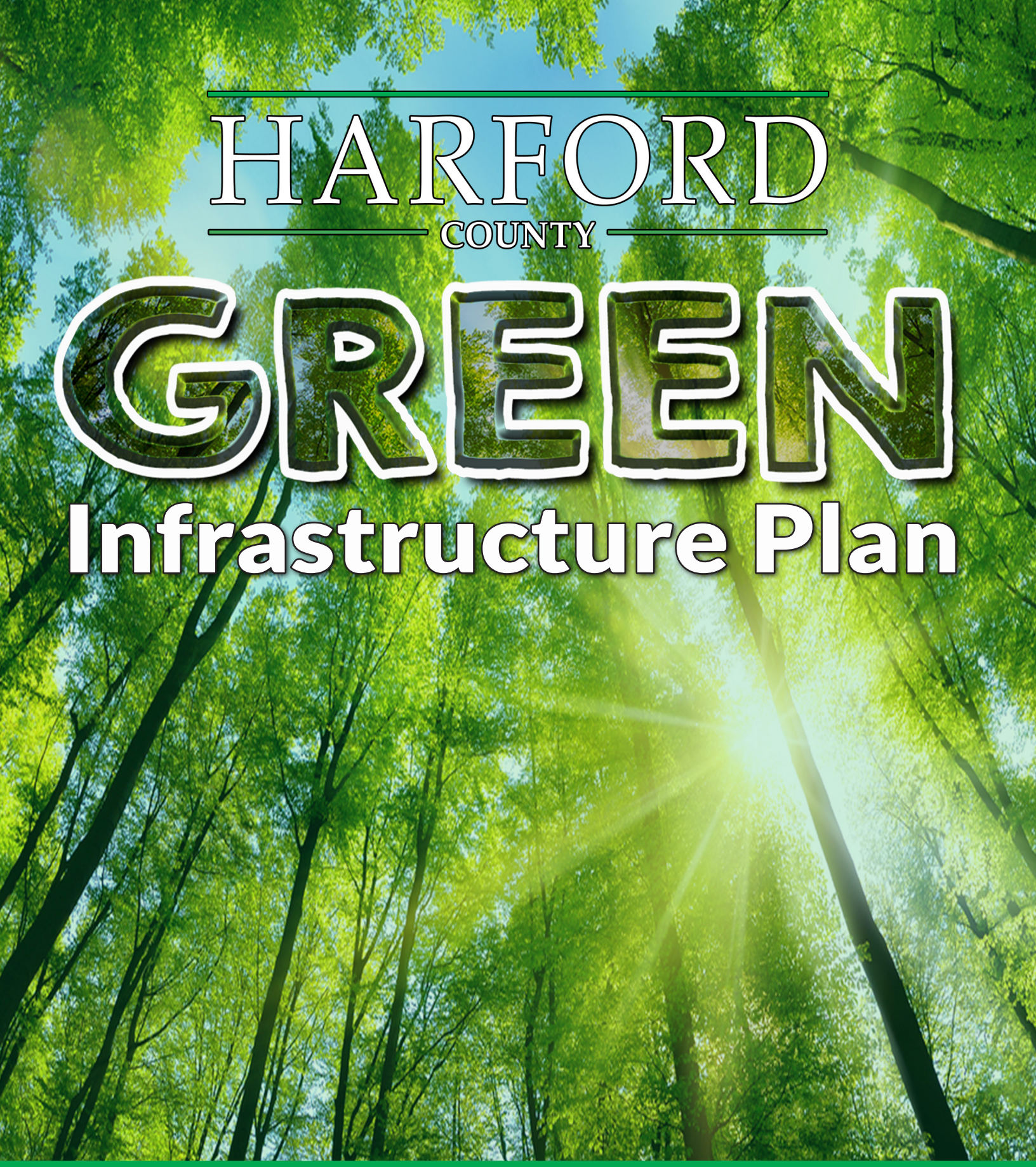

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harfordcountymd.gov/2461/Green-Infrastructure-Plan

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This is a Policy Document of the Harford County Department of Planning and Zoning and an implementation of the county master plan, HarfordNEXT, A Master Plan for the Next Generation, adopted in 2016.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Harford County's Green Infrastructure Plan (GI Plan) is a Department of Planning and Zoning policy document intended to implement strategies from the county's master plan, HarfordNEXT: A Master Plan for the Next Generation, adopted in 2016. Chapter Four of HarfordNEXT identifies green infrastructure (GI) as a strategy to protect and restore a network of streams, wetlands, and their buffers. Other environmental stewardship goals of HarfordNEXT are met or facilitated by this GI Plan.

The purpose of the GI Plan is to identify the GI network of Harford County and provide strategies for maintaining and improving this network. Certain concentrations of natural habitat are classified as GI when they provide wildlife habitat as well as public benefits - including flood protection, erosion control, and removal of pollutants from the air and water. In addition to protections, GI provides resources and promotes valuable benefits, such as recreation, to the community.

The GI Plan provides maps of the GI network to help identify potential locations for county strategies to be implemented regarding environmental stewardship, education, and partnership. Other actions are identified for individuals, landowners, and conservation organizations to inspire wider support for the needs uncovered during the plan-making process. An interactive, web-based Geographic Information System (GIS) viewer is made available for citizens to navigate on their own. This GIS viewer will facilitate a better understanding of green infrastructure locations in the county.

The GI network is composed of three general features: core areas, hubs, and corridors. Core areas provide high-quality natural habitat. Adjacent to core areas, hubs are large areas with some natural habitat value, potentially located on the outskirts of some agricultural zones. Corridors are generally narrow, linear natural areas that link core areas together and allow animal movement between those areas.

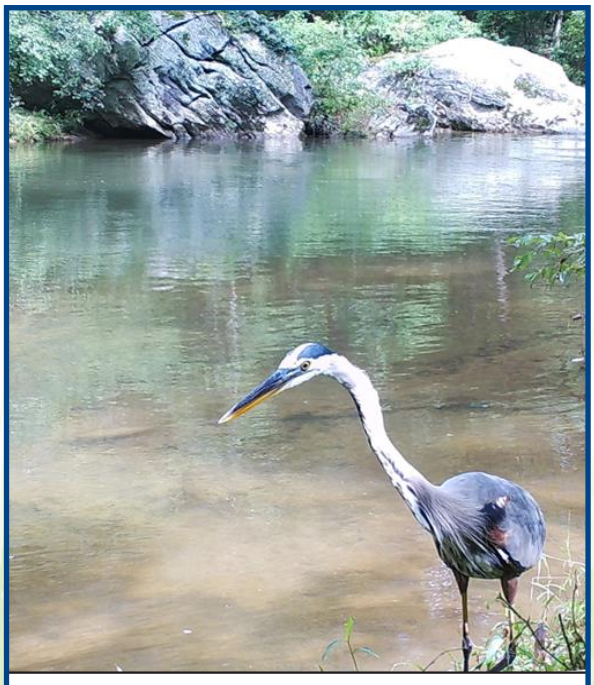


Figure 1. A great blue heron fishing in the Bynum Run watershed.

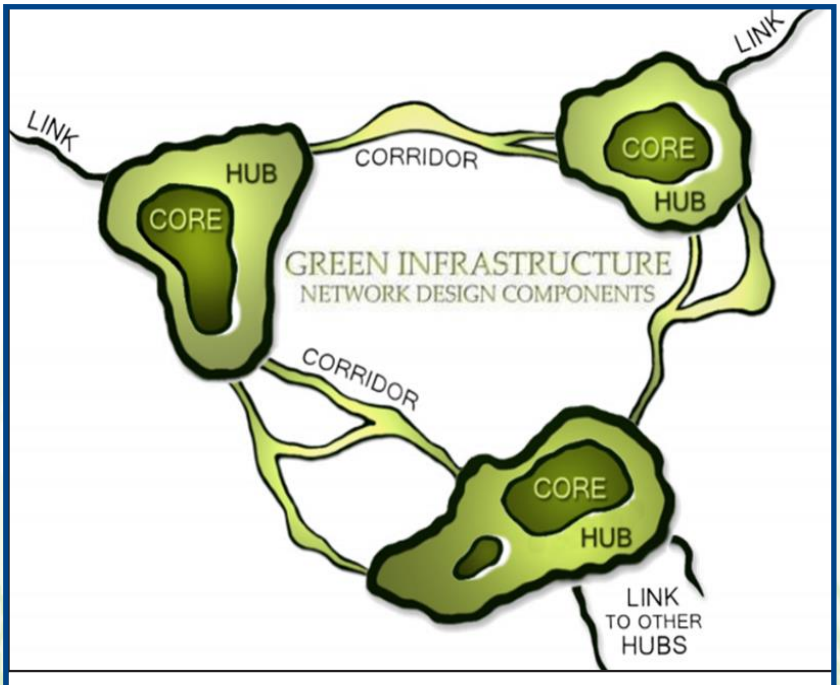
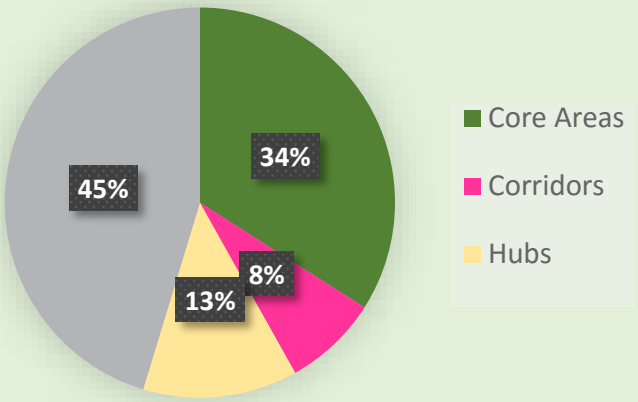


Figure 2. Conceptual diagram of a green infrastructure network (Image: The Conservation Fund).

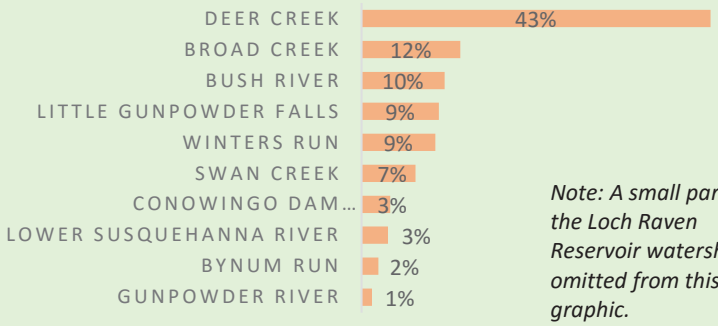
The Harford County GI network was first identified using multiple datasets from local, state, and federal sources. Specific data about the land such as soil type, forest cover, water quality, and habitat requirements were tabulated and weighted in a scoring process (Appendix C). Those areas that scored high for habitat were mapped as the primary features of the GI network - core areas, hubs, and corridors. Biologists visited these mapped areas to verify that the scoring process had correctly identified green infrastructure.

Figure 3. Percentage of County in Green Infrastructure Network



During the research phase of this plan, all county and municipal areas of Harford County were evaluated except Aberdeen Proving Ground and open water, as they are beyond local authority. Fifty-five percent of the County has been identified as having green infrastructure network. Within the areas being assessed, analyses identified 82,711 acres of core areas, 19,077 acres of corridors, and 31,155 acres of hubs. Not all of these areas are considered preserved land. Land is preserved through various easements or public ownership. Presently, approximately 34% of the identified GI network is preserved.

Figure 4. Percentage of Core Area by Watershed



Note: A small part of the Loch Raven Reservoir watershed is omitted from this graphic.

Green infrastructure is unevenly distributed across the county because of land use policies. Since 1977, County Master Plans have sought to focus growth where infrastructure was available or planned. Watersheds like Winters Run and Bynum Run host large sections of the development envelope and consequently have a much smaller percentage of core area (see Figure 4). On the other hand, the Deer Creek Watershed hosts the largest concentration of green infrastructure, especially high-quality core area, of all of the major county watersheds. Agricultural land use in the watershed has been retained through agricultural preservation programs. The watershed also hosts large areas of state parkland. These uses left more green infrastructure intact, evidenced by the variety of plant and animal species. In fact, the Deer Creek Watershed has been recognized by the state of Maryland as a stronghold watershed, with the third best biodiversity ranking in the state.[1]

The GI network can be broadened with ecosystem-improving projects in hubs and in more urbanized watersheds. Projects such as stormwater best management practices have been identified in the GI Plan. These investments add resilience to the built environment with services like water purification, flood control, and carbon sequestration while also creating recreational opportunities. The pursuit of future grants for environmental planning and remediation is facilitated by this plan.

[1]2011 Maryland Biological Stream Survey

County efforts to meet state and federal requirements to reduce the impacts of stormwater runoff in streams, rivers, and the Chesapeake Bay are also supported by this plan. Lower cost investments in green infrastructure can offset expensive capital improvements for pollution control.

Public input has been a vital feature of this planning process, helping to shape and prioritize the implementation strategies of this GI Plan. In setting priorities, "natural resource protection" was the top-ranked goal, followed by "wildlife habitat and corridors." Attendees ranked "acquiring key natural areas" as the key strategy, followed by "acquiring key corridors."

County properties host both degraded and excellent green infrastructure which present some of the best green infrastructure opportunities. A potential reforestation project at Mariner Point Park can show the costs and benefits of lawns versus woodlands.

Figure 5. Reforesting plan for a steep slope in Mariner Point Park.

The District courthouse parking lot in Bel Air offers a highly visible location to demonstrate green stormwater management. This parking lot draws many visitors for the farmers' market and other local events. A project to modify the existing conventional stormwater engineering with a bio-retention area will show how green infrastructure slows and cools water runoff from the parking lot. Signage for the project will demonstrate how the courthouse parking lot location relates to the watershed and how the erosion of stream banks can be lessened by implementing bio-retention retrofits in parking lots.

Documenting and mapping the components of the Harford County GI network allows the county to direct efforts to build the integrity and stabilize the entire ecosystem. Conveying a best-practice mentality sets the county, partner agencies, and county citizens on a course to make educated decisions for a better quality of life. Concentrating on green infrastructure conservation or restoration is a wise use of land and nature to defer long-term operating and capital costs to all of Harford County.

INTRODUCTION

Green infrastructure is our natural life support system - an interconnected network of forests, wetlands, and waterways. This system links across parkland, open spaces in subdivisions, and farms. Green infrastructure protects communities and critical public works from extreme weather, providing natural barriers and avoiding costly repairs. Green infrastructure also protects against subtle threats, cleaning water and collecting carbon dioxide within trees.

Figure 6. Protections afforded by the GI network.

Investments in green infrastructure also support the animals and plants of the natural environment. Healthy populations of native species reinforce the green infrastructure. Native species naturalize within the green infrastructure network and suppress invasive species. Invasive species are exotic plants that disrupt the ecological balance. Green infrastructure supports fisheries, pollination of crops, and supports quality soils.

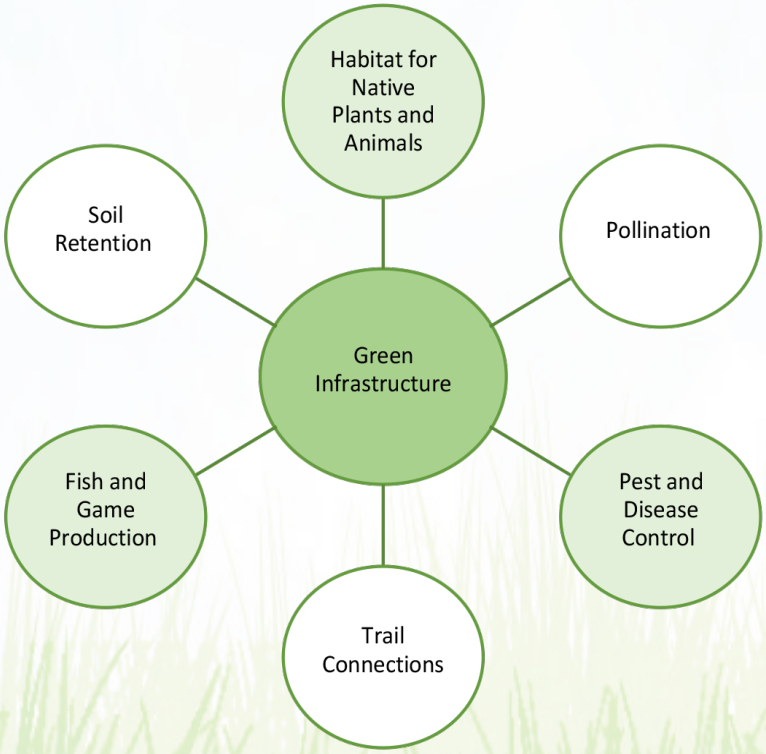


Figure 7. Resources provided by the GI network.

The concept of green infrastructure planning became a local priority in Harford County, MD in April 2016, when the American Planning Association (APA), through its professional institute - the American Institute of Certified Planners (AICP) - organized a Community Planning Assistance Team project in the county. This project was selected from a Hurricane Sandy Coastal Resiliency Grant, awarded by the National Fish and Wildlife Foundation to The Conservation Fund on behalf of the Greater Baltimore Wilderness Coalition (GBWC). In partnership with the Conservation Fund, the Susquehannock Wildlife Society, and planner Jean Akers (AICP, PLA), Harford County applied for and received a Coastal Zone Management grant to develop and refine a county-wide GI Plan.

Focusing on green infrastructure promotes strategic conservation and restoration that is proactive, holistic, and systematic. A policy concept that unifies action across landscapes, watersheds, and jurisdictions, the county-wide GI plan was highlighted as a "Big Idea" in the County's master plan, HarfordNEXT. The GI plan identifies opportunities to use natural (green) infrastructure protection and restoration strategies like stormwater green infrastructure investments. By developing a comprehensive GI plan and incorporating that information across county departments with various planning programs, Harford County hopes to reduce pollution, be more cost-effective, and protect taxpayer-financed investments. The GI plan is designed to identify multiple benefits from the network of managed and protected natural areas, green stormwater approaches, and associated open lands. The identification of multiple benefits can help diversify sources of capital, operation, and maintenance resources to support the network and broaden the base of support among residents and other county stakeholders.

Green infrastructure can help coordinate land and water conservation efforts and integrate them into a cohesive strategy for reaching long-range goals. It can also help inform the county of sustainable patterns of development, how to minimize negative environmental impacts, and where restoration could provide tangible benefits.

Harford County's GI Plan establishes a local focus for green infrastructure coordination. It refines and expands on statewide planning efforts by the Maryland Department of Natural Resources (DNR) to define Maryland's Green Infrastructure, adapting the state methodology to county-scale analysis and planning priorities.

Figure 8. Benefits promoted by the GI network.

Green Infrastructure Concept

The basic building blocks of the green infrastructure network include core areas, hubs, and corridors (Figure 9). Core areas contain fully-functioning natural ecosystems and provide high-quality habitat for native plants and animals. Core areas are the most ecologically valuable parts of the green infrastructure network. Large core areas are usually more effective than small areas for protecting aquifers and watersheds, sustaining viable populations of most interior species, providing core habitat and escape cover for wide-ranging vertebrates, and allowing natural disturbance regimes.[2]

Hubs are larger areas that contain a mix of natural habitats and other land uses. Consequently, hubs hold potential for improvement with forest mitigation projects. Hubs generally form a contiguous margin around core areas. Hubs may also have fragments of core areas, corridors, or other natural cover. Hubs are large enough to support populations of native species and serve as sources for emigration into the surrounding landscape. Like core areas, hubs provide ecosystem services such as water purification, flood control, carbon sequestration, and recreation opportunities. Since hubs are already supportive components of the green infrastructure network, but not functioning exactly as core areas, they are likely to be excellent locations for reforestation or other measures to enhance the green infrastructure network.

Figure 9. Green infrastructure network of Edgeley Grove Park. Large forested core areas are shown in green. Adjacent hub areas noted in a yellow outline include some forest and some fields. Corridors which connect to other hub areas are indicated with pink.

[2]Dramstad, W. E., J. D. Olson, and R. T. T. Forman. 1996. Landscape ecology principles in landscape architecture and land-use planning. Island Press, Washington, DC. 80 pp.

Corridors are narrow or linear natural lands that link core areas together. Corridors are generally wide enough to provide adequate habitat cover for species that move in the environment. Corridors provide a passage through unsuitable environments such as row crops or developments. Species movement includes animals, but corridors support the naturalization of native plant species as well. Suitable connectivity depends on the type of organism. High-volume roads or urban areas block terrestrial wildlife. Aquatic species are unable to traverse dams and other blockages without fish ladders or similar structures. (See Appendix D for more details.) Retaining or providing connectivity can improve the green infrastructure network by linking otherwise separated populations within discrete habitat patches.[3]

Identifying Harford County Green Infrastructure

The Harford County Green Infrastructure network was first identified using a geographic information system (GIS). Core areas were identified for different habitats such as streams, wetlands, and forest using natural facts about the land cataloged in different local GIS databases as well as databases from state-led surveys.

The following criteria[4] were used for different natural resources:

1. Forest patches with at least one acre of interior forest & greater than 100 acres
2. Wetlands and their minimum regulatory buffer
3. Wetlands of special state concern
4. Floodplains
    a. 100 year
    b. 500 year
5. Regulated stream buffers
6. Slope exceeding 25%
7. Soils classified "highly erodible" by the U.S. Department of Agriculture
8. Habitat information for over 250 animal species

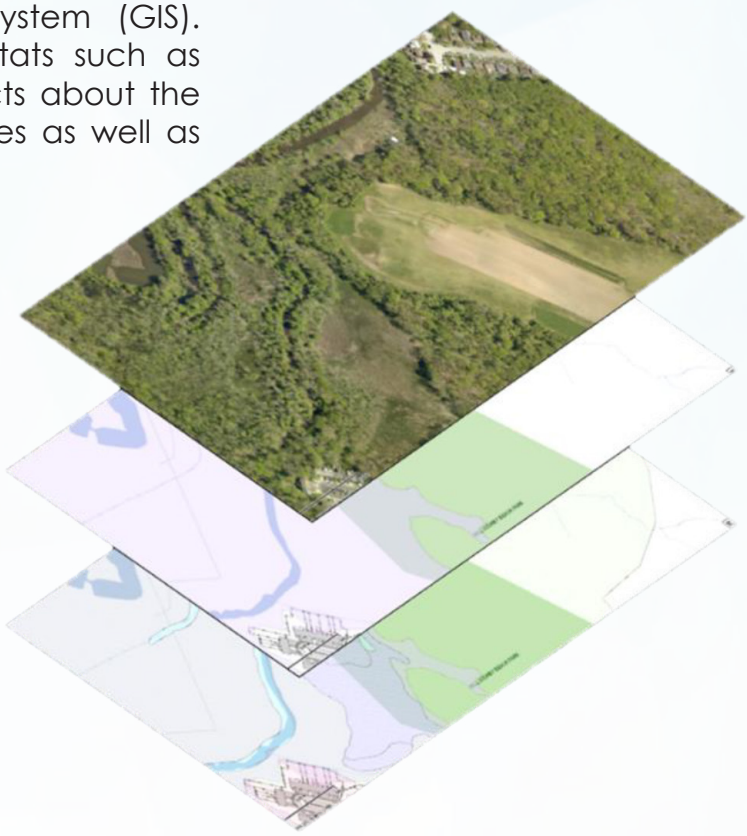


Figure 10. GIS databases were searched to identify cores, hubs and corridors of the GI network.

Aquatic core areas were found by mapping the local streams, determining their drainage area, and creating a shape from the stream that corresponds to the setbacks of the natural resource zoning district.[5] Portions of that shape were then flagged as higher quality if state stream surveys had rated the location for high biological integrity. The specific steps of the process are detailed in Appendix D. The data that was used to determine quality is documented in Appendix A.

[3]Bennett, A. F. 1998. Linkages in the landscape: the role of corridors and sensitivity in wildlife conservation. IUCN, Gland, Switzerland and Cambridge, UK. 254 pp.
[4]Appendix C documents the criteria and rationale for selecting natural resources.
[5]§ 267-62. NRD Natural Resource District subsection B.

Field Verification of Harford County Green Infrastructure

With the green infrastructure network identified, biologists visited some mapped areas to verify in the field that the scoring process had correctly identified green infrastructure. The key measure for field research was seeking focal species. Focal species are indicators that optimal priority habitats exist in sufficient quantity to be considered core areas (see Appendix B). During the field surveys, opportunities were also identified and discussed later in the strategy section of the plan. Similar methods were used for hub identification. The connectivity requirements of species that range in small areas, such as amphibians, and barriers to their movement were used to model corridors.

