


Figure 5.2.—Urban heat island effect in Washington, DC. Measurements taken on August 28, 2018, at 3:00 PM with a reported temperature of 88 °F. (Courtesy graphic from Shandas and others 2019)

The Washington, DC, Department of Energy and Environment (DOEE) and Department of Transportation (DDOT) are currently working to develop a comprehensive heat policy to address these increasing threats. One element of this effort is using heat modeling to evaluate the potential to cool the city through design. They are using the universal thermal climate index (UTCI) to provide an indication of how temperature is experienced by people on the ground. Although there is still a lot of uncertainty about modeling UTCI, preliminary results show that urban trees can reduce heat by 5 to 10 degrees, confirming that trees are a good investment for providing cooling benefits in high-density urban environments. At present, urban tree planting resources are being directed to areas experiencing the greatest urban heat island effects. As heat modeling results are verified, DC DOEE and DDOT will work to ensure that the green infrastructure interventions providing the greatest cooling benefits are incorporated into future development.

As part of its comprehensive heat planning efforts, DC is also working to evaluate the relative heat sensitivity for different populations across the city. For example, children, the elderly, and low-income populations may be especially vulnerable to the impacts of extreme heat. By mapping heat sensitivity onto heat exposure, DC DOEE will be able to show where urban greening and other cooling solutions are needed most.

New York Climate Legislation

In 2019, New York passed the Climate Leadership and Community Protection Act. The legislation sets a goal to achieve net-zero greenhouse gas (GHG) emissions by 2050 and sets a limit on GHG emissions at 40% below 1990 levels by 2030 and 85% below 1990 levels by 2050. Under the Act, the New York State Department of Environmental Conservation must ensure regulations meet these emissions reductions targets by 2024.

The Act also created a Climate Action Council, which was recently appointed. By 2023, the Climate Action Council must complete a final Scoping Plan that outlines recommendations for meeting emissions reductions targets. Relevant to forest restoration, in addition to setting a plan for net-zero emissions, this Scoping Plan must make recommendations related to achieving long-term carbon sequestration and/or promoting BMPs in forestry and identifying measures to achieve healthy forests. The Act therefore has potential to stimulate additional forest restoration activities as a way to reach climate mitigation targets in New York in the years to come. The Act also created multiple justice-oriented working groups charged with identifying and assisting disadvantaged communities, as well as a Just Transition Working Group to help establish a process for social and economic transitions to avoid negatively impacting vulnerable populations.

SECTION 6 - CONCLUSIONS

Restoring forest cover on the landscape is one of the best investments that can be made for the Chesapeake Bay ecosystem and its inhabitants. Chesapeake forests are essential for clean water, clean air, wildlife habitat, and a host of community benefits, yet they continue to be lost. The ambitious restoration goals set forth in the Chesapeake Bay TMDL and the 2014 Watershed Agreement will only be met through robust efforts to both conserve and restore forest cover. Fortunately, forest restoration can be a simple, cost-effective way to improve water quality and habitat while also creating vibrant, sustainable communities.

In a region with many people, the pressures to remove forests are prominent, but so is the need to restore forests to the landscape. To this end, we aim to collaborate to advance the actions outlined in each landscape section as well as the following overarching key actions:

Build capacity for sustainable, large-scale restoration projects by expanding the restoration economy and supply chains.
- Improve availability of training and cross-training with technical service providers in other sectors, such as agriculture and conservation, to build capacity to scale-up forest restoration activities.
- Increase funding for forest restoration job training programs, including programs that target youth and groups with barriers to employment.
- Increase coordination with nurseries to improve capacity and supply of tree stock, including the growing need for larger tree stock and early successional species.

Seek private capital investments to accelerate forest restoration economies.
- Leverage public funding to attract private investments in forest restoration activities through public-private partnerships or other financing models.
- Develop transparent methods to quantify natural capital and explicitly communicate the return on investment from forest restoration to attract private investment.
- Engage local officials in the development of ecosystem services markets.
- Develop pilot studies that aggregate restoration projects on smaller plots of private forest land to a scale that is attractive to private investors.
- Assess the potential to use existing Chesapeake Bay Program infrastructure and reporting systems to support aggregating restoration projects for private investment.

Train and educate leaders at all levels so they can better support forest restoration through funding and policies.
- Engage county officials through planning efforts, such as comprehensive plans and county-level Watershed Implementation Plans.
- Provide forest restoration training and educational materials for these leaders at forums where they are already gathering.

Expand outreach and education on forest restoration.
- Organize exchanges to listen as well as educate, remembering that communication is a two-way street.
- Expand communications partners and identify core messages that will resonate with different stakeholder groups.
- Seek opportunities to facilitate peer-to-peer communication by working with “keystone landowners” who are likely to influence their friends and neighbors.
- Compile available online tools for education and implementation tracking into a centralized repository.

This Strategy addresses opportunities to accelerate forest restoration in priority areas of the landscape that are particularly ripe for collaboration. While the sections treat urban and community, agricultural, and natural landscapes separately, there are many potential areas of overlap. Indeed, shared stewardship can help maximize the positive impact of forest restoration by targeting places that generate multiple co-benefits and leveraging resources from a variety of partners. For example, riparian forest buffers can be targeted to brook trout streams, meeting the interests of farmers and conservation organizations while also helping to achieve TMDL goals. Communities working to expand urban tree canopy can find new planting ground and partnership resources through “greening” brownfields and other contaminated sites.