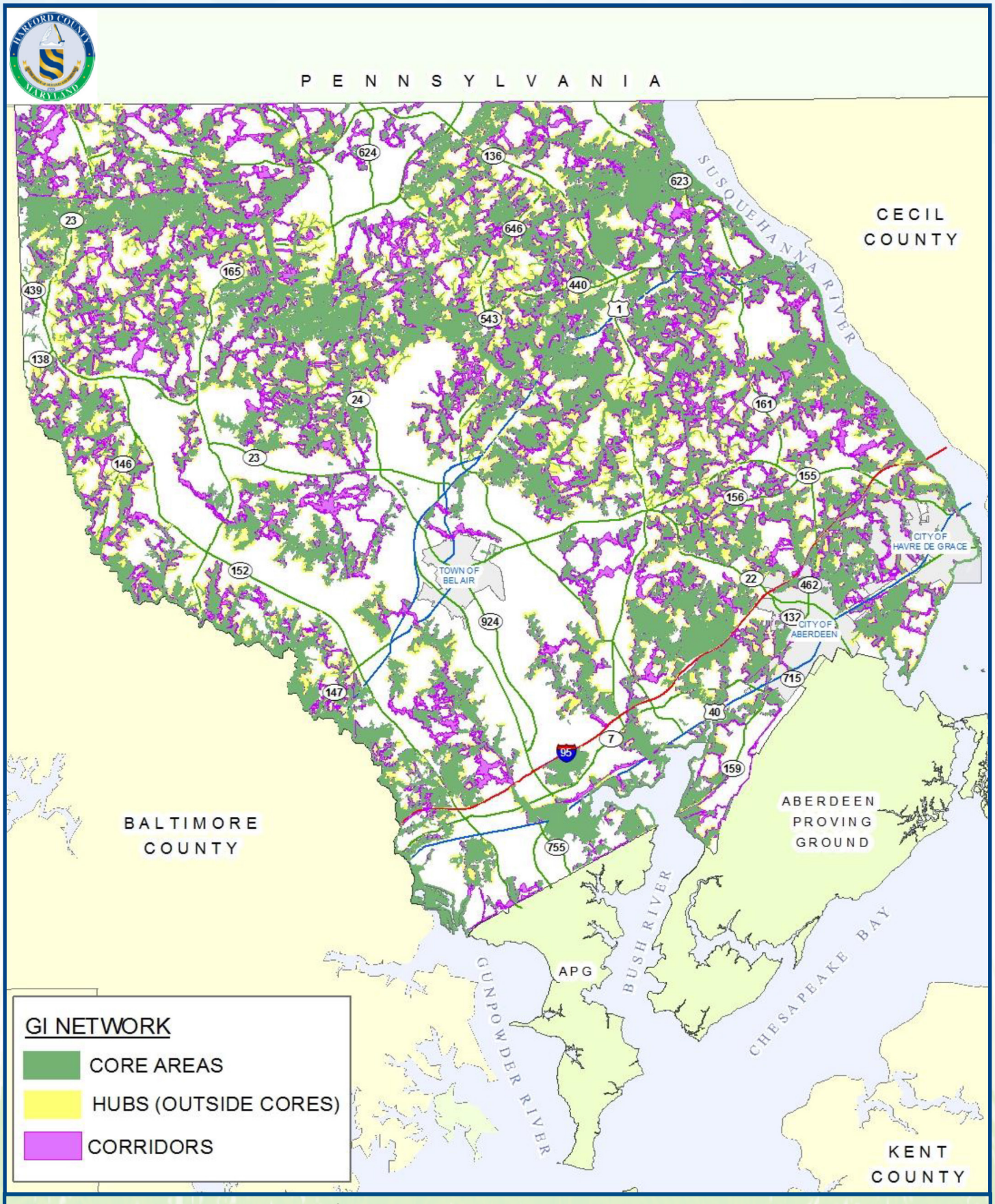
Figure 11. Hooded warbler can only thrive in core forests. (Photo: USFWS)

Many plant and animal species are adapted to interior forest conditions and cannot survive outside of an interior forest environment. Temperatures, wind, and humidity are more stable in the interior forest than in the edges of forests. Increased solar radiation and wind disturbance at forest edges increase ambient temperatures and decrease soil moisture and relative humidity, which can desiccate plants. Increased winds commonly knock down trees at the forest edge that are no longer sheltered by the adjacent trees and their canopies. Noise from nearby development disrupts natural activity for territorial boundary establishment, courtship and mating behavior, detection of separated young, prey location, predator detection, and homing. Opportunistic animals like raccoons, opossums, and cowbirds also colonize forest edges and often invade the interior, outcompeting, or parasitizing the core forest species.

Figure 12. Brook trout is an indicator species for healthy streams. (Photo: The Conservation Fund)

Tidal and non-tidal wetlands provide vital habitat and ecosystem services to native plant and animal species. Five classes of natural aquatic areas and their associated riparian zones were combined using Harford County's definition of stream protection zones. These classes were identified based on indicator species of fish and other aquatic organisms. The GI network includes all naturally occurring wetlands in Harford County (not farmed, drained, ditched or excavated wetlands) and their accompanying buffers.

The result of mapping and field survey efforts is a new map element of the green infrastructure network, which is displayed in maps and available in the interactive web tool. Map 1 illustrates the green infrastructure network at the county-wide scale.



Map 1. Core areas, hubs, and corridors in Harford County.

PUBLIC INVOLVEMENT

The GI Plan process gathered critical public opinion and preferences about the direction of the planning effort and its role in implementing the recommendations outlined in HarfordNEXT. A county webpage for green infrastructure shared planning information and resources. An email list of key stakeholders throughout the county was used for communication and notifications for meetings, open houses, etc.

Open House meetings raised awareness about the GI Plan while also providing information about the GI Plan process, schedule, and ways to get involved. Stakeholders and community members voiced their thoughts about what should be included in the green infrastructure network; their priorities for implementation; and their ideas for green infrastructure restoration/ preservation/protection activities. Citizens also had the opportunity to provide comments on the plan by emailing the county.

Figure 13. Photo from the February 8th open house.

Details of the plan were posted on the county's dedicated green infrastructure page found on the Harford County Department of Planning and Zoning's webpage. The draft plan was available to the public for several months, and comments were provided to the County through December 2018. A web-based data viewer was developed to allow citizens to review the green infrastructure data sets available (see Figure 14). Additional details regarding public comments and open house meetings may be found in Appendix H.

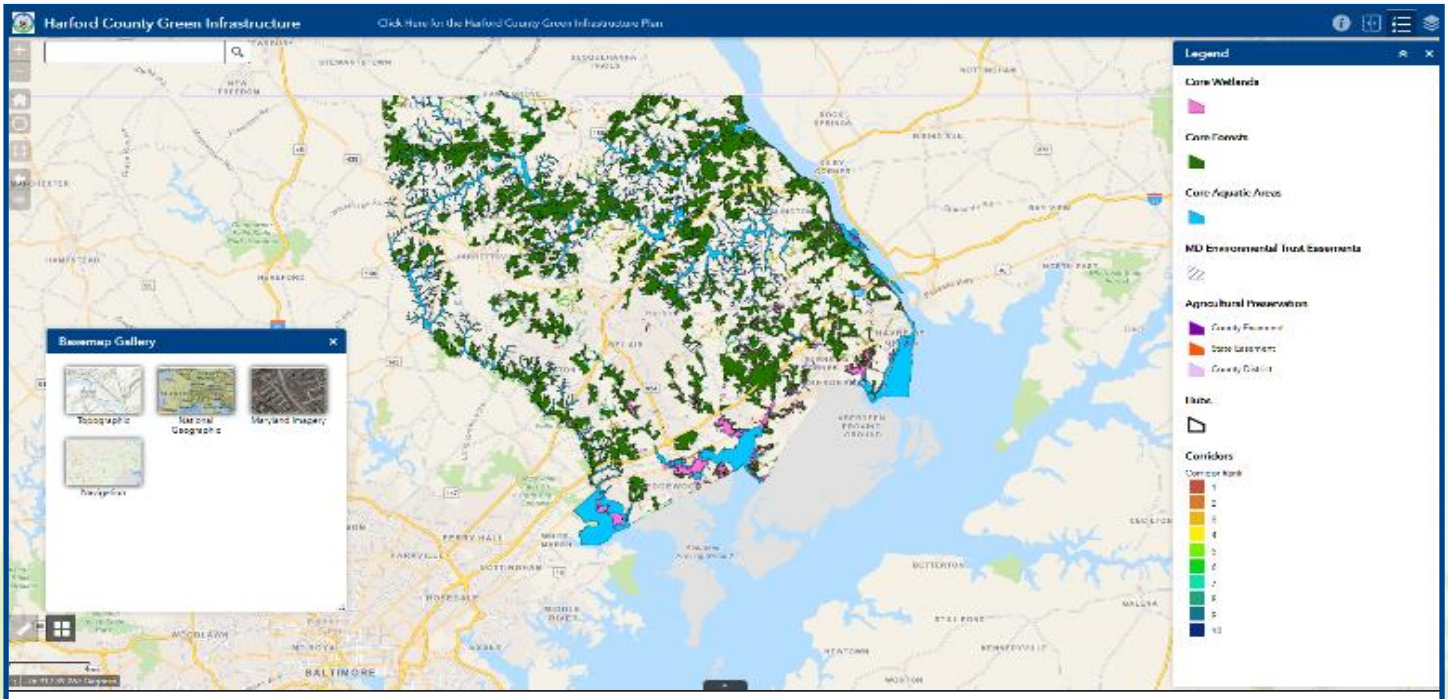


Figure 14. The Green Infrastructure web viewer educates and facilitates implementation at many levels.

The core, hub and corridor concept as a model is effective for a land conservation in Harford County. As will be demonstrated with the following specific studies and strategies, the overall network builds upon healthy and resilient natural resources. Further protection of interconnecting lands, along with focused management and enhancements to associated woodlands, wetlands, and waterways will help maintain a healthy home for wildlife and residents alike.

Actions to protect, restore, and manage County green infrastructure start with direct county stewardship, educational outreach, and regulation. Since the green infrastructure network is systemic across the county, other strategies like partnerships and models for landowners have been identified. In broadening actions beyond county projects and regulations, the research is leveraged to empower the entire community to nurture the green infrastructure network and enjoy increased ecological services all the sooner. To help visualize these potential actions using green infrastructure may work, this plan introduces strategies. Specific strategies summarized at the end of this document are identified and expanded in the subsections below.

Green Property Management

Low or no mow practices

The most easily initiated county actions are changes to operational practices like no-mow areas or invasive species plant management plans (See Figure 15). Creating or expanding no-mow or reduced (low) mow zones can increase surface water infiltration, reduce maintenance costs and enhance landscape diversity and resilience. As a sustainable practice for County-owned land (adhering to Goal ES 5.7), visually demonstrating the potential for reduced mown turf grass cover can encourage other landowners to consider more sustainable landscape practices. In this park demonstration site, establishing "low-mow" zones on the steep slope can enable better soil stabilization by allowing taller plantings that have deeper root depths and greater water uptake potential. Replacing cool-season grasses with more suitable native grasses and herbaceous flowering plants can further enhance the ecological value of no-mow areas by providing habitat. No-mow areas should eventually change to woody fields followed by forest with selective mowing for weed suppression. These changes do require adjustments to current maintenance practices. Successful no-mow areas are still managed. While summer mowing work is reduced, it may be replaced with winter cutting and spring planting of annual native plants or replanting of native perennials. Ultimately this no-mow represents an operational cost savings. As the no-mow plans are implemented and new plantings established, the overall workload will be lower than in mowed areas.

Figure 15. Mown edge of low-mow field in a regional park.

Invasive Species Property Management

Undesirable and often hazardous invasive plants thrive in the edges created by human settlement. Retaining resilient native tree species suppresses invasive growth, which reduces maintenance costs. Native tree species also support ecological processes involving natural hydrology, insect life cycles, bird and mammal habitat, nutrient recycling and microclimate modification. Native plant species support an organic renewal process that creates healthier soils which can absorb more water and support more plant growth. Context is important in selecting specific species. Species that tolerate the built environment play an important role in green stormwater management. Forest assessments[6] were conducted to determine the range of forest conditions in Harford County and compare core forest conditions to edge forest conditions. A forest assessment protocol[7] was applied to random locations in parks for forested and non-forested locations. The results are reported by park and sample point with the percentage of invasive plants and overall score. Moisture level and forest succession were noted.

Forest assessments conducted using the green infrastructure data found that invasive plants were a problem at all county parks, dominating the ground and shrub cover in half the plots. Core forest had, on average, significantly fewer invasive plants than non-core forest and invasive plants were more common near forest edges than the interior. (See Figures 16 & 17.) Wetter soils tended to have more invasive plants, and younger forest tended to have more invasive plants. Many of the sites had little native groundcover, especially native herbaceous plants. In some cases, this appears to have been caused by deer excessively browsing native plants.

For maximum ecological value, the return to forest cover is the preferred landscape. Remediation strategies for invasive plant management could allow native tree seedlings to colonize areas plagued by invasive plants. A pilot study could examine native plant recovery in plots grazed by goats versus plots managed with conventional weeding and glyphosate application. Financial costs could also be compared as well as the level of volunteer engagement for each measure. At sites with too many deer, population control coupled with fencing and restoration might benefit forest undergrowth composition and viability.

Figure 16. Core forest at Anita C. Leight Estuary Center with no invasive exotic plants.

Figure 17. Edge-dominated, non-core forest in Dublin Park, overrun with exotic plants.

[6]Appendix F details the forest assessment methodology for parkland.
[7]Appendix F-1 explains the forest assessment protocol in detail.

Wildlife Surveys and Management Recommendations

Four habitat assessments on county-owned land were completed to help identify future management needs, while also helping guide strategies to improve habitat throughout the green infrastructure network. The four sites were chosen to represent different geographic regions of the county and to evaluate green infrastructure network connectivity in representative locations. The overall observation was that these four County-owned parks contain functioning green infrastructure habitat and corridors and some of the premier wildlife hotspots in Harford County. Each area did support species that require connectivity between sites. The largest consistent threat to the future health of these sites were invasive species of plants outcompeting native plants, overgrazing by white-tailed deer, and sedimentation of wetlands or waterways. The development of invasive species management plans should be considered at all County parks, with the highest priority to those parks that have green infrastructure resources. A complete analysis and full report of each habitat area can be found in Appendix G.

Figure 18. Spotted turtle, a sensitive wetland species.

Swan Harbor Farm

This highly-used county park in the southeast portion of the county contains a wide variety of habitats that transition from agriculture including and hardwood and conifer forests. Natural and human-made wetlands lie close to Swan Creek, a characteristically piedmont creek, which enters a tidal area just outside of the park, at the freshwater tidal coastline of the Susquehanna Flats. The green infrastructure of this site connects the lower Susquehanna to some of the watershed below Deer Creek in the southeastern portion of the county.

While there is a high amount of human activity at this park, along with significant deer graze and some invasive plant species, the habitat diversity is high due to seasonal wetlands and transition areas that can support a wide variety of species including some sensitive species. This site is also an important stopover for migrating birds due to its location in the flight path and other various habitats found within close proximity. Habitat could benefit from a portion of the agricultural lands being converted into a native meadow, along with deer and invasive species controls.

Figure 19. Red foxes at Swan Harbor Farm.

Parker Conservation Area

This remote and infrequently accessed section of the Deer Creek valley in the northwest corner of the county features the large rock outcrops and characteristic riffles that can be observed along most stretches of this scenic river. This heavily forested green corridor stretches diagonally across the northern region of the county to the east where it eventually flows into the Susquehanna River. Along the floodplain, there is a wide stand of healthy forest and a mix of seasonal and spring-fed seep wetlands.

This site remains wild and intact as a natural landscape. The narrow floodplain and steep slopes may reduce some species diversity in the site. However, there are a variety of habitats, such as spring seeps, small tributaries, and rock outcrops that support breeding grounds. Other than some invasive species along the floodplain of the site, the forest is mostly dense and healthy. Deer grazing does not appear to be a significant issue at this site. Most importantly, this core green infrastructure area represents one of the many protected areas along the Deer Creek corridor that allows wildlife to travel freely and flourish.

Figure 20. Tadpoles and red-spotted newt swim in a spring seep at Parker Conservation Area.

Mariner Point Park

This actively used county park located in the southwest corner of the county lies within the coastal plain and borders the tidal sections of the Gunpowder watershed. There are scattered forest and temporary wetland areas, with most of the park focused on human recreational activities. This site was chosen to evaluate how a substantially disturbed area may still allow for some functioning corridor connectivity and habitat.

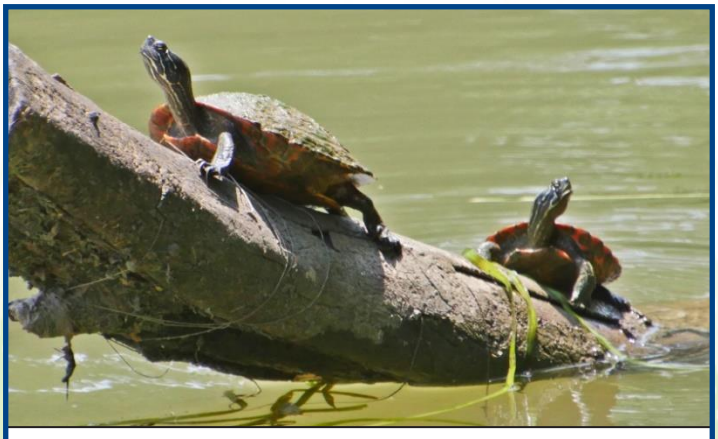


Figure 21. Northern red-bellied cooters at Mariner Point Park.

This site had a fair amount of wildlife activity, especially in certain areas of the park at night when human activity is reduced. However, there were significant deer graze and invasive species at this site and not many sensitive or indicator species found. Adding areas of refuge by increasing forest density, native meadows areas, and reducing some eroding open spaces would increase wildlife potential at this site.

Bynum Run Conservation Area

This infrequently accessed green space was preserved to buffer the Bynum Run watershed as it passes through residential areas, creating a unique wildlife corridor just outside of the town of Bel Air in central Harford County, connecting the northern, more rural region of the county to the coastal plain marshes and forests. The site has mixed hardwood forest, streams, and some seasonal wetlands.

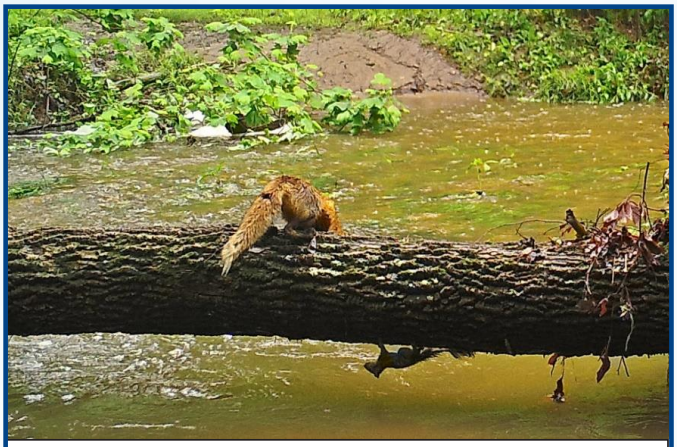


Figure 22. Red fox hunting a squirrel on a natural bridge across Bynum Run.

Although this site is narrow and sandwiched between developments, there is high habitat diversity and wildlife use this area as a corridor. The species diversity may be a result of funneling of wildlife using Bynum Run as a corridor to more protected areas to the south, as suggested by the presence of river otters. The forest does suffer from the overgrazing of deer and invasive species, and a beech tree monoculture could be enhanced with more native tree diversity. There are seasonal wetlands that support sensitive amphibian breeding and a healthy diversity of mammal species in this area.

NATURAL RESOURCE PROTECTION WITH GREEN INFRASTRUCTURE

Parkland Preservation

The Harford County public recreation system is comprised of sites owned by municipal, county, state, and federal government, and the Harford County Board of Education and is comprised of 177 sites encompassing 13,747.7 acres of land. The Harford County Land Preservation, Parks and Recreation Plan describes the county's current status and efforts not only in recreation and parks, but in agricultural preservation and natural resource conservation as well. Parks are host to a significant portion of the GI network (See Figure 23).

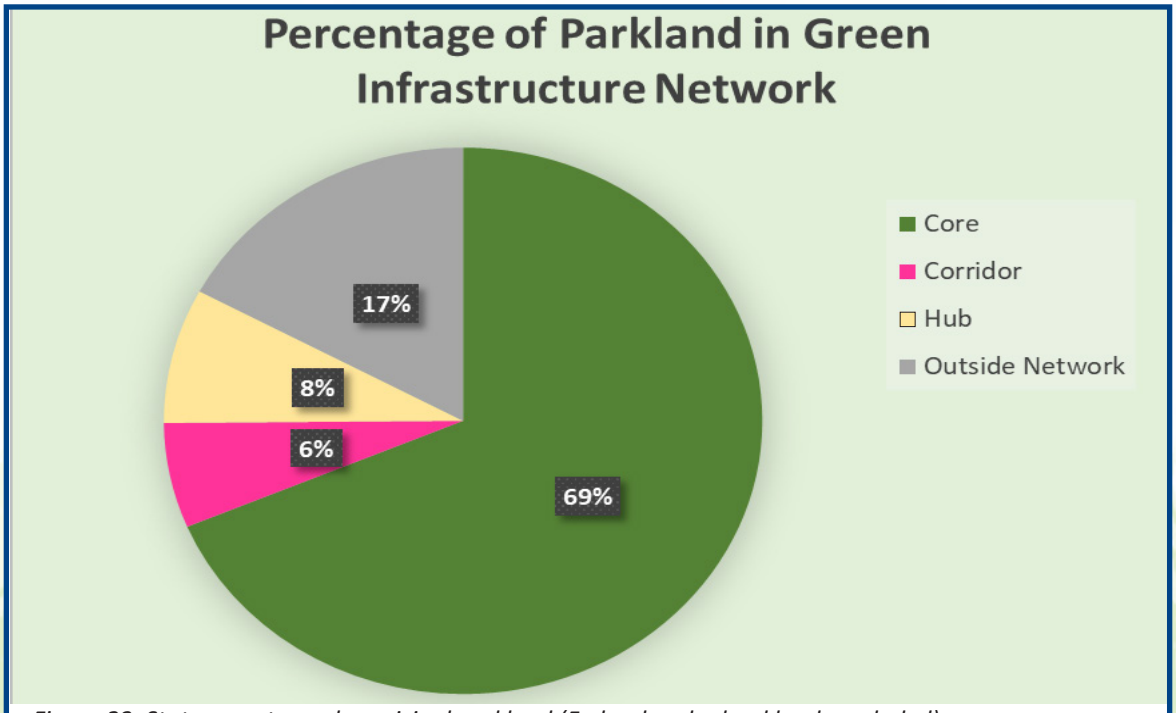


Figure 23. State, county, and municipal parkland (Federal and school lands excluded).

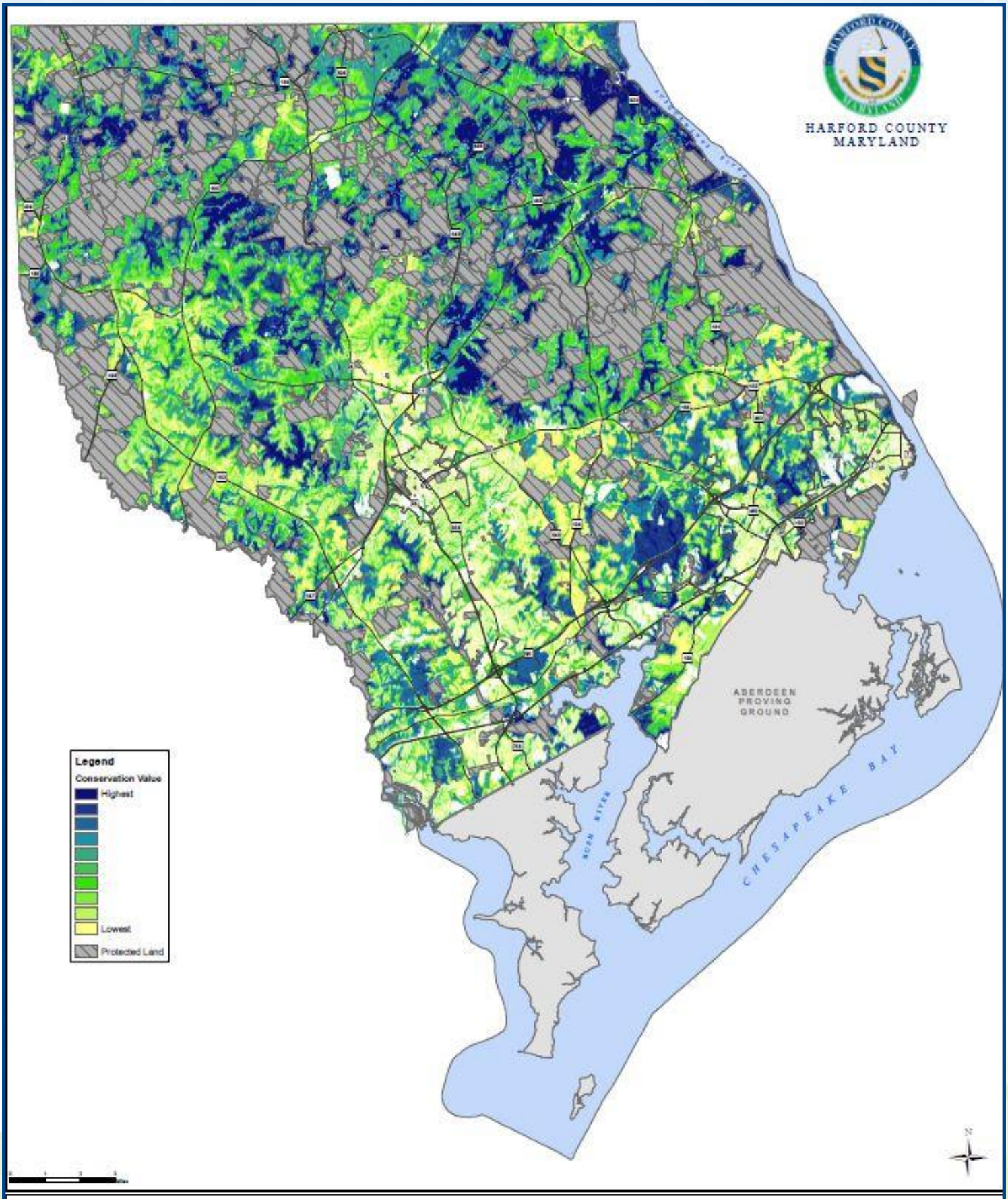
Preservation Easements

With over 50,000 acres preserved, Harford County has been a nationally recognized leader in farmland preservation since 1977. The Harford Agricultural Land Preservation Program (HALPP) and Maryland Agricultural Land Preservation Foundation (MALPF) easement programs are augmented by other programs and partners, such as Maryland's Rural Legacy Program, Maryland Environmental Trust, and the Harford Land Trust. These programs don't specifically preserve land for green infrastructure, but they serve the network better than unprotected land. For example, agricultural preservation easements promote agricultural best management practices (BMPs) like separating herds from streams, storing animal waste, and preventing soil erosion with cover crops.

Since the U.S. Environmental Protection Agency (EPA) limits the amount of nutrients and sediments entering the Chesapeake Bay, the Maryland Department of Agriculture develops watershed implementation plans (WIPs) for agriculture through local soil conservation districts. As the nutrient standards increase, stream and wetland restoration BMPs are a new focus which in turn help the GI network. As future easements are discussed, GI network-promoting BMP options can be incorporated. In addition to the proceeds of the purchase of development rights and tax abatement, grants support BMP investments on farms.

Figure 24. Stream restoration and riparian buffer fencing at Locust Hill Farm of Churchville, winner of the 2016 Harford Soil Conservation District Conservation Farm of the year award.

This plan provides an analysis to prioritize conservation actions using the green infrastructure network. Map 2 (on page 17) shows undeveloped lands that are not under easement or in park ownership ranked by natural resource value as well as land already protected by easement or park ownership in grey. Appendix E shows this in more detail, including how the factors were weighted. Future conservation acquisitions can use this map or the resulting data in prioritizing acquisition options.



Map 2. Current unprotected lands ranked by conservation value.

GREEN STORMWATER INFRASTRUCTURE

The earliest urban settlements were built with channels and pipes to convey rain water away from buildings and streets. Prior to development, stormwater flows were moderated because much of the rainfall was absorbed into the ground or passed into the atmosphere by vegetation. Conventional stormwater infrastructure conveys runoff through ditches, culverts, and detention basins. These measures, sometimes known as "grey infrastructure," protect buildings and streets, but the flows into receiving waters are stronger and degrading.

Harford County has required stormwater management for most new development since 1978. Structural devices or grey infrastructure are common techniques. There are over 1,000 stormwater structures within Harford County. The Bureau of Stormwater Management reviews proposed structures and conducts maintenance inspections of existing structures on a tri-annual basis. Newer installations reflect higher state and federal standards but the grey infrastructure system, as a whole, has capacity and performance issues during peak weather events. The summer rains of 2018 created peak flows from urban runoff, with hazardous floods, scoured stream banks, and sediments washed downstream into the Chesapeake Bay. Grey infrastructure even shows weaknesses during average conditions. For example, since roofing and paving hold heat until washed by rain, warm stormwater has changed aquatic habitat to the disadvantage of native species like brook trout.

Stormwater management in Harford County dramatically changed in 2010 when Bill 10-11 was adopted by the County Council to bring local stormwater regulations into compliance with new state requirements. The most marked change was managing stormwater through environmental site design (ESD). This method shifts the engineering objective from conveyance of stormwater away from sites to treating water where it falls and incorporating biology into engineering. Code requires that developments utilize ESD to the maximum extent practical to address water quality, groundwater recharge, and channel protection. Through ESD, stormwater management begins to mirror the hydrology of the predevelopment landscape. Consequently, ESD installations represent green stormwater infrastructure.

Green stormwater retrofit projects can help manage stormwater runoff in the urbanized portions of the county. This also includes retaining existing forests and wetlands, using environmental site design (ESD) where areas are developed or redeveloped, and preventing erosion and sediment runoff during construction. Trees and other vegetation intercept rainfall, reduce surface runoff and allow water to infiltrate into the soil. Areas already developed without adequate stormwater controls can even be retrofitted to mitigate stormwater impacts.

A very simple example of green stormwater infrastructure is a rain garden. A rain garden intercepts runoff from building gutters into a bowl-shaped garden. Water-tolerant plants are planted in the lower center. The edge of the rain garden is planted with species that tolerate fluctuating water levels. A buried sand filter and infiltration pipe along with an overflow pipe complete the design. Figure 25 shows an example of a rain garden. Other options incorporate the same blend of engineering and landscape architecture. Site plans that incorporate grass swales, porous pavement, and vegetated filter strips reduce flooding and water pollution while allowing for infiltration. Permeable concrete, permeable asphalt, and other engineered systems may be appropriate depending upon level of use. Green roofs, more common in areas with high rise development, can accent lower profile buildings and when paired with rain chains, rain tables, and rain gardens, offer striking visual appeal and stormwater management.

Figure 25. Rain garden to hold and treat stormwater.

Green stormwater infrastructure options are evolving. Street and parking lot trees can remove stormwater if curbs are cut to direct stormwater to trees, as evaluated in this report for the courthouse parking lot. Street or parking lot trees are often short lived. A stormwater tree planting, with adequate soil volume for mature growth and diverted stormwater, grows into highly efficient green infrastructure.

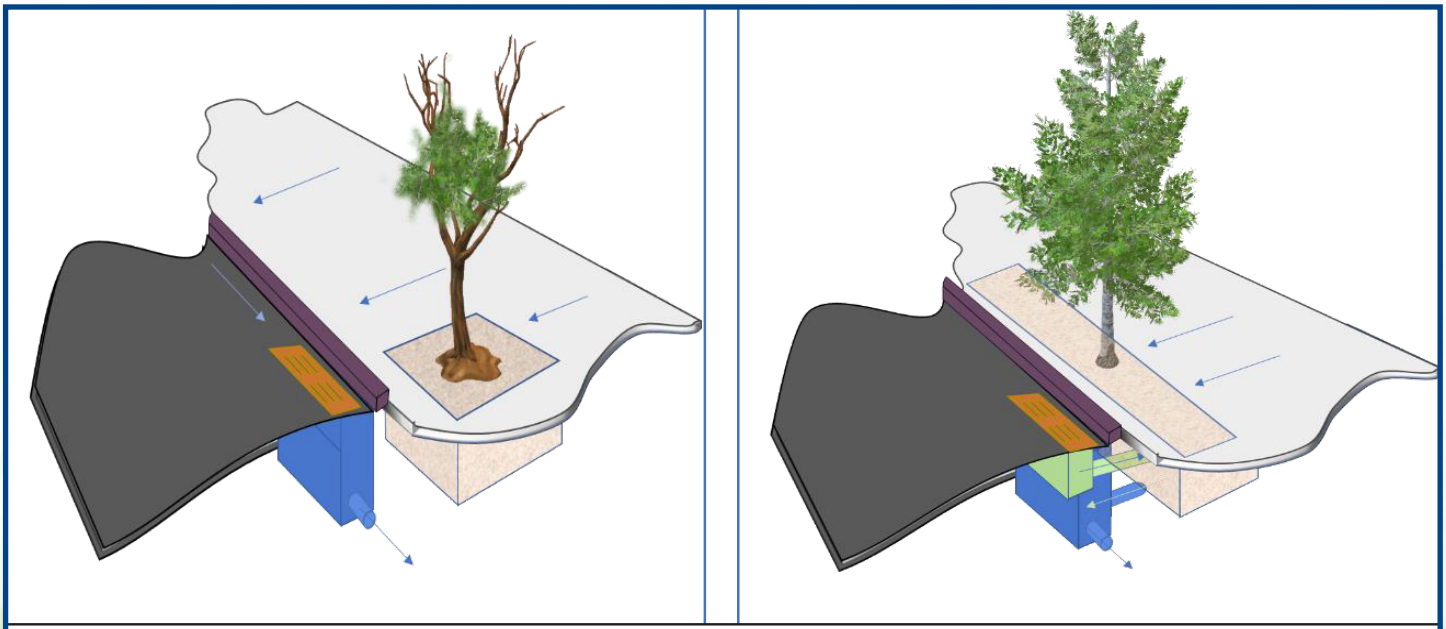


Figure 26. The conventional tree pit on the left intercepts little stormwater. With confined roots, trees are less viable, requiring more maintenance to trees and paving cracked by thirsty roots. The stormwater tree planting on the right provides a larger soil volume for heathy tree growth and wider openings to intercept more stormwater before it reaches the street. The street storm drain is tied to the tree planting trench so the tree can capture even more water as well as pollution and nutrients. The trench drains to a sump and back into the storm drain system.

Based on EPA reports[8] a 60-foot section of a neighborhood street lined with stormwater trees can divert the first inch of rainfall from the drainage system fulfilling requirements of the Harford County Zoning Ordinance.[9] This means stormwater trees can easily fulfill landscaping requirements and complete ESD requirements. Canopy trees outperform other vegetation in green stormwater installations[10] by drawing more water than smaller plants to carry nutrients up to the leaves and out to the atmosphere as water vapor. The leaves and branches of trees also create more surface area for water to collect and later evaporate in the sun than smaller plantings. Finally, trees, when offered room for adequate root growth, dramatically improve the infiltration capacity of the soil by channeling water down the trunk into the roots.

While new development can present opportunities for green infrastructure many opportunities remain for retrofitting existing conditions. Existing stormwater ponds can be renovated to include wetland trays or other retention measures. Infiltration basins or dry ponds can be replanted with native species and reduce mowing. Existing buildings can be renovated with rain barrels, cisterns, and rain gardens to augment other green stormwater measures. Public facilities occasionally require renovations or expansions, opening up new green infrastructure opportunities.

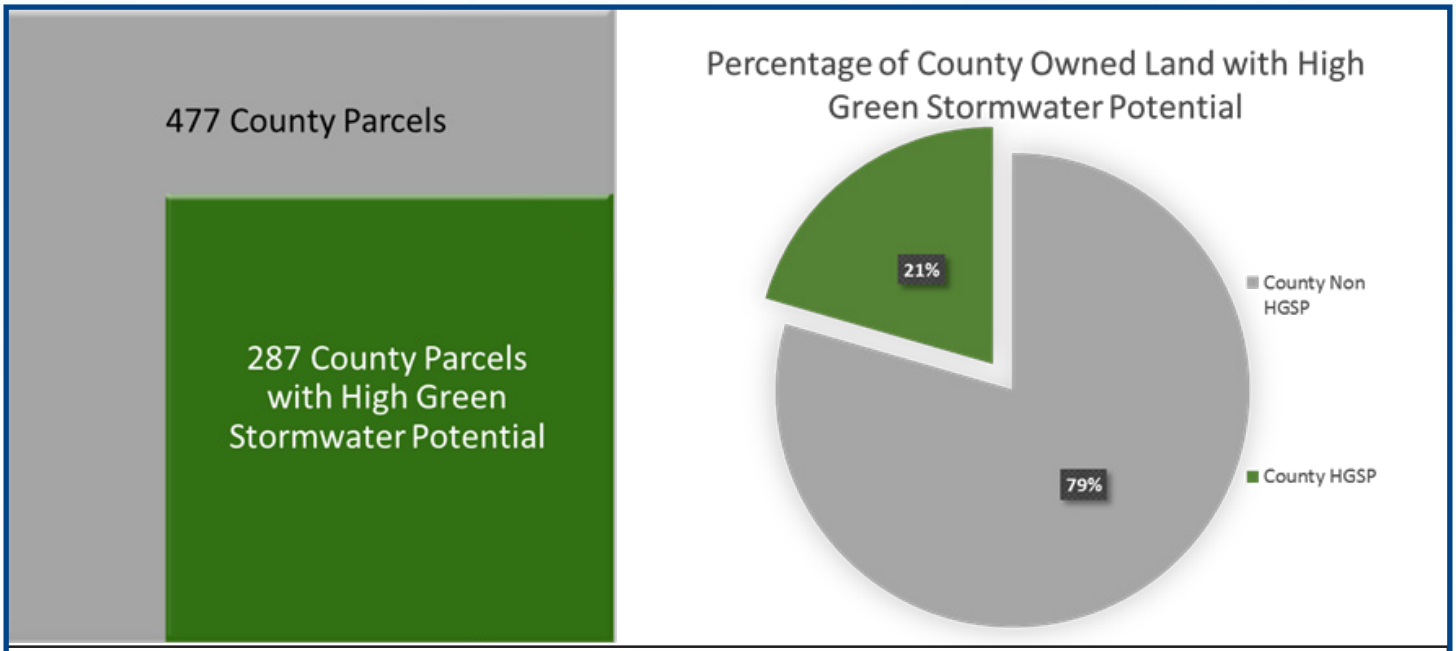


Figure 27. Analysis in this plan indicates more than half of county parcels have high green stormwater potential. This excludes parkland which offers some additional green stormwater potential but has the highest values as natural resource protection hosting the green infrastructure network.

[8]United States Environmental Protection Agency (2016) Stormwater Trees Technical Memorandum (EPA Contract No. EP-BPA-13-R5-0001 by Tetra Tech, Inc)

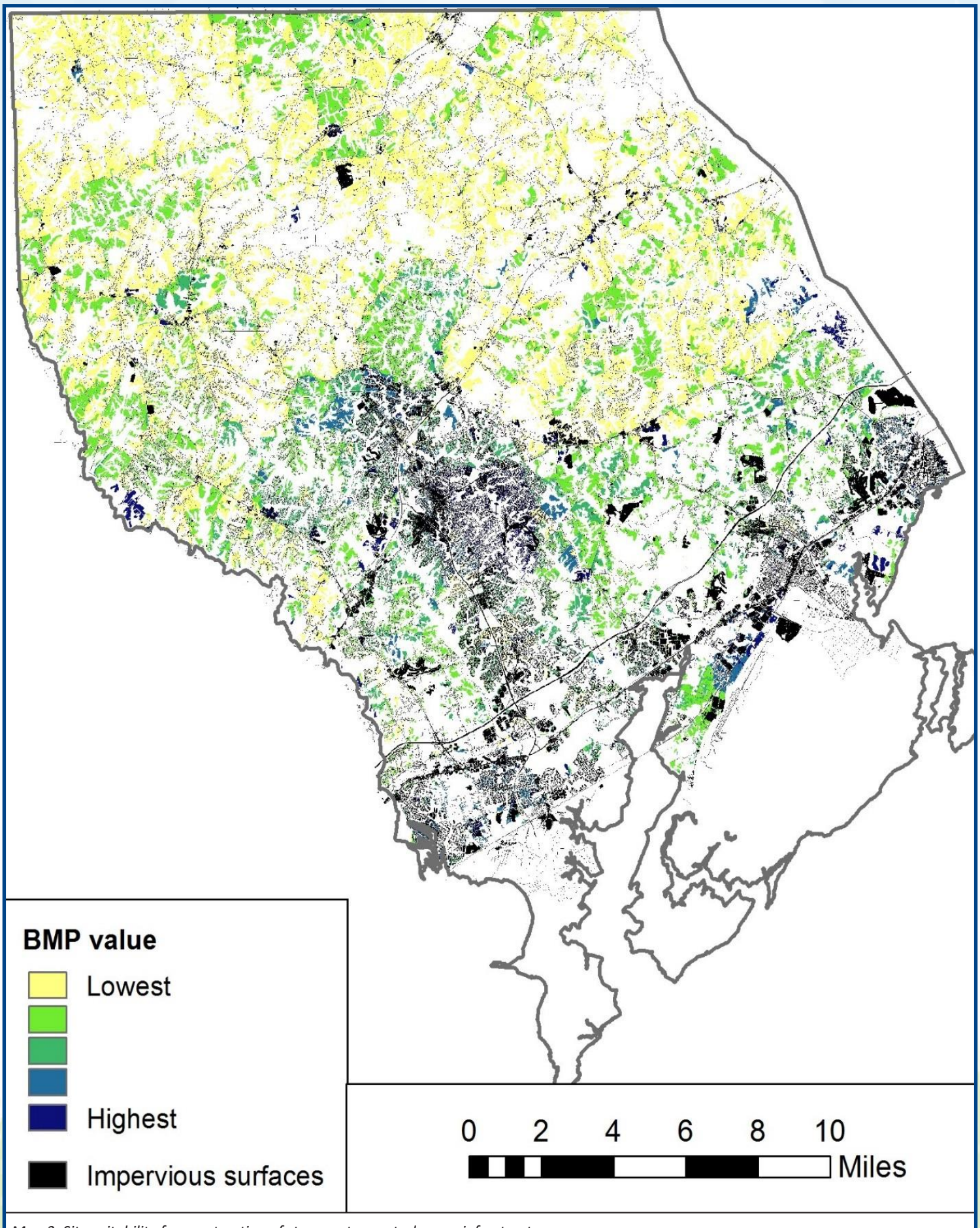
[9]Article V. Supplementary Regulations § 267-29. Landscaping, subsection G calls for one large street tree for every 40 linear feet of interior road or 1 medium street tree for every 30 linear feet of interior road. Subsection H requires one shade tree per 10 surface parking spaces in parking lots.

[10]Scharenbroch BC, Morgenroth J, Maule B. Tree Species Suitability to Bioswales and Impact on the Urban Water Budget. Journal of Environmental Quality. 2016;45(1):199-206. doi:10.2134/jeq2015.01.0060.

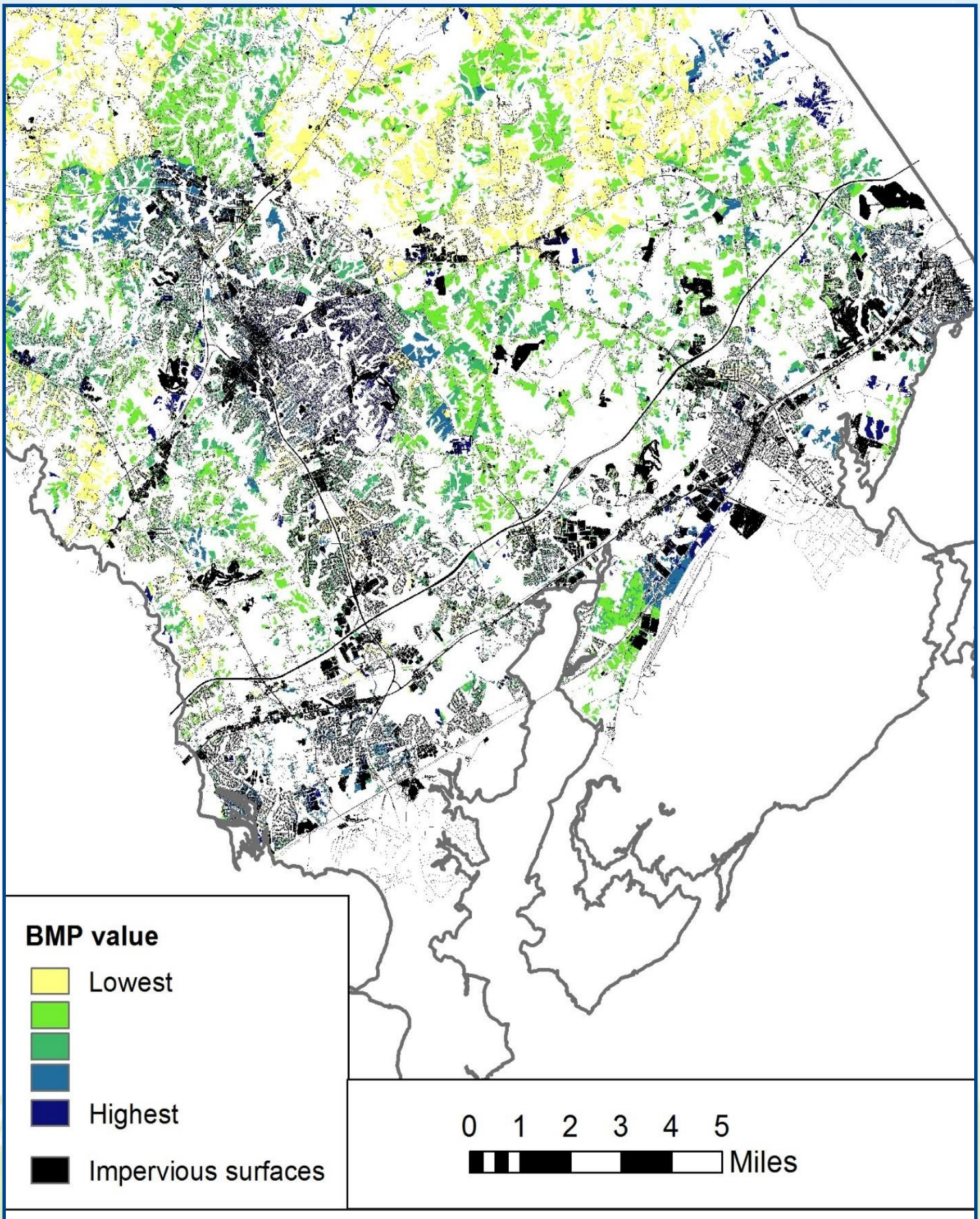
This plan identifies areas where green storm stormwater BMPs will provide the best benefit. Map 5 shows county-owned parcels which are highly suitable for installing green stormwater management practices. Table E-2 of Appendix E lists the factors used to rank areas for siting new stormwater treatment BMPs. Factors such as soil erodibility, the number of acres of impervious surface draining to the site, and development that precedes stormwater regulations are examples of considerations for scoring listed in Table E-2. These factors were applied to the green infrastructure network and mapped. Map 3 and Map 4 display a range of areas suitable for BMPs. The scoring is indicated with a color transition ranging from yellow to blue. Blue indicates the best locations for green stormwater infrastructure. Black indicates impervious surfaces that were not included in this analysis. The scan for potential BMPs was a broad initial step; locations must be examined in the field to confirm their suitability and to engineer appropriate designs.

Many county capital projects already incorporate some elements of green infrastructure. The Department of Public Works engages in work to comply with the Maryland Department of the Environmental (MDE) management of the National Pollutant Discharge Elimination System program (NPDES). Under Municipal Separate Storm Sewer Systems (MS4), storm drain discharge requires permits. MDE allows restoration credit for stream restoration projects, tree planting in open spaces or floodplains, and stormwater retrofits. The suitability analysis of this plan supports future restoration efforts in service of the MS4 program.

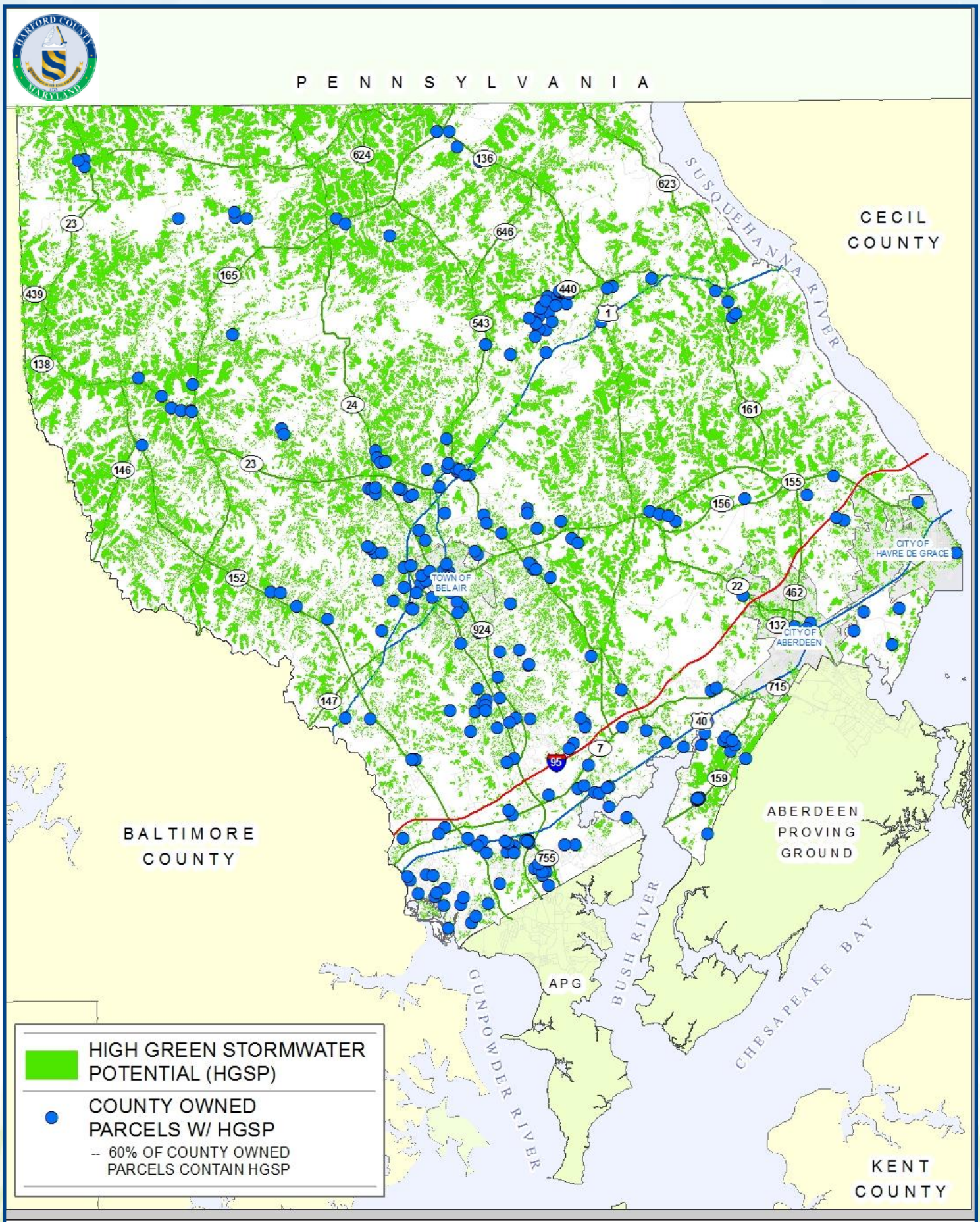
Map 5 shows 287 county-owned parcels (60% of all county-owned parcels) were highly suitable for installing green stormwater management practices. The scan for potential BMPs was a broad initial step; locations must be examined in the field to confirm their suitability and to engineer appropriate designs.