A number of tools can be used to facilitate these overlapping opportunities in the Chesapeake:
- The Chesapeake Bay Watershed Data Dashboard is an online data visualization and mapping tool that can be used for watershed restoration planning and implementation. The Dashboard includes data on water quality trends, land use, estimated nutrient and sediment loads from different parts of the watershed, current BMP implementation, and land available for riparian buffers, among other datasets.
- The Chesapeake Assessment Scenario Tool (CAST) is an online modeling tool designed to quantify the water quality impacts of BMP implementation and land use change.

- The Forests for the Bay program provides a comprehensive clearinghouse of information and resources for landowners and other groups to learn about forest management and restoration opportunities.
- EJScreen: Chesapeake is an interactive mapping tool that provides data on a variety of demographic and environmental indicators that can be used to incorporate environmental justice considerations into decisions on where to target forest restoration activities.

Although not specific to the Chesapeake Bay, there are also other tools and data sources available that may be beneficial to forest restoration efforts in the watershed:

- The i-Tree suite of tools, available online through a U.S. Forest Service partnership, provides user-friendly software programs to help communities assess and manage urban trees and quantify their environmental and economic benefits.
- The Environmental Protection Agency's EnviroAtlas tool provides spatial data, analysis tools, and interpretive information on ecosystem services and their benefits to people.
- Forests to Faucets is a U.S. Forest Service tool that enables identification of areas where forests are most important for surface drinking water supply and the extent to which these forests are threatened by development, insects and disease, and wildland fire.
- RIOS is a Natural Capital Project tool that can be used to prioritize restoration investments based on where restoration can generate the greatest benefits for various ecosystem services.

Forest restoration is a long-term endeavor. From planting and caring for trees to improving the management of existing forests, forest restoration is advanced through fundamentally local, grassroots actions. It is carried out in private yards and public lands, along city streets and rural streams, by the many hands that recognize the innumerable gifts that trees return to us. Community-based efforts are bolstered by strong local, State, and Federal programs that promote forest restoration. These important programs, highlighted throughout the Strategy sections, should be prioritized in agency budgets and expanded in years to come as a central, cost-effective strategy to meet restoration goals in the Chesapeake Bay TMDL and the 2014 Watershed Agreement.

The vision reflected in this Strategy was developed with significant collaboration from partners across the watershed and sets forth broad actions to guide forestry partnership efforts in the Chesapeake Bay watershed in the years ahead. We look forward to working together to plant and restore Chesapeake forests.

Top: Correctional Conservation Collaborative planting trees in Huntingdon County, PA. (Courtesy photo by Will Parson, Chesapeake Bay Program)

Right: Trail bridge through the George Washington and Jefferson National Forests. (Courtesy photos by Alliance for the Chesapeake Bay)

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Links to Websites

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- Watershed Implementtion Documents - https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-watershed-implementation-plans-wips

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- 2014 Chesapeake Bay Agreement - https://www.epa.gov/sites/production/files/2016-01/documents/attachment1chesapeakebaywatershedagreement.pdf

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- Chesapeake Conservation Partnership - https://www.chesapeakeconservation.org/

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- Water Implementation Plans: https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-watershed-implementation-plans-wips
- Chesapeake Bay Total Maximum Daily Load (TMDL) - https://www.epa.gov/chesapeake-bay-tmdl
- Chesapeake Bay Watershed Data Dashboard - https://gis.chesapeakebay.net/wip/dashboard/

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- Urban Forest Strike Team - https://urbanforestrysouth.org/ufst
- innovative partnerships in Baltimore (http://baltimorewoodproject.org/), DC (https://urban-wood-reuse-dcgis.hub.arcgis.com/), and Virginia (https://treesvirginia.org/outreach/virginia-urban-wood-group) can serve as a model.

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- Chesapeake Canopy Network - http://chesapeaketrees.net/
- Financing Urban Tree Canopy Programs: Guidebook for Local Governments in the Chesapeake Bay Watershed - http://chesapeaketrees.net/category/funding/
- Making your Community Forest-Friendly: A Worksheet for Review of Municipal Codes and Ordinances - https://owl.cwp.org/mdocs-posts/making-your-community-forest-friendly-a-worksheet-for-review-of-municipal-codes-and-ordinances/
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- State Wildlife Action Plans - https://www.fishwildlife.org/afwa-informs/state-wildlife-action-plans

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- Sustainable Forestry Initiative - https://www.sfiprogram.org/
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- Forest Stewardship Program - https://www.fs.usda.gov/managing-land/private-land/forest-stewardship
- Forest Health Protection - https://www.fs.fed.us/foresthealth/
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- My Land Plan - https://mylandplan.org
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- Tools for Engaging Landowners Effectively - https://www.engaginglandowners.org/

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- Climate Change Atlas - https://www.fs.fed.us/nrs/atlas/products/#ra
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