Map 3. Site suitability for construction of stormwater control green infrastructure.



Map 4. Site suitability for construction of stormwater control green infrastructure in the more urbanized portion of Harford County.



Map 5. Locations of county-owned parcels with high green infrastructure stormwater potential.

An evaluation of potential demonstration sites for green stormwater projects was conducted on several County park properties and the two parks within the Town of Bel Air. Site assessments were conducted for seven (7) public properties, including:

- Alice & William Longley Park
- County courthouse parking lot
- Mariner Point Park
- Oakington property
- Plumtree Park (Bel Air)
- Shamrock Park (Bel Air)
- Tudor Hall

Details of the individual site assessments and their feasibility for potential stormwater best management practices (BMPs), value for high visibility as demonstration sites as well as landscape management considerations can be found in Appendix I. The data in Map 5 was used make a final selection of two County-owned properties for the conceptual design of demonstration projects. The County courthouse parking area and Mariner Point Park were chosen as project sites to provide highly visible and demonstrative changes through green stormwater techniques.

Courthouse Parking Lot

Directing stormwater runoff across healthy soils and growing vegetation allows for a degree of beneficial water quality treatment as surface water comes off hot pavements and other impervious surfaces. Native plantings can shade the runoff, slow its flow, and capture some harmful sediment and nutrients. The amount of runoff filtration can vary greatly depending on factors such as speed, slope, depth of planting, and permeability of the soil. The added benefit of capturing runoff through vegetated swales is the provision of additional water to support landscape areas that provide shade and aesthetics to urban settings.

Figure 28. Courthouse demonstration project site.

The corner of the courthouse parking lot could provide a demonstration of green stormwater techniques. (See Figure 29.) Currently, the parking lot is paved asphalt where stormwater runoff flows directly to storm drains. A raised curb contains the parking pavement and is bordered by a planting strip with approximately a 4-foot width. The planting strip was planted with shade/ street trees and mown grass. Over the years, the trees have continually declined. Several dead trees have been removed; many remaining trees are showing stress or actively declining.

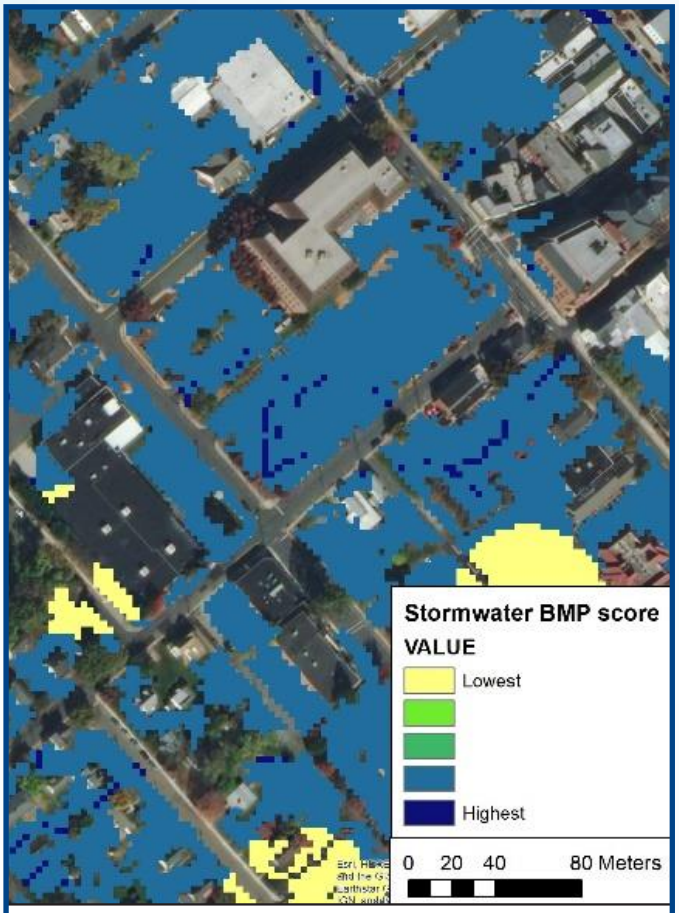


Figure 29. Existing site conditions at corner of courthouse parking lot (Hays & Thomas streets).

With runoff separated from the landscape, rainwater runs off hot asphalt without pretreatment and plantings are separated from the extended surface area with little opportunity to capture the quantity of water needed to sustain healthy growth and longevity. Water from this parking lot flows into Plumtree Run, a tributary to the Winter's Run watershed. This demonstration would build upon recent stream restoration efforts constructed by the town of Bel Air. Plumtree Run watershed is also a focus watershed for the Department of Public Works stream restoration projects both for MS4 credit and to protect Atkisson Reservoir, an open water habitat located immediately downstream of the Plumtree Run watershed.[11] These streams drain into Winters Run, an important MDE designated Tier II watershed. The suitability analysis of this plan supports future conservation efforts to gain credit in the MS4 program.

The parking lot site also provides an opportunity to create a rain garden or bioretention area for a more direct connection with parking lot runoff to benefit the shade trees needed to reduce the heat island effect and cool the parking lot. The corner of the parking area has a small planting area as well as a corner of pavement where no parking space can fit. The existing corner planting area would be converted to a bioretention facility with the removal of the corner asphalt area (approximately 200 square feet) and the removal of curbing. Sections of curbing could be removed to allow for connection of surface runoff to the narrow planting strips to act as vegetated swales, complete with shade trees and appropriate swale plantings. Sections of the planting strips could be contoured to drain towards the corner. The stormwater BMP would provide rainwater capture and pretreatment of runoff before entering the stormwater drain and conveyance system. The provision of additional rainwater to any plantings along the parking lot perimeter would help sustain growth and encourage tree longevity. Healthy street trees along the sidewalks of Hays and Thomas streets would also benefit the pedestrian environment. This BMP demonstration project with interpretive signage will convey that green infrastructure helps to manage runoff. A strategy from HarfordNEXT regarding education and increased awareness is fulfilled by this project. (See Figure 30 on next page.)

[11]Plumtree Run Watershed Small Watershed Action Plan, June 1, 2017, Bay Land Consultants & Designers, Inc. and Clear Creeks Consulting, LLC for Harford County Department of Public Works.

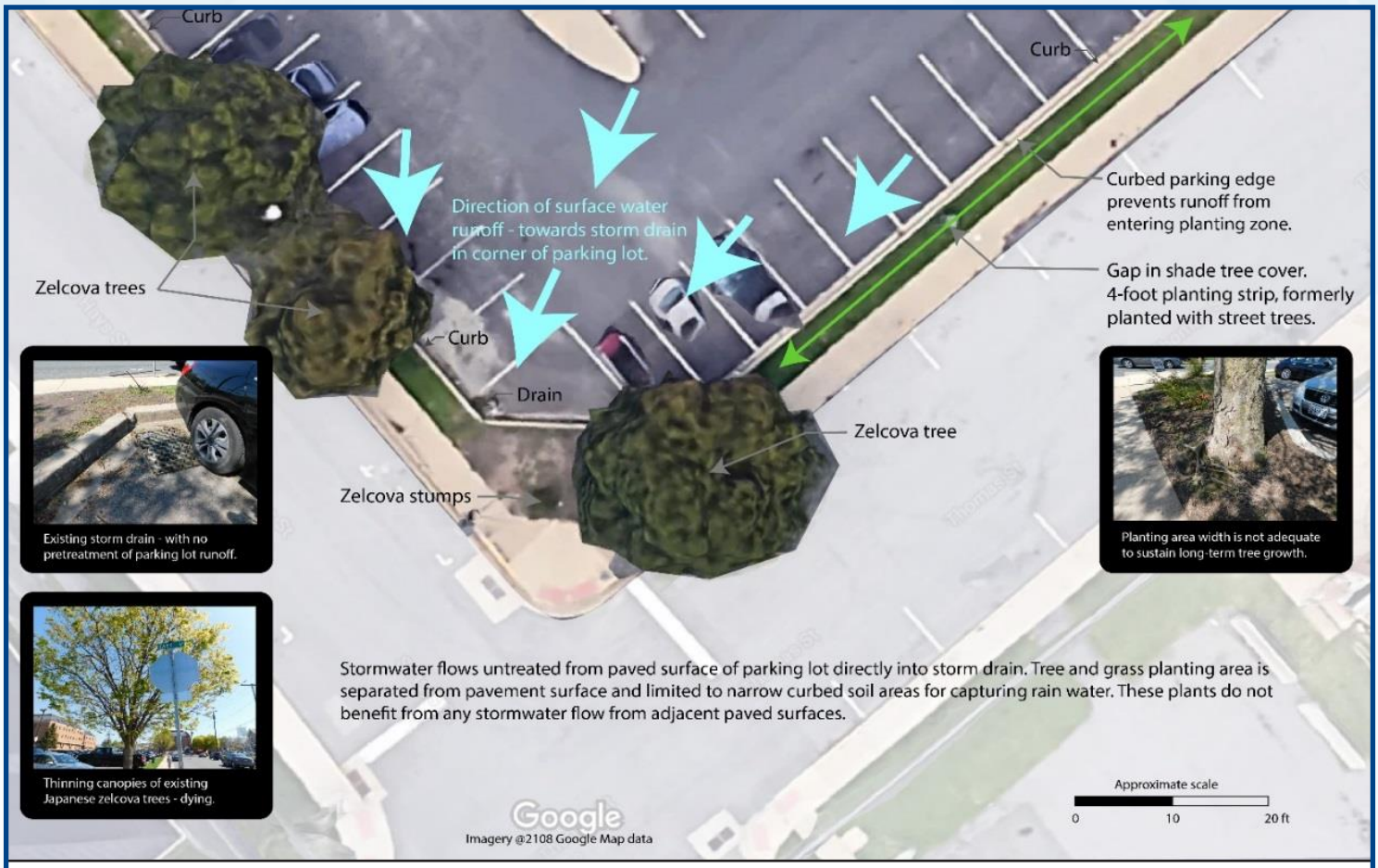


Figure 30. Existing site conditions at corner of courthouse parking lot (Hays & Thomas streets).

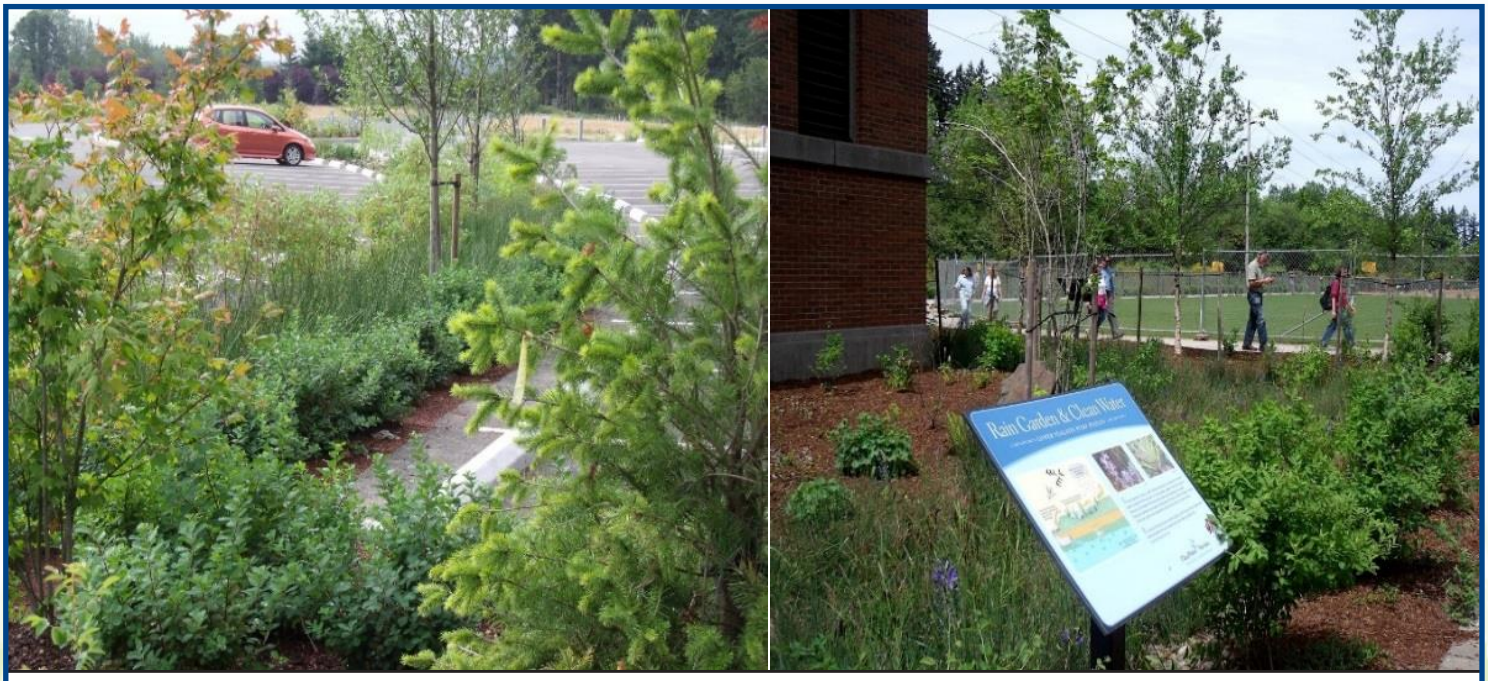


Figure 31. Example of green stormwater infrastructure adjacent to a parking lot and an interpretive sign conveying green stormwater practices.

Mariner Point County Park

Selected as a demonstration project site with high visibility and high BMP value, this non-forested steep slope planting will provide a straightforward demonstration of better sustainable practices in the landscape that benefit water quality and lower maintenance costs. Existing conditions on the steep slope to the east of the main launch parking area consist of mown grass with a few scattered trees. The grass cover is eroded on sections where the mowers regularly slip on the steep slope. The slope's pitch appears to be too steep for a sustainable vegetative cover that withstands regular mowing. Under wet conditions, the mown grass would create a slippery slope, unstable for large mowers. Bare strips generally follow the slope contours indicating that the erosion is primarily due to mower tires skidding on the slope. The erosion continues with each rain occurrence, deepening the tire ruts and preventing potential regrowth of vegetative cover. (See Figure 32.)

Figure 32. Mariner Point Park BMP example of expanding tree canopy and no-mow area.

Proposed steep slope plantings would begin with the practice of designating a "no-mow" or "low mow" zone to allow existing grasses to grow taller with a corresponding deeper root system to help stabilize the slope and reduce the need for heavy mowing equipment. Native canopy trees planted on the slopes can establish a future forest condition. A border of native shrubs at the top of the slope can be planted to help delineate the limited mowing area. Along the front (lower) edge of the naturalized planting area, a strip of grass should continue to be regularly mowed to maintain the post and chain fence and the overall look of intended care and maintenance. This more formal front allows for foot traffic, provides space for an interpretive sign promoting no-mow practices and helps explain the green stormwater practice to park users.

Tree plantings in the lower parking lot are selected as an additional demonstration project in Mariner Point County Park for high visibility and a high BMP value. The addition of canopy trees along the perimeter of the lower parking lot will follow the recommended HarfordNEXT green infrastructure practices of connecting the forest canopy, reducing the heat island effect created from asphalt pavement, and incorporating native tree species in landscape plantings. The parking lot was identified as an area with limited tree canopy. The site sits on the peninsula of the point with close proximity to coastal resources. (See Figure 33.) Expanding tree cover and lowering stormwater runoff temperatures using additional shade trees provides value to nearby aquatic habitats. Reducing sun exposure to vehicles in the parking lot creates more enjoyable conditions for park visitors as well.

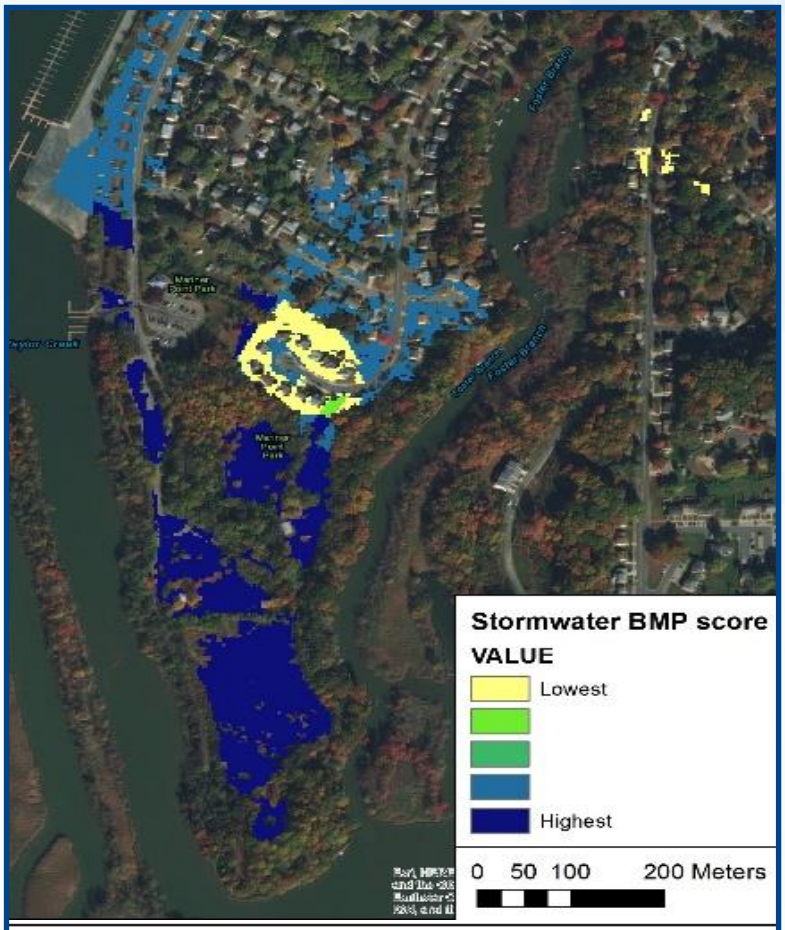


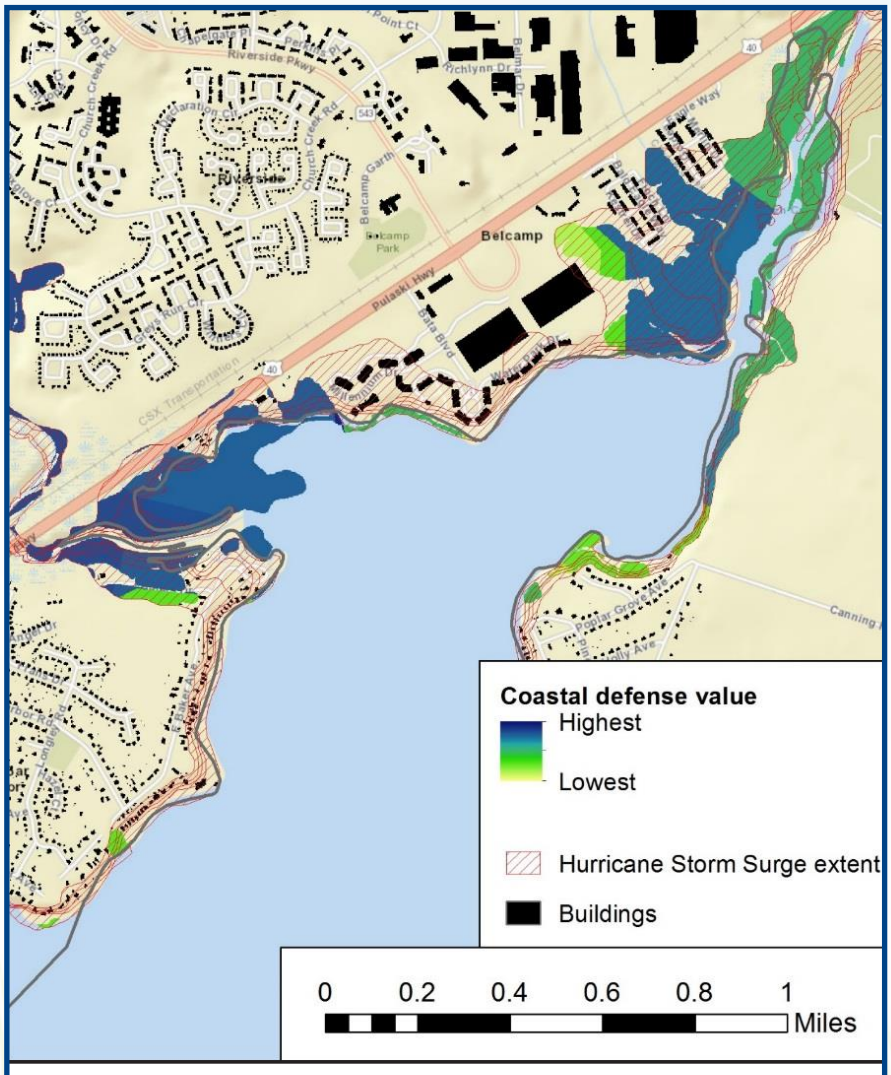
Figure 33. BMP score overlay for Mariner Point Park.

Figure 34. Lower parking lot shade tree plantings at Mariner Point Park.

Approximately 15 - 20 native canopy tree species could be added to the perimeter of the lower parking lot at Mariner Point Park. (See Figure 34.) The trees would help reduce the pavement surface temperatures (and therefore stormwater runoff temperatures) and provide relief for park users with shade for parked cars. The native canopy trees can also help connect the gap in the forest created by the parking area and roadway.

Coastal Defense

Natural habitats, such as coastal forests, marshes, and submerged aquatic vegetation (SAV), can buffer coastal areas and form a defense from the impacts of flooding, storm surge, and sea level rise. Coastal vegetation attenuates the energy of waves, increases the infiltration of precipitation, and stabilizes sediment to improve water quality and reduce silting of waterways. The Maryland DNR, in partnership with The Nature Conservancy, completed a statewide coastal resiliency assessment in 2016, summarized in Map 6. By examining potential hazards, their risk to people, and the role of natural habitats in reducing that risk, priority areas for restoration and conservation actions were identified based on the presence of existing habitat, its current role in risk reduction along the shoreline, and the presence of nearby coastal neighborhoods.[12] Tier I shorelines are those with a high habitat role or would create a high hazard if the habitats were removed. Tier II shorelines have a moderate habitat role that would create a moderate hazard if the habitats were removed. Five percent of Harford County shoreline fell in Tier I and is found along the Gunpowder River and shores of Aberdeen Proving Ground. Sixteen percent of Harford County shoreline was assessed Tier II and was found along the Gunpowder River, as well as the Bush River tributaries, Swan Creek and the Susquehanna River.



Map 6. Natural features ranked for their coastal defense importance in the Belcamp area on the Bush River. The rest of the County's coastline was also evaluated.

This plan applies the coastal resiliency assessment to the green infrastructure network. In prioritizing conservation for coastal defense, all currently unprotected forests, wetlands, and submerged aquatic vegetation beds (SAV beds) within the storm surge zone were credited for their ability to reduce flood risk to people. Their provision of coastal habitat was also identified. Appendix E shows the ranking criteria in more detail, including how the factors were weighted. As an illustration, Map 6 shows how areas scored in the Belcamp area on the Bush River.

[12]Canick, M. R., N. Carlozo and D. Foster. 2016. Maryland Coastal Resiliency Assessment. The Nature Conservancy, Bethesda, MD. http://dnr.maryland.gov/ccs/Documents/MARCH-2016_MDCoastalResiliencyAssessment.pdf

Nuisance Flooding

During the 2018 Legislative session, a bill titled "Sea Level Rise Inundation and Coastal Flooding-Construction, Adaptation and Mitigation" (HB 1350/SB 1006) was passed and became effective on July 1, 2018. Part of the legislation is titled Nuisance Flooding and requires that by July 1, 2019 "a local jurisdiction that experiences nuisance flooding shall develop a plan to address nuisance flooding." Nuisance flooding is "high tide flooding that causes public inconvenience." In coordination with the county's Department of Public Works Resource Management Office, it has been determined that there are no such areas in Harford County (not including APG or municipalities). Many of the roads in Harford County that are near the shoreline are under federal control (APG). Harford County will continue to monitor county roads to address impacts associated with sea level rise and coastal flooding.

Critical Infrastructure Protection

Green infrastructure can buffer critical infrastructure from extreme weather impacts like flooding and high winds. Critical infrastructure includes power production and transmission facilities, hospitals, police stations, fire stations, emergency management centers, water supplies, wastewater treatment facilities, evacuation routes, and more.

Critical infrastructure locations were compared in Harford County to floodplains and hurricane storm surge extents. The evaluation was confined to critical infrastructure with potential vulnerability to flooding or storm surge. It was determined that almost no critical infrastructure is in flood-prone areas. Harford County is fortunate that most of the shoreline and coastal areas are within APG, which was not part of the study area for this plan.

The few critical infrastructure facilities that lie in flood-prone areas consist of a water plant and some electrical substations. (See Table 1.) The "threat" column lists whether they fell within a 100 or 500 year floodplain, or in a storm surge zone (Category 3 hurricanes in some cases, Category 4 in others). With the potential for sea level to rise and storm strength to increase, these threats likely have a higher probability of occurring than in the past when floodplains and hurricane surges were originally mapped.

The "current protection" column lists whether the facility is buffered by existing forest (in all cases but one, yes), and potential actions to increase protection (planting more trees, constructing wetlands, raising walls or equipment above maximum flood heights if this hasn't already been done, etc.). For all sites, it may be possible to elevate existing & future equipment to minimize risk. Site analyses should be carried out before considering these recommendations.

Table 1. Potentially vulnerable critical infrastructure in Harford County.

Facility	Threat	Current protection	Possible measures to increase protection
Van Bibber Water Plant in Edgewood	In 500-year floodplain and Category 4 storm surge zone	Existing forest provides some protection	Raise walls /tank above flood height.
BGE Electrical substation in Joppatowne	In Category 3 storm surge zone	Little natural protection or space to restore	Little space to restore; move substation or raise equipment.
BGE Electrical substation in Edgewood	In 500-year floodplain	Existing forest provides some protection	Plant more trees in the floodplain, maybe construct wetlands.
Wastewater treatment plant	In 100-year floodplain and Category 3 storm surge zone	Existing forest provides some protection. Some components walled or elevated.	Consider raising walls or elevating additional components.

CAPITAL PLANNING WITH GREEN INFRASTRUCTURE

Grants that promote trail connections for citizens to access parks and open space areas can result in projects that double as green infrastructure. As retrofits of parks are budgeted, green infrastructure improvements can be worked into the plans. Future parkland and open space acquisitions may be based on the GI network. This serves to implement GI practices related to the county's Land Preservation Parks and Recreation Plan (LPPRP) goals as well as HarfordNEXT goals for conservation lands and justify alternative sources of funding and extend precious local capital dollars.

Public building and renovation projects can benefit by leveraging the GI Plan. For example, public school construction is tied to meeting green construction standards as they are a prerequisite for state financial participation. Leadership in Energy and Environmental Design Certification (LEED) uses a scoring system to award sustainable construction. The score can factor in the site plan. Joppatowne Elementary was the first LEED certified school project in Harford County, gaining six of fourteen sustainable site points. Public projects seeking LEED or other rating systems can emphasize points for protecting or restoring habitat, green stormwater management, and limiting impervious surface. The green infrastructure network can aid the facility planning process, support grants, and aid justification for green awards.

The green stormwater projects discussed previously can play an important role in future road capital projects. For example, the concept of tree trenches can allow the Department of Public Works to increase bioretention into narrow linear opportunities.

MANAGING PERFORMANCE WITH GREEN INFRASTRUCTURE

Performance-based management helps document progress toward reaching a more extensive and complete green infrastructure network. Collecting performance data increases government transparency, aids permit review, and bolsters grant applications. Performance measures can follow the HarfordNEXT practice of online tracking of accomplishments. A "GI Implementation Tracker" may include measuring the conversion of lawn to forest or mowed areas converted to low or no-mow. Progress in acquiring high green infrastructure priority land by either public or private entities may be measured. Land management changes including green stormwater management and reductions of impervious coverage can be tracked.

OUTREACH, EDUCATION, AND PARTNERSHIPS

The outreach to develop this plan, such as the website and the interactive web-based viewer of the green infrastructure network, can continue to engage community members. The county Green Infrastructure Story Map, another web tool, explains the GIP-related project/future program(s) in a manner that is accessible to the community. Story mapping updates can connect with other county public relations efforts to celebrate or market county projects and programs that demonstrate green infrastructure practices. These resources can inspire voluntary actions to preserve/restore the GI network core areas. For example, organizations like the Nature Conservancy can collaborate with watershed stewards, the Land Trust, and the Environmental Advisory Board using green infrastructure network data. The resources may inspire individual actions to preserve privately owned segments of forest, streams, wetlands, and meadows. An official coalition with partner agencies, organizations could be organized to meet periodically, coordinate, and further conservation, acquisition and management activities that advance and expand the green infrastructure network in the county.

UPDATE REGULATIONS WITH GREEN INFRASTRUCTURE FINDINGS

Much of the existing green infrastructure network remains because of existing programs and regulations. The findings of this plan can support adjustments to existing regulations or a few areas where new regulations would be effective. The Natural Resource District (NRD) is an overlay zone of the county zoning ordinance that is based upon a setback from freshwater resources. Some development activities are permitted in the zone. While some may be reasonable, the data in this plan suggests more restrictive considerations for NRD buffers that are also elements of the green infrastructure network. A similar approach could be applied to the Forest and Tree Conservation Ordinance. Buffer yards or landscaping requirements could be adjusted for properties that contain green infrastructure network resources. Lawn to forest conversion, lawn to meadow, or rain gardens could be considered in an evaluation of existing property code requirements.

A tree canopy ordinance would support the goals of the Green Infrastructure Plan. Chapter four of HarfordNEXT, titled Environmental Stewardship, states a goal to establish a tree canopy program to maintain tree canopies' both rural and urban environments. Recognizing that increasing tree canopy in more densely developed areas helps to attenuate stormwater flows and mitigate pollution from stormwater runoff, adding trees on county-owned properties is a direct demonstration of the county's commitment to the stated goal of increasing canopy by 2%. Both demonstration projects propose the addition of canopy shade trees to reduce surface heat, enhance water permeability, and reduce runoff. Locating additional tree canopies near waterways and coastlines is especially important to help protect water quality and aquatic resources. Part of the HarfordNEXT goal (ES 3.2) about increasing tree canopies encourages implementation through partnerships with State Highway Administration (SHA), DPW, Parks, and Recreation to incorporate tree canopies into the design of projects.

ENGAGE LANDOWNERS TO INCORPORATE PRACTICES

Only approximately 7% of the green infrastructure network is located in county parks. It will take the efforts of private landowners, conservation, and nonprofit organizations to make substantial strides in protecting or enhancing the GI network. Residential property owners can do their part by incorporating green infrastructure practices on their lands. They can do things such as reduce impervious surface on their property, install rain gardens, remove invasive species and plant native trees and shrubs. Large property owners can consider placing conservation easements on their property in exchange for tax benefits and other incentives. Nonprofit and conservation organizations can play a key role in enhancing green infrastructure by matching property owners with the appropriate grant, cost-share, or financial/estate planning resources to property owners. The Harford Land Trust and the Maryland Environmental Trust are two active land trust organizations in the county. The State Rural Legacy program is a great option for property owners with ecologically significant resources. The voluntary donation of land by easement or estate planning can provide financial benefits to owners and have long lasting benefits to our green infrastructure.

Agricultural lands are one of the most important pieces of maintaining a healthy green infrastructure network in Harford County. The county and state agricultural preservation programs are key to protecting the GI network. There are many other voluntary programs and cost-share opportunities available to agricultural landowners. Various programs through the National Fish and Wildlife Service and the Harford Soil Conservation District offer cost-share opportunities for measures that can benefit the GI network.

SUMMARY OF GREEN INFRASTRUCTURE STRATEGIES

The following GI strategies are derived from the goals and strategies outlined in the county master plan, HarfordNEXT. Citations are referenced at the end of each strategy to reflect the derivation from HarfordNEXT.

STEWARDSHIP ON COUNTY-OWNED LANDS

- The County will explore establishing no-mow areas on county roads and properties that have high-value GI core areas. [ES 1.4 (f): Protect and restore forest resources.]
- Use GI practices on county lands where feasible (park retrofits, capital projects, etc). [ES 3.1 (c): Reduce the footprint of development through innovative design concepts.]
- Prioritize the county's Land Preservation Parks and Recreation Plan (LPPRP) future parkland/open space acquisition(s) based on the GI network. [ES 1.3 (a): Protect rare, threatened, and endangered species (RTE) and ecologically significant areas from encroachment.]
- Implement GI practices related to the county's LPPRP goals for conservation lands. [ES 5.7 (c): Encourage sustainable maintenance practices for county-owned land.]
- Develop invasive species plant management plans for county parks. [ES 5.7 (c): Encourage sustainable maintenance practices for county-owned land.]
- Explore grants that promote trail connections for citizens to access parks and open space areas. [Goal MC 2.3 (b) Develop access to county and state parks and expand waterfront access.]
- Evaluate mitigation strategies of the county's critical infrastructure that have been identified as potentially vulnerable to storm surge (Table 1), and mitigate these risks where warranted. [Goal ES 5.5 (b): Incorporate coastal resiliency strategies into the development of the Green Infrastructure Plan and future updates of the Harford County Hazard Mitigation Plan.]
- Conduct additional habitat studies on public land to determine where conservation efforts and other best management practices should be considered. [Goal ES 5.7 (c): Encourage sustainable maintenance practices for county-owned land.]
- Establish performance measures to indicate proposed target areas and percentage of accomplishment toward reaching a more extensive and complete green infrastructure network. In other words, a "GI Implementation Tracker": [Goal GWP 5.1 (a) Develop and maintain a HarfordNEXT monitoring program.]
    a. Measure conversion of lawn to forest
    b. Measure mown areas converted to low or no-mow zones
    c. Quantify land acquisitions of high GI priority (could be both public & private lands)
    d. Cite land management changes to GI stormwater
    e. Measure reduction of impervious coverage (maybe this has to be weighed against new development)
- Facilitate green stormwater practices and enhance the GI network on Harford County school campuses. [Goal ES 3.3 (d) Increase outreach and education activities related to stormwater management.]

OUTREACH AND EDUCATION

- Develop the interactive web-based viewer to show and display the various GI datasets. [Goal ES 4.1 (d): Increase citizen stewardship of land and resources.]
- Continue to update the county Green Infrastructure Story Map, which explains the GIP-related project/future program(s) that are accessible to the community. [Goal ES 4.1 (d): Increase citizen stewardship of land and resources.]
- Initiate an official green infrastructure education & awareness program that collaborates with watershed stewards, land trust, EAB, etc. (County could encourage this program but leave it to other organizations or conservancy to implement.) [Goal ES 4.1 (d): Increase citizen stewardship of land and resources.]
- Celebrate all county projects and programs that demonstrate green infrastructure practices. [Goal ES 4.1 (e): Increase citizen stewardship of land and resources.]
- Establish an active/official coalition with partner agencies, organizations, etc. to coordinate and further conservation, acquisition and management activities that advance and expand the green infrastructure network in the county. (Perhaps this group meets 1-2 times per year.) [Goal ES 4.1 (e): Increase citizen stewardship of land and resources.]
- Promote voluntary actions to preserve/restore the GI network core areas. [Goal ES 4.1 (e): Increase citizen stewardship of land and resources.]
- Encourage conservation of privately owned segments of forest, streams, wetlands, and meadows. [Goal ES 1.4 (b): Protect and restore forest resources.]

PARTNERSHIP OPPORTUNITIES

- The County will explore a "lawn to woodland" program that will enhance the GI network. [Goal ES 1.4 (c): Protect and restore forest resources.]
- Work with Harford Land Trust and Maryland Environmental Trust to identify and prioritize key properties with high-value habitat and acquire conservation easements. [Goal ES 1.3 (a): Protect rare, threatened, and endangered species (RTE) and ecologically significant areas from encroachment.]
- Conserve critical habitats, connect protected lands, and provide access for recreation through grants such as the National Fish and Wildlife Foundation Acres for America program. Goal ES 1.3 (b): Protect rare, threatened, and endangered species (RTE) and ecologically significant areas from encroachment.]
- Assist DNR Fisheries in identifying key properties for voluntary actions to improve habitat and improve the trout fishery. Collaborate with organizations such as Trout Unlimited, and the National Fish and Wildlife Foundation. [Goal ES 1.3 (e): Protect rare, threatened, and endangered species (RTE) and ecologically significant areas from encroachment.]
- Explore providing additional points for properties applying for the county ag preservation program that have high-value GI network lands. [Goal ES 5.1 (b): Preserve our agricultural heritage and resources for future generations.]
- Explore obtaining additional Community Rating System credit to assist citizens in getting discounted flood insurance with measures that protect floodplain areas within the GI network. [Goal ES 1.2 (c) Preserve 100-year floodplain.]
- Establish a partnership with the Watershed Stewards Academy to help implement GI projects. [Goal ES 3.3 (b) Increase outreach and education activities related to stormwater management.]

POSSIBLE REGULATORY APPLICATIONS

- Develop a tree canopy ordinance that supports the goals of the Green Infrastructure Plan. [Goal ES 1.4 (h): Protect and restore forest resources.]
- Consider limiting forest clearing and requiring mitigation within the NRD buffers in the GI network. [Goal ES 1.1 (c): Protect streams, wetlands, and their buffers.]
- Consider higher conservation standards for clearing of forests within the GI network within the Forest and Tree Conservation Ordinance. [Goal ES 1.4 (h): Protect and restore forest resources.]
- Consider developing an overlay district for the GI network to include forest interior dwelling species protection and impervious surface limitations. [Goal ES 3.1 (b) Reduce the footprint of development through innovative design concepts.]
- Consider enhancing the buffer yard/landscaping requirements for properties that have GI network resources. [Goal ES 3.1 (c) (d) Reduce the footprint of development through innovative design concepts.]

PRIVATE INDIVIDUALS/LANDOWNERS & NON-PROFIT ORGANIZATIONS

- Incorporate green stormwater practices on your land. [Goal ES 3.3 (b) Increase outreach and education activities related to stormwater management.]
- Conserve/preserve/restore core GI areas on your land.
- Reduce impervious surfaces, where feasible. [Goal ES 3.3 (c) Increase outreach and education activities related to stormwater management.]
- Reduce mown grass areas by converting to low-mow or by actively reforesting areas. [Goal ES 3.2 (a) Establish a tree canopy program that encourages citizens to maintain and increase forest canopy in rural and urban environments.]
- Consider selling development rights as a permanent conservation action if your property contains critical habitat or GI valued-land. [Goal ES 1.4 (b) Protect and restore forest resources.]
- If your land has GI or conservation value, consider donating your property (as a life estate) to a land trust, conservancy or county parks to contribute to the future GI network. [Goal ES 1.4 (b) Protect and restore forest resources.]

AGRICULTURAL LANDS

- Encourage partnerships with NRCS programs for promoting conservation practices. [Goal POH 4.5 (a) Continue support for organizations and programs that benefit the larger agricultural and natural resource community.]
- Connect The Nature Conservancy Growing Green &/or Chesapeake Bay programs to Harford County agribusiness partners. [Goal POH 4.5 (a) Continue support for organizations and programs that benefit the larger agricultural and natural resource community.]
- Support the Harford County Soil Conservation District in helping the agricultural community implement best management practices and improve GI network resources. [Goal POH 4.5 (a) Continue support for organizations and programs that benefit the larger agricultural and natural resource community.]

APPENDICES
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APPENDIX A: Data dictionary

Category	Data set	Data set name	Type of data	Year of ground condition	Spatial accuracy
Biodiversity	BioNet - Biodiversity Conservation Network	BioNet	polygon shapefile	2011	1:24,000
Biodiversity	Ecologically Significant Areas	MDDNR_ESA_HarfordCounty_2018	polygon shapefile	2018	
Biodiversity	Red salamander locations	RedSalamander_HarfordCounty_MBSSrecords.xlsx	Excel spreadsheet	2014	
Biodiversity	Vernal pool locations	VernalPools_HarfordCounty_MBSSrecords.xlsx	Excel spreadsheet	2016	
Biodiversity	Wetlands of special state concern (linear)	SWwsscL	line shapefile	1998	1:24,000
Biodiversity	Wetlands of special state concern (polygon)	SWwsscP	polygon shapefile	1998	1:24,000
Census	Census block groups	harfblkgrp2010_83f	polygon shapefile	2010	
Census	Census blocks	2010_Block	polygon shapefile	2010	
Census	Est. 2015 pop. by age group	ACS_15_5YR_B01001_POP_AGE_BG_ALL_AGE.xlsx	Excel spreadsheet	2015 (est.)	
Census	Language spoken	ACS_15_5YR_B16002_Language_Spoken.xlsx	Excel spreadsheet	2015 (est.)	
Census	Poverty status	ACS_15_5YR_B17021_POVERTY_STATUS.xlsx	Excel spreadsheet	2015 (est.)	
Critical infrastructure	Fire stations	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Hospitals	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Police stations	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Schools	MEMA_USNG_Critical_Infrastructure.mdb	Access database		
Critical infrastructure	Utility Structures	Utilities Structures.shp	polygon shapefile	2008	
Critical infrastructure	Wastewater treatment plants	WWTP	point shapefile		
Ecosystem services	Air Pollution Removal	aq_kg_yr	raster (GRID)		30 m
Ecosystem services	Air Pollution Removal Economic Value	aq_d_yr	raster (GRID)		30 m
Ecosystem services	Carbon Sequestration	carb_seq_g_yr	raster (GRID)		30 m
Ecosystem services	Carbon Sequestration Economic Value	carb_seq_d_yr	raster (GRID)		30 m
Ecosystem services	Groundwater Recharge	gw_cm3_m2_yr	raster (GRID)		30 m
Ecosystem services	Groundwater Recharge Economic Value	gw_d_yr	raster (GRID)		30 m
Ecosystem services	Nitrogen Uptake	nutr_kg_m2_yr	raster (GRID)		30 m
Ecosystem services	Nitrogen Uptake Economic Value	nutr_d_yr	raster (GRID)		30 m
Ecosystem services	Stormwater Mitigation Economic Value	sw_d_yr	raster (GRID)		30 m
Ecosystem services	Stormwater Mitigation Potential Index	sw_index	raster (GRID)		30 m
Ecosystem services	Surface Water Protection Economic Value	wtr_prot_d_yr	raster (GRID)		30 m
Ecosystem services	Total Ecosystem Service Economic Value	sum_es_d_yr	raster (GRID)		30 m
Ecosystem services	Wildlife Habitat and Biodiversity Economic Value	wild_d_yr	raster (GRID)		30 m
Ecosystem services	Wildlife Habitat and Biodiversity Potential Index	wild_index	raster (GRID)		30 m
Fish blockages	Fish blockages	MD_fish_blockages	point shapefile		
Floodplains	Floodplains (0.2%)	500_YR_FLOODPLAIN	polygon shapefile		
Floodplains	Floodplains (1%)	Floodplain	polygon shapefile		
Hydrology	Hydrology polygons	Hydrology_Polygons	polygon shapefile		
Hydrology	Northeastern Aquatic Habitat Classification System	MD_flowlines_NAHCS.shp	line shapefile	2006	1:100,000
Hydrology	Streams, rivers, and ditches	Hydrology_Lines	line shapefile		

Category	Data set	Data set name	Type of data	Year of ground condition	Spatial accuracy
Land cover	Buildings	Buildings_2013	polygon shapefile	2013	
Land cover	Impervious surfaces	impervious2014	polygon shapefile	2014	
Land cover	Land cover	HARF_24025_USGS.tif	raster (TIFF)	2013-2014	1 m
Land cover	Parking lots	Parking_2013	polygon shapefile	2013	
Land cover	Vegetation	Vegetation_2013	polygon shapefile	2013	
Parcels	Parcels	24025_parcel	polygon shapefile	2014	
Protected land	Ag Districts and Easements	agpres2	polygon shapefile	2013?	
Protected land	Ag Districts and Easements	AgPreservation	polygon shapefile	2017?	
Protected land	Federal lands (includes military)	SWplfe	polygon shapefile	2014	
Protected land	Forest Conservation Easements	SWFCA	polygon shapefile	2013	
Protected land	Forest Legacy Easements	ForestLegacyEasement	polygon shapefile	2017?	
Protected land	Historic Easements	HistoricEasements	polygon shapefile	2009?	
Protected land	Lower Deer Creek Valley Rural Legacy Easement properties	DeerCreekValleyRuralLegacyEasements	polygon shapefile	2017?	
Protected land	Manor Rural Legacy Easements	manorlease	polygon shapefile	2010	
Protected land	Maryland Environmental Trust Easements	Maryland_Environmental_Trust_Easements	polygon shapefile	?	
Protected land	Parks and recreation areas	Parks	polygon shapefile	2009	
Protected land	Rural Legacy Easements	Rural_Legacy_Easements	polygon shapefile	?	
Roads & railroads	Bridges maintained by Harford County	Bridges	point shapefile	2011	
Roads & railroads	Railroads	Railroads_2013	line shapefile	2013	
Roads & railroads	Roads	Roads_2013	polygon shapefile	2013	
Shorelines	Blue Infrastructure Baywide Rank Segments (Aquatic near-shore)	BI_2010_AQ	polygon shapefile	2010	1:24,000
Shorelines	Blue Infrastructure Baywide Rank Segments (Terrestrial near-shore)	BI_2010_LD	polygon shapefile	2010	1:24,000
Shorelines	Chesapeake Bay Critical Area	Chesapeake_Bay_Critical_Area	polygon shapefile		
Shorelines	Coastal Resiliency Assessment	CRP_Harford.gdb	Geodatabase		250 m segments
Shorelines	Hurricane storm surge extents (SLOSH model)	GBW_HurricaneStormSurge_USACE	polygon shapefile		
Slope	Areas of >25% slope over 40,000 ft2	over25over40k	polygon shapefile		
Slope	Slope	MD_harford_slope_m	ImageServer link		5 ft
Soils	Hydric soils	HydricSoils	polygon shapefile		
Soils	Soil Classifications	Soil_Classifications	polygon shapefile		
Soils	SSURGO soils	soils_SSURGSDM_md025_2955787_01	Geodatabase		
State GI	State GI corridors	corridors2014clipped	polygon shapefile	2014	30 m
State GI	State GI hubs	hubs2014clipped	polygon shapefile	2014	30 m
State GI	Targeted Ecological Areas	Targeted_Ecological_Areas	polygon shapefile	2016	
Stormwater BMPs	Retrofit and stream restoration drainage areas	Retrofit_and_Stream_Restoration_Drainage_Areas	polygon shapefile	2015	
Stormwater BMPs	Stormwater BMP drainage areas		polygon shapefile	2015	
Stormwater BMPs	Stormwater BMP locations		point shapefile	2015	

Category	Data set	Data set name	Type of data	Year of ground condition	Spatial accuracy
Stream buffers	150 foot buffer around streams with a drainage area >400 acres	new150buffer_ActualBufferArea	polygon shapefile		
Trails	Trails	Trails_Area_2013	polygon shapefile	2013	
Utilities	Electric Utilities	Utilities Electric.shp	line shapefile	2008	
Water quality	BMP Drainage Areas	Drainage_Areas	polygon shapefile	2015	
Water quality	BMP locations	BMP	point shapefile	2015	
Water quality	MD Biological Stream Survey Sites	Maryland_Stream_Health__MD_Biological_Stream_Survey_Sites	point shapefile	1995-2016	
Water quality	Point Source Discharges	Maryland_Point_Source_Discharges	point shapefile	2015	
Water quality	Retrofit and Stream Restoration Drainage Areas	Retrofit_and_Stream_Restoration_Drainage_Areas	polygon shapefile	2015	
Water quality	SPARROW data	MD_SPARROW.gdb	Geodatabase	2015	
Water quality	State restoration priorities	TrustFund11_2014	point shapefile	2014	
Water quality	Stream reach condition	Maryland_Stream_Health__Stream_Reaches	line shapefile	1995-2009	
Water quality	Stream wader sites	Maryland_Stream_Health__Stream_Wader_Sites_volunteer_collected	point shapefile	2000-2012	
Water quality	Tier II stream reaches	Harford_TierII_segments_2016	line shapefile	2003-2012	
Watersheds	3rd order watersheds	swshed12	polygon shapefile	1998	
Watersheds	Blue Infrastructure High Priority Watersheds	High_percentage_rank_area_BI	polygon shapefile	2010	
Wetlands	Wetlands	DNR wetlands	polygon shapefile	1988-1995	1:12,000

APPENDIX B: Focal Species for Core Areas, Hubs, and Corridors

Native vertebrate species found in Harford County, and associated habitat

(Note: a separate spreadsheet is available with home range size, dispersal distance, separation distance for suitable habitat, separation distance for unsuitable habitat, dispersal barriers, dispersal conduits, watershed sensitivity, and other information.)

Species type	**Scientific Name**	**Common Name**	**Landscape Specificity**	**Habitat** (unless general)
Mammal	*Blarina brevicauda*	Northern short-tailed shrew	Specialist	Most abundant in hardwood forests with deep leaf-litter and abundant food; avoids areas with little cover and extremes of temperature and moisture.
Mammal	*Canis latrans*	Eastern coyote	Generalist	
Mammal	*Castor canadensis*	Beaver	Specialist	Forest along 2nd - 4th order streams, ponds, or lakes, with gradient <15% and valleys not too narrow
Mammal	*Cryptotis parva*	Least shrew	Intermediate	Generally occurs in open country with dense herbaceous vegetation. Also brushy areas, forest edges, and sometimes salt and freshwater marshes.
Mammal	*Didelphis virginiana*	Virginia opossum	Generalist	
Mammal (bat)	*Eptesicus fuscus*	Big brown bat	Generalist	Various wooded and semi-open habitats, including cities. Much more abundant in deciduous forest than in coniferous forest. Summer roosts generally are in buildings; also hollow trees, rock crevices, tunnels, and cliff swallow nests; prefers sites that do not get hot. Typically roosts in the twilight part of the cave. Maternity colonies form in attics, barns, and occasionally tree cavities.
Mammal	*Glaucomys volans*	Southern flying squirrel	Intermediate	Mature deciduous and mixed forest, particularly beech-maple, oak-hickory and poplar-dominated.
Mammal (bat)	*Lasiurus borealis*	Eastern red bat	Generalist	Wide range of forested and semi-forested areas
Mammal	*Lontra canadensis*	River otter	Specialist	Open water (e.g., perennial streams, ponds) with riparian forest
Mammal	*Lynx rufus*	Bobcat	Intermediate	Primarily large tracts of forest, including edges. Primarily terrestrial. When inactive, occupies rocky clefts, caves, hollow logs, space under fallen trees, etc.; usually changes shelter daily. Young are born in a den in a hollow log, under a fallen tree, in a rock shelter, or similar site. Hess: Requires large area of habitat with relatively low levels of human activity.
Mammal	*Marmota monax*	Woodchuck	Generalist	Open habitats (meadows, pastures, old fields, orchards) that often border wooded areas, which may be used for hibernation
Mammal	*Mephitis mephitis*	Striped skunk	Generalist	Prefers semi-open country with woodland and meadows interspersed, brushy areas, bottomland woods. Frequently found in suburban areas.
Mammal	*Microtus pennsylvanicus*	Meadow vole	Generalist	Found in a wide variety of habitats from dry pastures and wooded swamps to marshes and orchards. Needs loose organic soils for tunneling.
Mammal	*Microtus pinetorum*	Woodland vole	Specialist	Upland wooded areas with a thick layer of loose soil and humus. Spends most of time underground in shallow burrow systems.
Mammal	*Mustela frenata*	Long-tailed weasel	Generalist	Found in a wide variety of habitats, usually near water
Mammal	*Neovison vison*	Mink	Intermediate	Wetlands and riparian areas
Mammal	*Odocoileus virginianus*	White-tailed deer	Generalist	Various habitats from forests to fields with adjacent cover.
Mammal	*Ondatra zibethicus*	Common muskrat	Intermediate	Marsh
Mammal	*Oryzomys palustris*	Marsh rice rat	Intermediate	Marsh
Mammal	*Peromyscus leucopus*	White-footed mouse	Generalist	Old fields, marshes, and wet meadows.
Mammal	*Procyon lotor*	Raccoon	Generalist	Various habitats; usually in moist situations, often along streams and shorelines
Mammal	*Scalopus aquaticus*	Eastern mole	Generalist	Most commonly occurs in open areas with moist soils
Mammal	*Sciurus carolinensis*	Eastern gray squirrel	Generalist	Mature tree canopy
Mammal	*Sorex cinereus*	Masked shrew	Generalist	
Mammal	*Sorex fumeus*	Smoky shrew	Intermediate	Most abundant in damp wooded areas, both in conifer and hardwood habitats

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Mammal	*Sorex hoyi*	Pygmy shrew	Generalist	
Mammal	*Sylvilagus floridanus*	Eastern cottontail	Generalist	
Mammal	*Tamias striatus*	Eastern chipmunk	Intermediate	Prefers deciduous woodlands with ample cover. Also found in brushlands and hedgerows.
Mammal	*Urocyon cinereoargenteus*	Gray fox	Intermediate	Forest. Usually avoids open areas.
Mammal	*Vulpes vulpes*	Red fox	Generalist	
Mammal	*Zapus hudsonius*	Meadow jumping mouse	Intermediate	Moist lowland habitats; prefers relatively thick vegetation of open grassy and brushy areas of marshes, meadows, swamps, and streamsides.
Bird	*Accipiter cooperii*	Cooper's hawk	Intermediate	Robbins: Intermediate or mature forest. NatureServe: Primarily mature broadleaf interior forest. Generally inhabits deep woods, utilizing thick cover both for nesting and hunting.
Bird	*Agelaius phoeniceus*	Red-winged blackbird	Intermediate	Fresh-water and brackish marshes, bushes and small trees along watercourses, and upland cultivated fields. Usually nests near water, in cattails, rushes, sedges; occasionally in shrubs or trees.
Bird	*Aix sponsa*	Wood duck	Specialist	Robbins: Wetlands or riparian areas with old trees. NatureServe: Quiet inland waters near woodland, such as wooded swamps, flooded forest, ponds, marshes, and along streams. Nests in holes in large trees in forested wetlands, and in bird boxes, usually within 0.5 km of water and near forest canopy openings, sometimes 1 km or more from water. Elms and maples are important habitat components in most areas because they provide protein-rich samaras in spring and suitable nest cavities. Shallowly flooded habitat with good understory cover is important cover for broods.
Bird	*Ammodramus savannarum*	Grasshopper sparrow	Specialist	Robbins: Short fields. NatureServe: Grasslands of intermediate height and often with clumped vegetation interspersed with patches of bare ground. Other habitat requirements include moderately deep litter and sparse coverage of woody vegetation.
Bird	*Anas platyrhynchos*	Mallard duck	Generalist	
Bird	*Anas rubripes*	Black duck	Intermediate	Shallow margins of lakes, streams, bays, mud flats, and open waters. Nests in both dry and wet woodlands. Wide variety of wetland habitats in both freshwater and marine situations, in and around marshes, swamps, ponds, lakes, bays, estuaries, and tidal flats. Frazer et al. (1990) recommended maintaining large (30-50 ha) marshes containing dense emergent vegetation near a complex of diverse wetland types.
Bird	*Archilochus colubris*	Ruby-throated hummingbird	Generalist	
Bird	*Ardea herodias*	Great Blue Heron	Specialist	Freshwater and brackish marshes, along lakes, rivers, bays, lagoons, ocean beaches, mangroves, fields, and meadows. Nests commonly high in trees in swamps and forested areas
Bird	*Baeolophus bicolor*	Tufted Titmouse	Generalist	
Bird	*Bombycilla cedrorum*	Cedar Waxwing	Generalist	
Bird	*Branta canadensis*	Canada goose	Generalist	
Bird	*Bubo virginianus*	Great horned owl	Intermediate	Robbins: Medium to large blocks of forest with large trees and nearby fields.
Bird	*Bubulcus ibis*	Cattle egret	Generalist	
Bird	*Buteo jamaicensis*	Red-tailed hawk	Generalist	
Bird	*Buteo lineatus*	Red-shouldered hawk	Specialist	Robbins: Mature forest, esp. along streams. NatureServe: Mature forest with a well-developed high canopy, variable amounts of understory vegetation, and near streams, swamps, or other water.
Bird	*Buteo platypterus*	Broad-winged hawk	Specialist	Hess: "Requires extensive forested uplands." NatureServe: Broadleaf and mixed forest with large trees. Robbins: Large blocks of mature deciduous forest containing streams or other sources of water.
Bird	*Butorides virescens*	Green heron	Intermediate	Swamps, mangroves, marshes, and margins of ponds, rivers, lakes, and lagoons. Eggs are laid in platform nest in tree, thicket, or bush over water or sometimes in dry woodlands or orchards
Bird	*Caprimulgus vociferus*	Whip-poor-will	Intermediate	Robbins: Mature upland deciduous woods with fields nearby. NatureServe: Forest and open woodland with well-spaced trees and a low canopy.
Bird	*Cardinalis cardinalis*	Northern Cardinal	Generalist	
Bird	*Cathartes aura*	Turkey vulture	Generalist	
Bird	*Catharus fuscescens*	Veery	Specialist	Extensive moist forests with mature trees and a dense shrub layer. In the Piedmont, Veeries breed most abundantly in deep wet ravines (Robbins)

Species type	Scientific Name	Common Name	Landscape Specificity	**Habitat** (unless general)
Bird	*Chaetura pelagica*	Chimney swift	Generalist	
Bird	*Charadrius vociferus*	Killdeer	Generalist	Habitat includes various open areas such as fields, meadows, lawns, pastures, mudflats, and shores of lakes, ponds, rivers, and seacoasts. Nests are on the ground in open dry or gravelly situations, sometimes in similar situations on roofs, driveways, etc.
Bird	*Cistothorus palustris*	Marsh wren	Specialist	Robbins: marsh. NatureServe: Freshwater and brackish marshes in cattails, tule, bulrush, and reeds. Nesting success may be greatest in marshes with relatively dense vegetation and deep water.
Bird	*Coccyzus americanus*	Yellow-billed cuckoo	Generalist	Open woodland (especially where undergrowth is thick), parks, deciduous riparian woodland. Nests in deciduous woodlands, moist thickets, orchards, overgrown pastures.
Bird	*Coccyzus erythropthalmus*	Black-billed cuckoo	Intermediate	Forest edge and open woodland, both deciduous and coniferous, with dense deciduous thickets. Nests in groves of trees, forest edges, moist thickets, overgrown pastures; in deciduous or evergreen tree or shrub. Is a low or ground nesting species.
Bird	*Colaptes auratus*	Northern flicker	Generalist	
Bird	*Colinus virginianus*	Northern Bobwhite	Intermediate	Hess: "Needs abandoned fields, thickets, and woodland margins. Sensitive to development." Robbins: Forest-field or shrub-field edges. NatureServe: Heterogeneous, patchy landscapes comprised of moderate amounts of row crops and grasslands and abundant woody edges.
Bird	*Contopus virens*	Eastern wood-pewee	Generalist	
Bird	*Coragyps atratus*	Black Vulture	Generalist	Nearly ubiquitous except in heavily forested regions; more common in lowland than in highland habitats. In Maryland/Pennsylvania, nested in areas that were roadless, forested, and undeveloped.
Bird	*Corvus brachyrhynchos*	American crow	Generalist	
Bird	*Corvus corax*	Common raven	Generalist	
Bird	*Corvus ossifragus*	Fish crow	Generalist	
Bird	*Cyanocitta cristata*	Blue jay	Generalist	
Bird	*Dendroica cerulea*	Cerulean warbler	Specialist	Large tracts of mature, semi-open deciduous interior forest, particularly in floodplains or other mesic conditions. In MD, rarely nests in forest <250 ha; in TN, not found in forest <1600 ha. TN DNR: not found within 1/4 mile of clearcut.
Bird	*Dendroica discolor*	Prairie warbler	Intermediate	Scrub-shrub or early successional forest
Bird	*Dendroica dominica*	Yellow-throated warbler	Intermediate	Robbins: Riparian forest. NatureServe: Pine forest, sycamore-bald cypress swamp, riparian woodland, floodplain forest, live oak woodland. Nests in tall trees.
Bird	*Dendroica pinus*	Pine warbler	Specialist	Highest densities in pine forest at least 40 years old
Bird	*Dolichonyx oryzivorus*	Bobolink	Intermediate	Native and tame grasslands, haylands, lightly to moderately grazed pastures, no-till cropland, small-grain fields, old fields, wet meadows, and planted cover
Bird	*Dryocopus pileatus*	Pileated Woodpecker	Intermediate	Hess: "Requires large area of mature forest and large snags for breeding." NatureServe: Deciduous or mixed forest with a tall closed canopy and a high basal area. Most often in areas of extensive forest or minimal isolation from extensive forest. Robbins: Mature deciduous forest and woodlands
Bird	*Dumetella carolinensis*	Gray Catbird	Generalist	
Bird	*Empidonax traillii*	Willow flycatcher	Intermediate	Moist old-field habitats with willows and other shrubs or small trees (Robbins)
Bird	*Empidonax virescens*	Acadian flycatcher	Specialist	Robbins: Interior, mature riparian forest. NatureServe: Moist deciduous forests, primarily mature, with a moderate understory, generally near a stream. Requires a high dense canopy and an open understory. Tends to be scarce or absent in small forest tracts, unless the tract is near a larger forested area. Floodplain forests must be >400-500 feet wide for nesting.
Bird	*Eremophila alpestris*	Horned lark	Generalist	Flat areas with areas of exposed soil (Robbins)
Bird	*Falco sparverius*	American kestrel	Generalist	
Bird	*Geothlypis trichas*	Common Yellowthroat	Intermediate	Marshes (especially cattail), thickets near water, bogs, brushy pastures, old fields, and, locally, undergrowth of humid forest.
Bird	*Haliaeetus leucocephalus*	Bald Eagle	Intermediate	Breeding habitat most commonly includes areas close to (within 4km) coastal areas, bays, rivers, lakes, or other bodies of water. Typically roosts in larger, more accessible trees. Robbins: Wooded tidal shorelines
Bird	*Helmitheros vermivorum*	Worm-eating warbler	Specialist	Robbins: Large (>150 ha) blocks of upland deciduous forest. B&T: mature forest. NatureServe: Well-drained upland deciduous forest with understory patches of mountain laurel or other shrubs, drier portions of stream swamps with an understory of mountain laurel, deciduous woods near streams; almost always associated with hillsides. Most abundant in mature woods but also may be in young and medium-aged

Species type	Scientific Name	Common Name	Landscape Specificity	**Habitat** (unless general)
				stands.
Bird	*Hirundo rustica*	Barn swallow	Generalist	
Bird	*Hylocichla mustelina*	Wood thrush	Intermediate	Deciduous or mixed forests with a dense tree canopy and a fairly well-developed deciduous understory, especially where moist. Bottomlands and other rich hardwood forests are prime habitats. Also frequents pine forests with a deciduous understory and well-wooded residential areas. Thickets and early successional woodland generally not suitable. Vulnerable to edge predators and cowbirds. Nest survival positively correlated with forest area, interior forest area, and % forest within 2 km.
Bird	*Icteria virens*	Yellow-breasted chat	Specialist	Early successional shrub-scrub. "Although chats will tolerate moderate amounts of grass and other herbaceous plant cover, a considerable amount of dense woody vegetation in the shrub/sapling successional stage must be present. These conditions generally develop from clear-cutting within two years but abandoned agricultural fields often take several years to reach a shrub/young tree dominated successional stage. In either situation, the shrubland habitat created persists no longer than five-ten years. Shrubland habitats typically have a good diversity of wildlife due to the mix of grasses, herbs, small trees, and shrubs. However, once the canopy closes and the growing space becomes dominated by trees, the habitat is no longer suitable for chats. In clear-cut situations, where all the trees are of equal age, this phase occurs when the canopy reaches approximately three meters in height." (Esley)
Bird	*Icterus galbula*	Baltimore Oriole	Generalist	
Bird	*Icterus spurius*	Orchard Oriole	Generalist	
Bird	*Ixobrychus exilis*	Least bittern	Specialist	Unimpaired marsh at least 5 contiguous ha, with 30m upland buffer
Bird	*Lophodytes cucullatus*	Hooded merganser	Intermediate	Streams, lakes, swamps, marshes, and estuaries. Nests usually in tree cavities in forested regions near water, often near fast-flowing streams, also forest ponds and lakes, flooded forest, riverside swamps.
Bird	*Megaceryle alcyon*	Belted kingfisher	Intermediate	Along water with adjacent trees
Bird	*Megascops asio*	Eastern screech owl	Generalist	
Bird	*Melanerpes erythrocephalus*	Red-headed woodpecker	Intermediate	Open woodland, especially with beech or oak, open situations with scattered trees, parks, cultivated areas, and gardens.
Bird	*Meleagris gallopavo*	Wild turkey	Intermediate	NatureServe: Mature forest with clearings or fields nearby. Robbins: forest
Bird	*Melospiza georgiana*	Swamp sparrow	Intermediate	Robbins: Marshes, or wet meadows with scattered shrubs and small trees. NatureServe: Marshes, wet brushy fields, meadows, lakeshores, stream borders, swamps, pine barrens shrub-sedge bogs; also brackish marshes along mid-Atlantic coast. Nests in tussock of grass, sedge, or in low bush, commonly over water.
Bird	*Melospiza melodia*	Song Sparrow	Generalist	
Bird	*Mimus polyglottos*	Northern Mockingbird	Generalist	
Bird	*Mniotilta varia*	Black-and-white warbler	Intermediate	Robbins: Large blocks (>300 ha) of intermediate or mature forest. NatureServe: young, medium-aged and mature deciduous and mixed forests. Forest-interior, area sensitive species
Bird	*Molothrus ater*	Brown-headed Cowbird	Generalist	
Bird	*Myiarchus crinitus*	Great crested flycatcher	Generalist	Robbins: Mature deciduous forest (although adaptable). NatureServe: Deciduous (mainly), mixed, or pine woodland or somewhat open forest, parks, orchards, wooded residential areas, areas of scattered trees in cultivated regions, clearings and edges of wooded areas, and swamps. Prefers semi-open habitats and edges.
Bird	*Nycticorax nycticorax*	Black-crowned night heron	Intermediate	Marshes, swamps, wooded streams, shores of lakes, ponds, lagoons; salt water, brackish, and freshwater situations.
Bird	*Oporornis formosus*	Kentucky warbler	Specialist	Robbins: Large blocks of mature, diverse, deciduous forest with a heavy shrub layer. NatureServe: Rich, moist deciduous forest; bottomland hardwoods and woods near streams are ideal as long as they have a dense hardwood understory. Being a ground-nester, requires well-developed ground cover, and a thick understory is essential. Occurs in stands of various ages but is most common in medium-aged forests.
Bird	*Pandion haliaetus*	Osprey	Intermediate	Primarily along rivers, lakes, reservoirs, and seacoasts. Nests in dead snags, living trees, cliffs, utility poles, wooden platforms on poles, channel buoys, chimneys, windmills, etc.; usually near or above water.
Bird	*Parula americana*	Northern parula	Specialist	Bushman and Therres (1988): mature interior forest (>100 m from edge). Robbins: Large blocks of mature floodplain or moist forest. NatureServe: Primarily a riparian species associated with epiphytic growth. Found in open deciduous, coniferous, or mixed forest, woodland, floodplain and swamp forest. Prefers

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
				mature forest but also occurs in young deciduous woods. Favors woods with a very dense understory of saplings and shrubs near slow or non-flowing water; canopy may range from poorly developed to mainly closed.
Bird	*Passerculus sandwichensis*	Savannah sparrow	Intermediate	Habitat with short to intermediate vegetation height, intermediate vegetation density, and a well-developed litter layer. These preferred habitats cover a wide range of vegetation types, including coastal salt marshes, sedge bogs, grassy meadows, and native prairie.
Bird	*Passerina caerulea*	Blue Grosbeak	Generalist	
Bird	*Passerina cyanea*	Indigo Bunting	Generalist	
Bird	*Petrochelidon pyrrhonota*	Cliff swallow	Generalist	
Bird	*Phalacrocorax auritus*	Double crested cormorant	Intermediate	Lakes, ponds, rivers, lagoons, swamps, coastal bays, marine islands, and seacoasts; usually within sight of land. Nests on the ground or in trees in freshwater situations, and on coastal cliffs.
Bird	*Picoides pubescens*	Downy woodpecker	Generalist	
Bird	*Picoides villosus*	Hairy woodpecker	Specialist	Large blocks of mature deciduous forest (>7 ha). Most abundant in mature woods with large old trees suitable for cavity nesting; also common in medium-aged forests; prefers woods with a dense canopy.
Bird	*Pipilo erythrophthalmus*	Eastern Towhee	Generalist	
Bird	*Piranga olivacea*	Scarlet tanager	Specialist	Robbins: Blocks at least 10ha of mature deciduous forest (preferably oak). NatureServe: Deciduous forest and mature deciduous woodland, including deciduous and mixed swamp and floodplain forests and rich, moist upland forests; prefers oak trees. Most common in areas with a relatively closed canopy, a dense understory with a high diversity of shrubs, and scanty ground cover; able to breed in relatively small patches of forest. Breeds in various forest stages but most abundant in mature woods.
Bird	*Piranga rubra*	Summer tanager	Intermediate	Robbins: Dry open pine, oak, and pine-oak woods. NatureServe: Deciduous woods (often near gaps and edges).
Bird	*Podilymbus podiceps*	Pied-billed grebe	Specialist	Ponds or streams with open water, some aquatic vegetation, and little wave action (Robbins)
Bird	*Poecile carolinensis*	Carolina Chickadee	Generalist	
Bird	*Polioptila caerulea*	Blue-gray gnatcatcher	Intermediate	Robbins: Most common in extensive forests with a high canopy. Common victim of cowbird parasitism. NatureServe: Deciduous forest, open woodland, second growth, scrub, brushy areas, often near water.
Bird	*Progne subis*	Purple martin	Generalist	
Bird	*Protonotaria citrea*	Prothonotary warbler	Specialist	Mature swamp or floodplain forest with standing water (Robbins), at least 300m wide (Mason et al., 2003). Bushman and Therres (1988) cite a minimum area of 100 ha, preferring interior forest (>100 m from edge). NatureServe: Mature deciduous floodplain, river, and swamp forests; wet lowland forest. Primary habitats are almost always near standing water; swamps that are somewhat open with scattered dead stumps are preferred. Bottomland forests and extensive willow thickets near lakes or ponds are also quite suitable. Requires dense underbrush along streambanks. Nests in cavity, in snag or living tree, often or always near or over water, at average height of 1.5-3 m.
Bird	*Quiscalus quiscula*	Common Grackle	Generalist	
Bird	*Rallus elegans*	King rail	Specialist	NatureServe: marsh. Largest minimum area required (60 ha) of marsh-dependent birds in PA GAP habitat models (Pennsylvania GAP Analysis Project, 2000).
Bird	*Rallus limicola*	Virginia rail	Intermediate	Freshwater and occasionally brackish marshes, mostly in cattails, reeds, and deep grasses, also in or close to other emergent vegetation. Inhabits shallow, freshwater, emergent wetlands of every size and type, from roadside ditches and borders of lakes and streams to large cattail marshes. Capable of using very small marshes (e.g., 5 nests have been found in a half-acre marsh). Interspersion of open water and vegetation is an important habitat component.
Bird	*Riparia riparia*	Bank swallow	Intermediate	Robbins: River valleys with sandy banks. NatureServe: Nests in steep sand, dirt, or gravel banks, in a burrow dug near the top of the bank, along the edge of inland water or along the coast, or in gravel pits, road embankments, etc.
Bird	*Sayornis phoebe*	Eastern phoebe	Generalist	
Bird	*Scolopax minor*	American woodcock	Generalist	Young forests and abandoned farmland mixed with forested land. Generally considered an edge species. Robbins: Early successional forest with bare ground; damp woodlands
Bird	*Seiurus aurocapilla*	Ovenbird	Specialist	Hess: "Prefers mature uplands with well-developed understory." Robbins: Large blocks of tall upland forest. B&T: mature forest. NatureServe: Typically nests in mid-late successional, closed-canopied

Species type	Scientific Name	Common Name	Landscape Specificity	**Habitat** (unless general)
				deciduous or deciduous-coniferous forests that have deep leaf litter and limited understory.
Bird	*Seiurus motacilla*	Louisiana waterthrush	Specialist	Riparian deciduous forest along natural perennial streams at least 300m wide. Bushman and Therres (1988) cite a minimum area of 100 ha, preferring interior forest (>100 m from edge). NatureServe: Moist forest, woodland, and ravines along streams; mature deciduous and mixed floodplain and swamp forests. Prefers areas with moderate to sparse undergrowth near rapid-flowing water of hill and mountain streams. Nests on the ground along stream banks, hidden in the underbrush or among the roots of fallen trees, in crevices or raised sites in tree roots, or in rock walls of ravines over water.
Bird	*Setophaga petechia*	Yellow Warbler	Generalist	
Bird	*Setophaga ruticilla*	American redstart	Intermediate	NatureServe: most abundant in mature deciduous forest, but also may occur in young woods <15 years old; requires closed canopy and prefers dense midstory and understory and well-developed undergrowth. Robbins: Large blocks of deciduous forest with an extensive understory. B&T: mature forest.
Bird	*Sialia sialis*	Eastern Bluebird	Generalist	
Bird	*Sitta carolinensis*	White-breasted nuthatch	Intermediate	Robbins: Extensive tall deciduous forest. NatureServe: Most frequent in open woodlands of mature trees (primarily oak or pine). Also in clearings, forest edges, parks, and partly open situations with scattered trees.
Bird	*Spinus tristis*	American Goldfinch	Generalist	
Bird	*Spiza americana*	Dickcissel	Intermediate	Grassland, meadows, savanna, cultivated lands, brushy fields
Bird	*Spizella passerina*	Chipping Sparrow	Generalist	
Bird	*Spizella pusilla*	Field sparrow	Intermediate	Old fields with some woody vegetation, or adjacent shrubs
Bird	*Stelgidopteryx serripennis*	Northern rough-winged swallow	Generalist	
Bird	*Sternula antillarum*	Least tern	Specialist	BREEDING: Seacoasts, beaches, bays, estuaries, lagoons, lakes, and rivers. Rests and loafs on sandy beaches, mudflats, and salt-pond dikes. Nests vulnerable to damage or predation.
Bird	*Strix varia*	Barred owl	Specialist	Hess: "Nests in mature, large trees; rarely forages far from bottomland." Rubino and Hess: "Barred owls occupy bottomland hardwood forests, which we identified using land cover, soils, and wetlands data. We eliminated from consideration bottomland forest habitat within 100 m of a road and within 60 m of open vegetative cover. Patches of the remaining bottomland forest larger than 86 ha in size were considered large enough to meet all barred owl habitat needs. Simple presence/absence surveys detected barred owls in approximately 65% of patches identified by our model as suitable habitat. Robbins: Mature deciduous forest, esp. along streams
Bird	*Sturnella magna*	Eastern meadowlark	Intermediate	Robbins: Fields or pastures that are undisturbed during breeding. NatureServe: Grasslands, savanna, open fields, pastures, cultivated lands, sometimes marshes. Nests on the ground in concealment.
Bird	*Tachycineta bicolor*	Tree swallow	Generalist	Robbins: Shorelines with nearby snags. NatureServe: Open situations near water, including streams, lakes, ponds, marshes, and coastal regions; savanna, pastures, etc. Nests usually near water in a natural tree cavity or abandoned woodpecker hole, less frequently in open woodland away from water. Also nests in bird boxes or in a crevice in a building.
Bird	*Thryothorus ludovicianus*	Carolina Wren	Generalist	
Bird	*Toxostoma rufum*	Brown Thrasher	Generalist	
Bird	*Troglodytes aedon*	House Wren	Generalist	
Bird	*Turdus migratorius*	American Robin	Generalist	
Bird	*Tyrannus tyrannus*	Eastern kingbird	Generalist	
Bird	*Tyto alba*	Barn owl	Intermediate	Need large grassland habitats including herbaceous wetlands for foraging and nest in cavities (which also could occur in wetlands).
Bird	*Vermivora pinus*	Blue-winged warbler	Specialist	Early successional shrubby areas, such as brushy hillsides, young forest (<7m, and preferably <3m), partly open situations with saplings, bogs, woodland edge and clearings, stream edges, overgrown pastures, swamps, shrubby powerline corridors.
Bird	*Vireo flavifrons*	Yellow-throated vireo	Specialist	Robbins: Floodplain forest. B&T: mature forest. NatureServe: Primarily open deciduous forest and woodland, riparian woodland, tall floodplain forest, lowland swamp forest, and less frequently, mixed forest. Most abundant in mature woods but also occurs in medium-aged forests and some pioneer stands; requires a high, partially open canopy and prefers woods with an intermediate tree density or basal area.

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
				Relatively low tolerance to forest fragmentation, though this may depend on forest quality and proximity to other forested areas.
Bird	*Vireo gilvus*	Warbling vireo	Generalist	
Bird	*Vireo griseus*	White-eyed vireo	Intermediate	Robbins: Scrub-shrub wetlands or riparian areas. NatureServe: Inhabits early-late successional, shrubby habitats such as deciduous scrub, old fields, abandoned pastures, regenerating clearcuts or other heavily logged areas, drainage and streamside thickets, forest edges, and reclaimed strip mines.
Bird	*Vireo olivaceus*	Red-eyed vireo	Specialist	B&T: mature forest. NatureServe: Most abundant in mature deciduous forest with sapling undergrowth. In much of the range, prefers shady oak forests with a high, well-developed closed canopy and a fairly open understory with scanty ground cover. Most common in forest tracts of at least 15-20 ha but may occur in patches as small as a few hectares. Prefers closed canopy but tolerates a wide range of canopy closures. In PA, more sensitive than other area-dependent birds to increased fragmentation via forest clear-cutting.
Bird	*Wilsonia citrina*	Hooded warbler	Specialist	Robbins: Extensive mature deciduous forest with dense shrub layers, often on floodplains. NatureServe: Nests in understory of deciduous forest, especially along streams and ravine edges, and thickets in riverine forests. Most abundant in mature forest. A dense shrub layer is important. Generally favors large tracts of uninterrupted forest, but sometimes nests in forest patches as small as 5 ha, probably where these are close to larger forested areas.
Bird	*Zenaida macroura*	Mourning dove	Generalist	
Reptile (turtle)	*N/A*	Turtles	N/A	Data from Burke and Gibbons (1995) indicated that freshwater turtles require a 275 m upland buffer zone to protect 100% of the nest and hibernation sites. Insulating 90% of the sites required a 73 m buffer zone.
Reptile (turtle)	*Glyptemys muhlenbergii*	Bog turtle	Specialist	Generally, inhabit small, open canopy, herbaceous sedge meadows, and fens, bordered by more thickly vegetated and wooded areas. Includes slow, shallow, muck-bottomed rivulets of sphagnum bogs, calcareous fens, marshy/sedge-tussock meadows, spring seeps, wet cow pastures, and shrub swamps; the habitat usually contains an abundance of sedges or mossy cover. The turtles depend on a mosaic of microhabitats for foraging, nesting, basking, hibernation, and shelter. Unfragmented riparian systems that are sufficiently dynamic to allow the natural creation of open habitat are needed to compensate for ecological succession. Beaver, deer, and cattle may be instrumental in maintaining the essential open-canopy wetlands.
Reptile (turtle)	*Chelydra serpentina*	Snapping turtle	Intermediate	Fresh water. Nests in soft soil in open area, often hundreds of meters from water. Also nests in muskrat houses.
Reptile (turtle)	*Chrysemys picta*	Painted turtle	Intermediate	Slow-moving, shallow water with soft bottom, basking sites, and aquatic vegetation: streams, marshes, ponds, lakes, creeks. May colonize seasonally flooded areas near permanent water. Hibernates in water in bottom mud. Nests in soft soil in open area up to several hundred meters from water (1-621 m, average 90 m, in Quebec; 1-164 m, average 60 m, in Michigan).
Reptile (turtle)	*Clemmys guttata*	Spotted turtle	Specialist	Mostly unpolluted, small, shallow bodies of water such as small marshes, marshy pastures, bogs, fens, woodland streams, swamps, small ponds, and vernal pools; also occurs in brackish tidal streams. Ponds surrounded by relatively undisturbed meadow or undergrowth are most favorable. Favors waters with soft bottom and aquatic vegetation. Eggs laid in open areas up to hundreds of meters away.
Reptile (turtle)	*Glyptemys insculpta*	Wood turtle	Specialist	Perennial streams and riparian areas within 150-300m
Reptile (turtle)	*Graptemys geographica*	Map turtle	Specialist	Slow rivers and lakes with mud bottoms, basking logs, and abundant aquatic vegetation. Often in mill ponds, oxbows, and river overflow ponds.
Reptile (turtle)	*Kinosternon subrubrum*	Eastern mud turtle	Intermediate	Wetlands + adjacent (135m) upland
Reptile (turtle)	*Pseudemys rubriventris*	Red-bellied cooter	Intermediate	Relatively large deep bodies of water: creeks, rivers, marshes, ponds, lakes. Soft bottom and abundant aquatic vegetation preferred. Wanders on land during fall and spring. Eggs are laid in nests dug in soft soil in open areas usually within 100m of water. Often nests in tilled or disturbed soil.
Reptile (turtle)	*Sternotherus odoratus*	Eastern musk turtle	Intermediate	Inhabits virtually any permanent body of freshwater having a slow current and soft bottom. Eggs are laid up to about 50 m (average 7 m in Pennsylvania) from water in soil; under logs, stumps, and vegetable debris; and in walls of muskrat houses; sometimes on open ground.
Reptile	*Terrapene carolina*	Eastern box turtle	Intermediate	Forests, fields with nearby cover, and wetlands. Eggs are laid in sandy or loamy soil in open areas. In

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
(turtle)				Maryland, females extended home range from bottomlands to lay eggs in drier and warmer upland sites; moved several hundred meters from center of bottomland range.
Reptile (snake)	*Agkistrodon contortrix*	Copperhead	Intermediate	Deciduous forest
Reptile (snake)	*Carphophis amoenus*	Eastern wormsnake	Generalist	
Reptile (snake)	*Coluber constrictor constrictor*	Northern black racer	Generalist	
Reptile (snake)	*Diadophis punctatus edwardsii*	Northern ring-necked snake	Intermediate	Prefers moist wooded areas, but also found in field edges or backyards
Reptile (snake)	*Elaphe obsoleta*	Black rat snake	Generalist	Habitats include hardwood forest and woodland, wooded canyons, swamps, rocky timbered upland, wooded areas of streams and rivers, farmland near woods, old fields, barnyards, and rural buildings in wooded areas. Often occurs where wooded and open habitats (such as fields or farmland) are intermixed.
Reptile (snake)	*Heterodon platirhinos*	Eastern hog-nosed snake	Generalist	Openly wooded upland hills, forest edges, fields, woodland meadows, prairies, forest-grassland ecotones, sand plains, barrier islands, fire-managed pinelands, river valleys, riparian zones, and various other habitats with loose soils and amphibian prey.
Reptile (snake)	*Lampropeltis getula*	Eastern kingsnake	Generalist	
Reptile (snake)	*Lampropeltis triangulum*	Milksnake	Generalist	
Reptile (snake)	*Nerodia sipedon*	Northern water snake	Intermediate	Water, wetlands and riparian banks
Reptile (snake)	*Regina septemvittata*	Queen snake	Specialist	Occurs only where crayfish are present and fairly abundant, generally in moderate to fast-flowing streams with ample cover, wooded or open conditions, and good exposure to sun.
Reptile (snake)	*Storeria dekayi*	Dekay's brownsnake	Generalist	
Reptile (snake)	*Storeria dekayi dekayi*	Northern brownsnake	Generalist	
Reptile (snake)	*Thamnophis sauritus*	Eastern ribbon snake	Intermediate	Wet meadows, marshes, seasonally flooded prairies, bogs, ponds, lake shorelines, swamps, and shallow slow streams; also hardwood hammocks and other wet or moist forest in some areas; usually this snake is in or near vegetative cover (often shrubs or clumps of sedges or grasses) in sun-exposed sites along the edge of standing or flowing water; it climbs into low vegetation, rarely into tree canopy.
Reptile (snake)	*Thamnophis sirtalis*	Common gartersnake	Generalist	
Reptile (lizard)	*Eumeces fasciatus*	Five-lined skink	Intermediate	Forest
Amphibian (salamander)	*N/A*	Salamander spp.	N/A	
Amphibian (salamander)	*Ambystoma maculatum*	Spotted salamander	Specialist	vernal pools + adjacent hardwood or mixed forest (>200-250m)
Amphibian (salamander)	*Ambystoma opacum*	Marbled salamander	Intermediate	vernal pools + adjacent hardwood forest (>200-250m). More tolerant of dry habitats than are most salamanders; can be found on rocky bluffs and slopes and wooded sand dunes. Adults terrestrial; usually under surface objects or underground. Eggs laid in forest depressions such as vernal pool basins and sometimes at the edges of permanent ponds, swamps, and slow-moving streams; in areas likely to be flooded by fall rains.
Amphibian (salamander)	*Cryptobranchus alleganiensis*	Eastern Hellbender	Specialist	Rocky, clear creeks and rivers, usually where there are large shelter rocks. Usually avoids water warmer than 20 C. Males prepare nests and attend eggs beneath large flat rocks or submerged logs. Maintenance of unpolluted, free-flowing rivers with a rocky substrate is the primary management need. Buffer zones around streams should be maintained.
Amphibian	*Desmognathus fuscus*	Dusky salamander	Intermediate	forested floodplains

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
(salamander)				
Amphibian (salamander)	*Eurycea bislineata*	Northern two-lined salamander	Intermediate	Rocky brooks, springs, seepages; may disperse into wooded terrestrial habitats in wet warm weather
Amphibian (salamander)	*Eurycea longicauda*	Long-tailed salamander	Specialist	Streamsides, spring runs, cave mouths, abandoned mines; also ponds in northern New Jersey. May disperse into wooded terrestrial habitats in wet weather.
Amphibian (salamander)	*Hemidactylium scutatum*	Four-toed salamander	Intermediate	forested or scrub-shrub wetlands
Amphibian (salamander)	*Notophthalmus viridescens*	Eastern newt	Intermediate	Ponds, swamps, and quiet stream pools with adjacent forest
Amphibian (salamander)	*Plethodon cinereus*	Eastern red-backed salamander	Specialist	Riparian forest
Amphibian (salamander)	*Plethodon glutinosus*	Slimy salamander	Intermediate	Wooded slopes, ravines, floodplains, shalebanks, and cave entrances; most often in hardwood forest, sometimes in pinelands.
Amphibian (salamander)	*Pseudotriton ruber*	Northern Red Salamander	Specialist	Cold, clear, rocky streams and springs in wooded or open areas. Adults occur in or near water in leaf litter and under rocks, and in crevices and burrows near water. Adults sometimes disperse into woods. Eggs are attached to underside of rocks in water. Larvae occur in still pools.
Amphibian (frog)	*Acris crepitans*	Northern cricket frog	Intermediate	marsh and pond edges
Amphibian (frog)	*Bufo americanus*	American toad	Generalist	
Amphibian (frog)	*Bufo fowleri*	Fowler's toad	Generalist	
Amphibian (frog)	*Hyla chrysoscelis*	Cope's gray treefrog	Intermediate	wetlands or other water + adjacent forest (few hundred meters)
Amphibian (frog)	*Hyla cinerea*	Green treefrog	Intermediate	Wetlands
Amphibian (frog)	*Hyla versicolor*	Gray treefrog	Intermediate	Forest with wetlands, vernal pools, or other standing water
Amphibian (frog)	*Pseudacris crucifer*	Spring peeper	Intermediate	Forest with wetlands, vernal pools, or other standing water
Amphibian (frog)	*Pseudacris feriarum*	Upland chorus frog	Generalist	Meadows, moist forests, bottomland swamps, vicinity of ponds, bogs, and marshes.
Amphibian (frog)	*Rana catesbeiana*	American bullfrog	Generalist	still, permanent water
Amphibian (frog)	*Rana clamitans*	Green frog	Generalist	permanent or temporary water
Amphibian (frog)	*Rana palustris*	Pickerel frog	Intermediate	Wetlands and riparian areas
Amphibian (frog)	*Rana sylvatica*	Wood frog	Specialist	Forest with wetlands, vernal pools, or other standing water
Amphibian (frog)	*Rana utricularia*	Southern leopard frog	Intermediate	Vicinity of virtually any freshwater habitat; also slightly brackish marshes. In summer disperses from water into moist vegetation.
Amphibian (frog)	*Scaphiopus holbrookii*	Eastern spadefoot toad	Generalist	Areas of sandy, gravelly, or soft, light soils in wooded or unwooded terrain. Burrows underground when inactive. Eggs and larvae develop in temporary pools formed by heavy rains.
Aquatic invertebrates			Int	High benthic IBI scores (e.g., rating of "Good") can indicate better (or reference standard) water quality and stream habitat. Pollution-intolerant invertebrate taxa include mayflies, stoneflies, caddisflies, water pennies, hellgrammites, and gilled snails.
Fish	*Alosa aestivalis*	Blueback herring	Intermediate	Spawning occurs in fresh or brackish water, in tidally influenced portions of coastal rivers. Larvae occur in or slightly downstream from spawning areas; juveniles may exhibit net upstream movement until emigration from freshwater in summer or fall (or, in some areas, the next spring).

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Fish	*Alosa mediocris*	Hickory shad	Intermediate	Adults live in saltwater except during the breeding season. Juveniles move from rivers to saltwater by fall or early winter; may linger in lower rivers, sounds, and bays before migrating to the sea. Spawning occurs as far as 200 km upstream from estuaries in creeks, ponds, lakes, and backwaters along major river courses, often in tidal freshwater areas.
Fish	*Alosa pseudoharengus*	Alewife	Intermediate	Spawn in quiet portions of rivers or streams. Larvae occur in or slightly downstream from spawning areas; juveniles may exhibit net upstream movement until leaving nursery areas in summer or fall (or, in some areas, in spring of the next year).
Fish	*Ambloplites rupestris*	Rock Bass	Intermediate	Pools and brushy margins in creeks and small to medium rivers
Fish	*Anguilla rostrata*	American Eel	Generalist	
Fish	*Campostoma anomalum*	Central Stoneroller	Intermediate	Headwater creeks and small to medium rivers with cool, clear water, moderate or sometimes rapid current, and gravel or rubble bottoms; it commonly occurs in pools with current, riffles of small rocky streams; also in medium to large rivers, and sometimes in slow-moving, turbid water
Fish	*Catostomus commersonii*	White Sucker	Generalist	Wide variety of lake and stream habitats.
Fish	*Clinostomus funduloides*	Rosyside Dace	Intermediate	Small to medium streams with clear to turbid water and moderate current, and rocky flowing pools of headwaters, creeks, and small rivers; this fish is most common in small clear streams.
Fish	*Cottus bairdii*	Mottled Sculpin	Intermediate	Clear, cold to warm (typically cool) headwaters, creeks, springs, small rivers, and lakes, with sand and gravel or (more typically) rocky substrate
Fish	*Cottus caeruleomentum*	Blue Ridge Sculpin	Specialist	Rocky riffles of headwaters and creeks, and springs. Habitat on the coastal plain is limited to cold, spring-fed streams.
Fish	*Cyprinella analostana*	Satinfin Shiner	Specialist	Rocky and sandy runs (less often pools) of creeks and small to medium rivers, usually near riffles
Fish	*Cyprinella spiloptera*	Spotfin Shiner	Intermediate	Moderate to large streams and rivers of low to high turbidity, with bottom of sand, gravel, mud or rubble
Fish	*Erimyzon oblongus*	Creek Chubsucker	Intermediate	Small rivers and creeks of various types; seldom in impoundments
Fish	*Etheostoma olmstedi*	Tessellated Darter	Intermediate	Sand- and mud-bottomed pools, slow runs, and backwaters of headwaters, creeks, and small to large rivers.
Fish	*Etheostoma sellare*	Maryland darter	SPECIALIST - May Be Extinct	Gravel riffles with rooted aquatic plants, and adjacent pools, in Deer Creek
Fish	*Exoglossum maxillingua*	Cutlip Minnow	Intermediate	Clear creeks and small to medium rivers with gravel, rubble, and boulder bottom relatively free of rooted plants; usually under or near boulders in quiet pools and runs
Fish	*Fundulus diaphanus*	Banded Killifish	Intermediate	Habitat includes quiet waters of lakes, ponds, and sluggish streams, usually over sand, gravel, or detritus-covered bottom where there are patches of submerged aquatic plants.
Fish	*Fundulus heteroclitus*	Mummichog	Specialist	Salt marsh flats, estuaries, and tidal creeks, especially where there are abundant submergent and emergent vegetation.
Fish	*Hybognathus regius*	Eastern Silvery Minnow	Intermediate	Quiet weedy inshore waters of lakes, and pools and backwaters of low gradient creeks and small to large rivers
Fish	*Hypentelium nigricans*	Northern Hogsucker	Specialist	Rocky riffles runs, and pools of clear creeks and small rivers; occasionally large rivers and impoundments
Fish	*Lepomis auritus*	Redbreast Sunfish	Intermediate	Rocky and sandy pools and margins of creeks and small to medium rivers, including tidal freshwater areas; also rocky and vegetated lake margins.
Fish	*Lepomis cyanellus*	Green Sunfish	Intermediate	Sluggish warm streams, ponds, and shallow weedy margins of lakes. Usually in vicinity of weed beds. Tolerates both clear and turbid water.
Fish	*Lepomis gibbosus*	Pumpkinseed	Intermediate	Lakes, reservoirs, ponds, sloughs, and sluggish streams; prefers quiet, clear water with aquatic vegetation and some organic debris.
Fish	*Lepomis macrochirus*	Bluegill	Generalist	Warm shallow lakes, reservoirs, ponds, swamps, sloughs, and slow-flowing rivers and streams. Bluegills are often associated with rooted aquatic plants and with bottoms of silt, sand, or gravel.
Fish	*Luxilus cornutus*	Common Shiner	Intermediate	Creeks and small to medium rivers with clear, cool weedless water, moderate to swift current, gravel to rubble bottom, and alternating pools and riffles (usually avoids riffles). Also lakes and reservoirs.
Fish	*Menidia beryllina*	Inland Silverside	Generalist	Coastal and freshwater habitats.
Fish	*Micropterus dolomieu*	Smallmouth Bass	Intermediate	Large clear lakes and clear mid-order streams with many large pools, abundant cover (rocks, shelves, logs, etc.), and cool summer temperatures.
Fish	*Morone americana*	White Perch	Intermediate	Occurs predominately in brackish water and generally close to shore in saltwater. It is common in quiet water, usually over mud, far up medium to large rivers in fresh water.

Species type	Scientific Name	Common Name	Landscape Specificity	Habitat (unless general)
Fish	*Morone saxatilis*	Striped Bass	Intermediate	Marine and estuarine coastal species that moves far upstream in channels of medium to large rivers during spawning migrations.
Fish	*Moxostoma erythrurum*	Golden Redhorse	Generalist	Creeks and small to large rivers with varied substrate; generally in pools, often over sand or silt. Occasionally in lakes. Spawns usually in runs and riffles in the main stream but may ascend small tributaries.
Fish	*Moxostoma macrolepidotum*	Shorthead Redhorse	Intermediate	Rocky pools, runs, and riffles of small to large rivers, natural lakes, and impoundments. Spawns usually over gravel in runs and riffles
Fish	*Nocomis micropogon*	River Chub	Intermediate	Swift current and flowing pools of small to medium rivers with high to moderate gradient, usually clear warm water, and gravel to boulder bottoms.
Fish	*Notemigonus crysoleucas*	Golden Shiner	Intermediate	Usually occupies clean, quiet, vegetated water with access to extensive shallows. It is generally common to abundant in ponds and lakes, and often inhabits sluggish sections of streams and rivers. It spawns over beds of submerged vegetation
Fish	*Notropis hudsonius*	Spottail Shiner	Intermediate	Large sluggish coastal rivers and brackish water to small clear rapidly flowing montane streams.
Fish	*Notropis procne*	Swallowtail Shiner	Generalist	Warm, moderate to low gradient, clear to often turbid, creeks and small to large rivers; usually occupies pools and slow runs with sand, gravel, or rock bottom
Fish	*Notropis rubellus*	Rosyface Shiner	Specialist	Typically in clear, swift, large creeks and small rivers with bottoms of clean gravel or rubble; usually in or around riffles
Fish	*Perca flavescens*	Yellow Perch	Intermediate	Usually in clear weedy backwaters or pools of creeks and small to large rivers, shallow waters of lakes, and large ponds. They occur and spawn in brackish water in some areas.
Fish	*Percina bimaculata*	Chesapeake Logperch	Intermediate	Common logperch: Small creeks to rivers, lakes, and reservoirs. Prefers clean riffles and runs over mixed sand and gravel.
Fish	*Percina peltata*	Shield Darter	Specialist	Moderate gradient riffles and runs of creeks and small to medium rivers. Most common over fine gravel on downstream side of rubble riffles. Sometimes aggregates in summer and fall in beds of aquatic plants. In same habitat all year. Eggs are buried in gravel.
Fish	*Petromyzon marinus*	Sea lamprey	Intermediate	Adults migrate from the ocean or lake to spawning streams
Fish	*Pimephales notatus*	Bluntnose Minnow	Generalist	Lakes, ponds, rivers, and creeks in a variety of habitats. Most common in clear rocky streams.
Fish	*Rhinichthys atratulus*	Eastern Blacknose Dace	Intermediate	Typically in cool, gravelly or rocky headwaters, creeks, and small rivers of high to moderate gradient; generally found in pools and slower runs. Often rests on bottom under or beside stones. Under banks in deepest water in winter. Spawns over gravel in fast water of shallow riffles.
Fish	*Rhinichthys cataractae*	Longnose Dace	Intermediate	Clean, swiftly flowing, gravel or bouldery creeks and small to medium rivers; also in inshore waters of lakes over gravel or boulder bottoms. May move offshore to deeper water in summer in warm lakes.
Fish	*Salvelinus fontinalis*	Brook trout	Specialist	Clear cool well-oxygenated creeks, small to medium rivers, and lakes. May move from streams into lakes or sea to avoid high temperatures in summer. Preferred temperature 14-16 C; does poorly where water temperature exceeds 20 C for extended periods. Spawns usually over gravel beds in shallow headwaters. Eggs buried in nest in gravel.
Fish	*Sander vitreus*	Walleye	Intermediate	Lakes; pools, backwaters, and runs of medium to large rivers; generally in moderately deep waters.
Fish	*Semotilus atromaculatus*	Creek Chub	Intermediate	Clear headwaters, creeks, and small rivers; prefers streams less than 12 m wide and with gravel-sand-silt substrate; occasionally in shallows of small clear lakes. Spawns in small gravelly streams in smooth water near a riffle, or over littoral areas of gravel in lakes.
Fish	*Semotilus corporalis*	Fallfish	Specialist	Clear, flowing, gravel- to rubble-bottomed small to medium rivers; lake margins. Young occur in more rapid water upstream but large adults seem to seek large pools and expanded regions of the lower reaches.
Fish	*Umbra pygmaea*	Eastern Mudminnow	Intermediate	Quiet, mud-bottomed, often heavily vegetated streams, sloughs, swamps, and ponds, particularly along margins, over sand, mud, and debris.
Mollusk	*N/A*	Freshwater mussel spp.	N/A	Perennial streams with good water quality. Primary threats include impoundments, channelization, pollution, and sedimentation.

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Core area focal species

Core area type	Landscape feature	Focal species or criteria	Optimal habitat	Size	GIS delineation
aquatic	Nontidal wadeable streams (1st-3rd order)	Pollution-sensitive fish and invertebrates	Stream reaches with "Good" combined (fish + benthic macroinvertebrate) IBI scores (>4), which can indicate good water quality and stream habitat.		Stream reaches with (a) "Good" combined (fish + benthic macroinvertebrate) MBSS IBI scores, or (b) MDE Tier II designation; plus associated 500-year floodplain
aquatic	Tidal streams and rivers	Anadromous fish, Mummichog, native submerged grasses	High Priority Blue Infrastructure		Stream reaches in High Priority Blue Infrastructure catchments, plus associated 500-year floodplain
aquatic	Offshore water	Striped bass, native submerged grasses	High Priority Blue Infrastructure		Open water in High Priority Blue Infrastructure catchments, plus associated shoreline
aquatic	Coldwater streams	Eastern Hellbender, Brook trout, Northern red salamander	Cold water (<20C) natural streams with stable hydrology and geomorphology, rocky or gravelly substrate, riffles and pools, perennial flow, minimal pollution, high D.O., low sedimentation, unimpounded, unchannelized, and riparian forest on both banks		Stream reaches containing hellbenders, brook trout, or northern red salamanders, plus associated 500 year floodplain
aquatic	Non-tidal rivers (typically, at least 4th order)	Pollution-sensitive fish	Natural rivers with stable hydrology and geomorphology, riffles and pools, minimal pollution, high D.O., low sedimentation, unimpounded, unchannelized, and riparian forest on both banks		Deer Creek and Little Gunpowder Falls (contain Tier II High Quality Waters) small river sections, plus 500-year floodplain
aquatic	Streams and rivers connected to the ocean	Anadromous fish	Natural streams and rivers with stable hydrology and geomorphology, riffles and pools, minimal pollution, high D.O., low sedimentation, unimpounded, unchannelized, riparian forest on both banks, and connected to the ocean.	<500 km from the ocean, without dams or other barriers	Streams supporting anadromous fish, plus associated 500-year floodplain
forest	Mature broadleaf forest	Forest interior breeding birds	Presence of 100+ yr old trees, a variety of ages and sizes of trees, a mix of native species dominated by oak in the canopy (25% oak), presence of herbaceous and shrub layers in patches/variability, presence of standing dead trees/snags, downed logs and woody debris, thick leaf litter/organic matter in duff, and occasional canopy gaps due to tree fall.	>100 ha of interior forest (>100 m from edges), preferably >700 meters maximum depth, and preferably >80% forest cover within 2 km of the centroid.	Forest blocks with >100 ha of interior forest (>100 m from edges)
forest	Mature broadleaf forest	Cooper's hawk, Red-shouldered hawk, Broad-winged hawk, Pileated Woodpecker, Worm-eating warbler, Wood thrush, Black-and-white warbler, Kentucky warbler, Hairy woodpecker, Scarlet tanager, Ovenbird, American redstart, Yellow-throated vireo, Red-eyed vireo	Mature broadleaf interior forest, preferably containing streams or other surface water, with large trees, a tall closed canopy, a mix of native hardwood species (including oaks), structural complexity (including some areas with thick subcanopies, some with thick shrub layers, and some with thick herbaceous layers), presence of snags, downed logs and woody debris, deep leaf litter, and occasional canopy gaps due to tree falls.	>100-300 ha (the larger, the better), with most >100m from edge. Blocks >4000 ha are optimal for all spp.	Forest blocks containing nests of these indicator birds
forest	Mature broadleaf forest	Cerulean warbler	Large tracts of mature, semi-open deciduous interior forest, particularly in floodplains or other mesic conditions.	>4000 ha, with most >400m from the edge	Forest blocks containing Cerulean warbler nests

Core area type	Landscape feature	Focal species or criteria	Optimal habitat	Size	GIS delineation
forest	Riparian forest	Stream salamanders	Streams (perennial or intermittent) with good water quality and riparian hardwood forest.	At least 93m of forest on each side of stream (salamanders)	Riparian forest at least 93 m from stream reaches with (a) "Good" combined (fish + benthic macroinvertebrate) MBSS IBI scores, or (b) MDE Tier II designation (see aquatic cores)
forest	Riparian forest	Acadian flycatcher	Large tracts of mature riparian deciduous forest, with a high dense canopy and a relatively open understory.	>30-120 ha, and >150m wide	Riparian deciduous forest >30 ha, and >150m wide
forest	Riparian forest	Louisiana waterthrush	Riparian deciduous forest along natural perennial streams at least 300m wide.	>100 ha of interior forest (>100 m from edges)	Forest blocks containing Louisiana waterthrush nests
forest	Riparian forest	Hooded warbler	Large tracts of mature deciduous forest with a dense shrub layer, and containing streams.	>30-600 ha of forest, mostly interior (>100 m from edges)	Forest blocks containing Hooded warbler nests
forest	Riparian forest	Wood turtle	Riparian forest along natural perennial streams	2km of streams with 150-300m of natural buffer	Forest blocks containing Wood turtles
forest	Pine forest	Pine warbler	Pine forest at least 40 years old	>=30 ha	Forest blocks containing Pine warbler nests
forest	Young deciduous forest	Whip-poor-will	Young to mid-aged deciduous forest with fields nearby	>120-400 ha (pref. 64,000 ha)	Forest blocks containing Whip-poor-will nests
forest	Scrub-shrub	Blue-winged warbler, Prairie warbler	Scrub-shrub or early successional forest (preferably <3m tall)	10-15 ha	Forest blocks containing Blue-winged warbler or Prairie warbler nests
forest	Natural forest (in general)	Natural forest communities	Large enough and far enough from edges, roads, and trails to provide resistance against invasive plants.	>400m from forest edges or trails and >1 km from developed land.	Forest blocks with interior area(s) >400m from forest edges or trails and >1 km from developed land
wetland	Wetlands of special concern		Wetlands of special state concern	N/A	Wetlands of special state concern plus min. 100 ft buffer
wetland	Forested wetland	Northern parula, Prothonotary warbler, Barred owl	Large blocks of mature bottomland hardwood forest (floodplains or swamps) containing standing water, and usually with streams	>100 ha of interior forest (>100 m from edges)	Forest blocks containing Northern parula, Prothonotary warbler, or Barred owl nests
wetland	Forested wetland	Wood duck	Large blocks of mature bottomland hardwood forest (floodplains or swamps) and adjacent open water	>200 ha	Forest blocks containing productive wood duck nests
wetland	Vernal pools	mole salamanders, wood frog	Unpolluted ephemeral pools (vernal pools) with at least 215m of surrounding forest.	>=215m of surrounding forest	Forest blocks containing vernal pools at least 215 m from the nearest edge
wetland	Fens and sedge meadows	Bog turtle	Unpolluted herbaceous sedge meadows and fens, usually spring-fed, bordered by more thickly vegetated and wooded areas. Includes slow, shallow, muck-bottomed rivulets of sphagnum bogs, calcareous fens, marshy/sedge-tussock meadows, spring seeps, wet cow pastures, and shrub swamps; the habitat usually contains an abundance of sedges or mossy cover.	>0.2 ha on natural or agricultural land	Bog turtle locations and catchments
wetland	Marsh	Least bittern, King rail, Marsh wren, Marsh rice rat, Muskrat	Unimpaired freshwater or brackish marshes with tall emergent vegetation.	>5 ha, with 30m upland buffer	Marsh blocks >5 ha, with 30m upland buffer

Core area type	Landscape feature	Focal species or criteria	Optimal habitat	Size	GIS delineation
wetland	Open water with turtle nesting areas nearby	Freshwater turtles	Unpolluted wetlands, ponds, and other bodies of open water, with open nesting areas with sandy or loamy soil within 100m. The nesting sites should not be subject to frequent disturbance.	>=100m buffer (preferably >=275m)	Turtle nesting sites and nearby water bodies and intervening land
wetland	Mudflats	Least tern	Shallow water of ponds, lakes, swamps, or lagoons.	?	Nest locations of least terns
grassland	Open fields and meadows	Grasshopper sparrow, Eastern meadowlark	Grasslands of intermediate height and often with clumped vegetation interspersed with patches of bare ground. Other habitat requirements include moderately deep litter and sparse coverage of woody vegetation. Undisturbed during breeding.	>=30 ha	Grassland patches containing Grasshopper sparrow or Eastern meadowlark nests
grassland	Old fields	Breeding grassland bird diversity	Old fields with some woody vegetation, or adjacent shrubs	>=30 ha	Grassy patches not mowed between spring and fall, and >=30 ha

Hub focal species

Landscape feature	Focal species	Habitat	Hub size (ha)
Forest hubs	Gray fox	Forest. Usually avoids open areas.	hundreds
Riparian forest hubs	River otter	Open water (e.g., perennial streams, ponds) with riparian forest	hundreds
Riparian forest hubs	Beaver	Riparian forest (2nd - 4th order streams or ponds)	>125
Forest hubs with nearby fields	Bobcat	Primarily large tracts of non-flooded forest, including edges. Requires relatively low levels of human activity.	hundreds
Forest hubs with nearby fields	Wild turkey	Mature forest with clearings or fields nearby	hundreds
Forest hubs with nearby fields	Great horned owl	Medium to large blocks of forest with large trees and nearby fields	hundreds
Wetland hubs with nearby fields	Barn owl	Need large grassland or wet meadow areas for foraging and nest in tree cavities (which also could occur in wetlands).	hundreds
Aquatic hubs	Pollution-sensitive fish and invertebrates	Catchments containing core aquatic areas	

Connectivity focal species

Core areas	Focal species	Best linkages	Search radius (km)
All core forest	Forest mammals, wild turkey, five-lined skink	Forest cover with interior habitat	10
Riparian forest and wetlands	River otter, mink, beaver, turtles, semi-aquatic snakes, salamanders, frogs	Wide riparian forest and wetlands preferred. Other wetlands and forest are generally better than open areas.	5
Wetlands (forested wetlands or vernal pools)	Salamanders, frogs, turtles	Moist woods with vernal pools, wetlands, and unpolluted streams	5
Wetlands (marsh)	Muskrat, marsh rice rat, meadow jumping mouse	Marsh, waterways	3
Wetlands (herbaceous fens, bogs, and sedge meadows)	Bog turtle	Clean streams in sedge meadows, fens, bogs, etc.	3
Streams and rivers	Fish and mussels	Unblocked perennial streams with unpolluted water	10
Meadows	Meadow butterflies	Old fields, pasture, or powerline corridors	10

Note: For all target species, urban areas and major roads (except under bridges) were considered barriers. Some species like turtles may avoid steep slopes (e.g., ravine sides). Linkages should pass through hubs and protected land where possible; hubs because they represent larger, more intact natural areas, and protected land to ease corridor implementation.

APPENDIX C: Harford County Natural Resource Identification

1. Forest

1.1. Forest patches with at least 1 ac of interior

1.1.1. Rationale:

1.1.1.1. Forest edges contain significant gradients of solar radiation, temperature, wind speed, and moisture between the forest patch interior and the adjacent land, especially if the adjacent land is developed. Increased solar radiation at the edge increases temperatures and decreases soil moisture and, with increased wind flow, decreases relative humidity, which can desiccate plants. Increased wind speed at a newly created edge commonly knocks down trees that are no longer buffered by adjacent canopy and not structurally prepared. This poses a problem especially for wetland trees, which have shallow roots and less stable soil. Wind can also carry dust or other small particles, which can adhere to vegetation. Noise from developed land disrupts natural activity in adjacent forest or marsh, by drowning wildlife cues for territorial boundary establishment, courtship and mating behavior, detection of separated young, prey location, predator detection, and homing. Sudden loud noises can also cause stress to animals. Changes in insolation and other physical parameters at created edges change plant and animal communities there, and processes like nutrient cycling.

1.1.1.2. Since the eastern U.S. was primarily unbroken forest prior to European colonization, many species are adapted to interior forest conditions. Edge habitat differs from interior forest in tree species composition, primary production, structure, development, animal activity, and propagule dispersal capabilities. The edge communities shift to more shade-intolerant, more xeric tree and shrub species, and early successional species. These then broadcast propagules that invade the forest interior. Edges can favor invasive species, which can then displace native species in adjacent areas. Opportunistic animals like raccoons, opossums, and cowbirds also colonize patch edges, and often invade the interior. These edge species often influence ecosystem dynamics by preying on, outcompeting, or parasitizing interior species. Cats and dogs from developed areas can also prey on or harass wildlife.

1.1.1.3. Source: Maryland's Green Infrastructure Assessment: A Comprehensive Strategy for Land Conservation and Restoration. http://www.dnr.state.md.us/greenways/gi/gidoc/gidoc.html.

1.1.2. Data layer: D:\Harford_GI\Harford_GI_GIS\forest\for_w_1ac_int

1.1.2.1. ESRI Grid format; cell size = 3 m

1.1.2.2. Took too long to run computations at 1 m, and possible some computations would not run at all.

1.1.3. Methodology:

1.1.1.1. Identify tree canopy from HARF_24025_USGS.tif. This layer was missing data for Aberdeen Proving Ground. It was more spatially accurate than layer Vegetation_2013.

1.1.1.2. Identify orchards from layer Vegetation_2013.

1.1.1.3. Convert building polygons and parking lots to grid format.

1.1.1.4. Select impervious road surfaces (IMPERVIOUS = "YES") & convert polygons to grid format.

1.1.1.5. Convert 2014 impervious surfaces to grid format (a lot of redundancy with above layers but not 100%).

1.1.1.6. Select active railroads and buffer lines by 2 meters (based on aerial photos). Then convert polygons to grid format.
1.1.1.7. Buffer power lines 10 meters (based on aerial photos) and convert polygons to grid format.
1.1.1.8. Convert road and railroad centerlines to grids so there are no artificial breaks as happens when converting polygons to grids.
1.1.1.9. Subtract impervious surfaces, roads, railroads, power line corridors, and orchards from tree canopy.
1.1.1.10. Identify interior forest (>30 m from nearest edge)
1.1.1.11. Identify contiguous groupings of at least 1 ac of interior forest, and add 30 m transition back.

2. Wetlands

2.1 Wetlands and minimum regulatory buffer
2.1.1. Rationale: Regulated
2.1.2. Note - This does not include expansions to include:
2.1.2.1. Slopes of 15% or greater (e.g., at a rate of 4' for every 1% of slope or to the top of the slope, whichever is greater)
2.1.2.2. Nontidal wetlands of special State concern (which are addressed under special habitat)
2.1.2.3. Adjacent highly erodible or hydric soils (e.g., to the lesser of the landward edge or 300 feet)
2.1.2.4. To note, an effective buffer width will vary according to type of wetland, sensitivity to disturbance, intensity of adjacent land use, groundwater depth and hydraulic conductivity, proximity and characteristics of drainage ditches and other water control structures, slope and soil characteristics, species present, and buffer characteristics such as vegetation density and structural complexity, soil condition, etc. (Brown et al, 1990; North Carolina State University, 1998).
2.1.3. Data layer: Harford_wetland_min_buffers.shp
2.1.3.1. ESRI shapefile
2.1.4. Methodology:
2.1.4.1. From DNR wetland layer, remove wetlands not within 200 m of the County boundary (distance added because boundary did not include open water).
2.1.4.2. Remove farmed wetlands ("Pf") and permanent open water.
2.1.4.3. Identify tidal vs. non-tidal wetlands
2.1.4.4. Tidal wetlands have a minimum buffer of 100 feet
2.1.4.5. For non-tidal wetlands, Harford County has a minimum buffer of 75 feet.
2.2. Wetlands of Special State Concern + 100 ft buffer
2.2.1. Rationale: Regulatory
2.2.2. In Maryland certain wetlands with rare, threatened, endangered species or unique habitat receive special attention. The Code of Maryland Regulations (COMAR) Title 26, Subtitle 23, Chapter 06, Sections 01 & 02 identifies these Wetlands of Special State Concern (WSSC) and affords them certain protections including a 100 foot buffer from development. The Maryland Department of the Environment is responsible for identifying and regulating these wetlands. In general, the US Fish and Wildlife Service's National Wetlands Inventory wetlands provide the basis for identifying these special wetlands. Additional information, determined from field inspections, is used to identify and classify these areas.
2.2.3. Data layer: Harford_WSSC_100ft_buffers.shp
2.2.3.1. ESRI shapefile

2.2.4. Methodology:
2.2.4.1. Downloaded; see metadata.
2.2.4.2. Buffer 100 feet

3. Floodplains

3.1. 1% (100 year) floodplain
3.1.1. Rationale: Regulated
3.1.2. Data layer: Floodplain.shp
3.1.2.1. ESRI shapefile
3.2. 0.2% (500 year) floodplain
3.2.1. Rationale: Areas vulnerable to severe storms. E.O. 13690 (1/30/15) established a new standard for flood risk reduction, which included delineating floodplains based on:
3.2.1.1. "(i) the elevation and flood hazard area that result from using a climate-informed science approach that uses the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science. This approach will also include an emphasis on whether the action is a critical action as one of the factors to be considered when conducting the analysis;
3.2.1.2. "(ii) the elevation and flood hazard area that result from using the freeboard value, reached by adding an additional 2 feet to the base flood elevation for non-critical actions and by adding an additional 3 feet to the base flood elevation for critical actions;
3.2.1.3. "(iii) the area subject to flooding by the 0.2 percent annual chance flood; or
3.2.1.4. "(iv) the elevation and flood hazard area that result from using any other method identified in an update to the FFRMS."
3.2.2. Data layer: 500_YR_FLOODPLAIN.shp
3.2.2.1. ESRI shapefile

4. Riparian buffers

4.1. Regulated stream buffers vary in width
4.1.1. The Natural Resource District for all perennial and intermittent streams shall be a minimum of 75 feet on both sides, measured from the top of the streambank or 50 feet beyond the 100-year floodplain, whichever is greater. For all streams that have a drainage area of more than 400 acres, as depicted on the Harford County Hydrology/Drainage Area Map, which is incorporated herein by reference, the Natural Resource District shall be expanded to a minimum distance of 150 feet on both sides, measured from the top of the streambank or 50 feet beyond the 100-year floodplain, whichever is greater.
4.1.2. Data layer: ha_stream_buffers.shp
4.1.2.1. ESRI shapefile
4.1.3. Methodology:
4.1.3.1. Extracted streams/rivers from County hydrology lines & buffered 75 ft.
4.1.3.2. Extracted streams/rivers from County hydrology polygons & buffered 75 ft.
4.1.3.3. Add 150-foot buffers around major streams (new150buffer_ActualBufferArea.shp)
4.1.3.4. Buffer 100 year floodplains 50 feet
4.1.3.5. Union above buffers
4.1.3.6. Dissolve overlaps

5. Steep slopes

5.1. Slopes >25%

5.1.1. Steep slopes (>25% in Harford County) are designated as Natural Resource Districts if >40,000 ft2, and protected from development.

5.1.2. Data layer: over25over40k.shp

5.1.2.1. ESRI shapefile provided by Harford County

6. Highly erodible soils

6.1. "Highly erodible soils" are defined as those soils with a slope greater than 15 percent or those soils with a K value greater than 0.35 and with slopes greater than 5 percent. Harford County protects erodible soils when they occur in the Critical Area (usually within 1000' of tidal shorelines/wetlands), and if they occur within the Critical Area Buffer, we extend the buffer to incorporate erodible soils.

6.1.1. Rationale: Regulatory (only within the Critical Area)

6.1.2. Data layer: high_erodible

6.1.2.1. ESRI grid

6.1.3. Slopes >15%

6.1.3.1. Slope grid was obtained from http://lidar.geodata.md.gov/imap/services

6.1.3.2. Reclassify slope values >15% to a value of 1; elsewhere No Data.

6.1.4. Soils with K > 0.35 and slopes > 5%

6.1.4.1. Used gridded SSURGO (gSSURGO_MD.gdb)

6.1.4.2. Joined table "component" based on field "mukey" (aka Mapunit Key)

6.1.4.3. Joined table "chorizon" based on field "component.cokey"

6.1.4.4. Reclassified K factors (field "kffact") > 0.35 to 1; elsewhere to 0.

6.1.4.5. As is common with soil data, which is compiled by County, values were inconsistent across County lines.

6.1.4.6. Reclassify slope values >5% to a value of 1; elsewhere No Data.

6.1.4.7. Multiply by soils with K > 0.35.

6.1.4.7.1. Grid of highly erodible soils with slope >5% is K_gt35_sl_gt5

6.1.5. Mosaic the above two grids

6.1.5.1. Grid: high_erodible

APPENDIX D: Harford County Green Infrastructure Network Identification Methodology

Core areas

1. Core aquatic areas
    1.1. Identify riparian zones
        1.1.1. Used regulated stream buffers
        1.1.2. Regulated stream buffers vary in width
            1.1.2.1. The Natural Resource District for all perennial and intermittent streams shall be a minimum of 75 feet on both sides, measured from the top of the streambank or 50 feet beyond the 100-year floodplain, whichever is greater. For all streams that have a drainage area of more than 400 acres, as depicted on the Harford County Hydrology/Drainage Area Map, which is incorporated herein by reference, the Natural Resource District shall be expanded to a minimum distance of 150 feet on both sides, measured from the top of the streambank or 50 feet beyond the 100-year floodplain, whichever is greater.
            1.1.2.2. Data layer: ha_stream_buffers.shp
            1.1.2.3. Methodology:
                1.1.2.3.1. Extracted streams/rivers from County hydrology lines and buffered 75 feet.
                1.1.2.3.2. Extracted streams/rivers from County hydrology polygons and buffered 75 feet.
                1.1.2.3.3. Add 150 foot buffers around major streams (new150buffer_ ActualBufferArea.shp)
                1.1.2.3.4. Buffer 100 year floodplains 50 feet
                1.1.2.3.5. Union above buffers
                1.1.2.3.6. Dissolve overlaps
    1.2. Nontidal wadeable streams (1st-3rd order)
        1.2.1. Focal species: Pollution-sensitive fish and invertebrates
        1.2.2. Optimal habitat: Stream reaches with "Good" combined (fish + benthic macroinvertebrate) IBI scores (>4), which can indicate good water quality and stream habitat.
        1.2.3. Identify stream reaches with "Good" combined (fish + benthic macroinvertebrate) MBSS IBI scores
        1.2.4. Add stream reaches with MDE Tier II designation
        1.2.5. Add associated riparian zone
    1.3. Stronghold watersheds
        1.3.1. Focal species: Four aquatic-dependent rare species: Chesapeake logperch, Shield darter, Bog turtle, and Creeper (a species of mussel)
        1.3.2. DNR provided a map of HUC12 stronghold watersheds in Harford County, which support populations of these species.
        1.3.3. Select connected streams (i.e., not isolated by impoundment dams, etc. in these watersheds.
        1.3.4. Add associated riparian zones.
    1.4. Coldwater streams
        1.4.1. Focal species: Brook trout

1.4.2. Optimal habitat: Cold water (<20C) natural streams with stable hydrology and geomorphology, rocky or gravelly substrate, riffles and pools, perennial flow, minimal pollution, high D.O., low sedimentation, unimpounded, unchannelized, and riparian forest on both banks.

1.4.3. Identify streams containing brook trout. DNR Freshwater Fisheries provided a map of HUC12 watersheds that contain brook trout, and wrote, "It is our belief that during the cooler months of the year brook trout use the main rivers in these two watersheds. During the hot months of the year, the brook trout are seeking thermal refuge from the warmer water in the main rivers. This most likely means that they are confined to tributaries with the cold water, but there is a possibility that do find cold water upwellings in the main rivers."

1.4.4. Select connected streams (i.e., not isolated by impoundment dams, etc.) in these watersheds.

1.4.5. Add associated riparian zones.

1.4.6. Northern red salamanders found in most spring-fed streams, typically in Piedmont. These were a better indicator of springs than streams.

1.4.7. Hellbenders apparently extirpated from County; not found in recent surveys

1.5. Non-tidal rivers (typically, at least 4th order)

1.5.1. Focal species: Pollution-sensitive fish

1.5.2. Optimal habitat: Natural rivers with stable hydrology and geomorphology, riffles and pools, minimal pollution, high D.O., low sedimentation, unimpounded, unchannelized, and riparian forest on both banks.

1.5.3. Identify Deer Creek and Little Gunpowder Falls (contain Tier II High Quality Waters) river sections from Harford flowlines NAHCS.

1.5.4. Add associated riparian zone

1.6. Tidal rivers and Chesapeake Bay

1.6.1. Focal species: Anadromous fish, mummichog, native submerged grasses

1.6.2. Optimal habitat: High Priority Blue Infrastructure, SAV beds, anadromous fish spawning and juvenile habitat

1.6.3. Identify High Priority Blue Infrastructure coastal watersheds

1.6.4. Identify 2015 SAV beds

1.6.5. Add striped bass spawning habitat

1.6.6. Add herring and perch spawning and juvenile habitat

1.6.7. Clip to Blue Infratructure nearshore segments (out to a depth of 2 meters) and shoreline buffers (up to 100 m from shoreline).

1.6.8. Note: All 263 segments fell into one or more of these habitat categories.

1.7. Combine

1.7.1. Created model to run much of this.

2. Core Wetlands

2.1. Identify wetlands and minimum regulatory buffer

2.1.1. Note - This does not include buffer expansions to include:

2.1.1.1. Slopes of 15% or greater (e.g., at a rate of 4' for every 1% of slope or to the top of the slope, whichever is greater)

2.1.1.2. Nontidal wetlands of special State concern (which are addressed under special habitat)

2.1.1.3. Adjacent highly erodible or hydric soils (e.g., to the lesser of the landward edge or 300 feet)

2.1.1.4. To note, an effective buffer width will vary according to type of wetland, sensitivity to disturbance, intensity of adjacent land use, groundwater depth and hydraulic conductivity, proximity and characteristics of drainage ditches and other water control structures, slope and soil characteristics, species present, and buffer characteristics such as vegetation density and structural complexity, soil condition, etc.

2.1.2. Data layer: Harford_wetland_min_buffers.shp

2.1.3. Methodology:

2.1.3.1. From DNR wetland layer, remove wetlands not within 200 m of the County boundary (distance added because boundary did not include open water).

2.1.3.2. Remove farmed wetlands ("Pf") and permanent open water.

2.1.3.3. Identify tidal vs. non-tidal wetlands

2.1.3.4. Tidal wetlands have a minimum buffer of 100 feet

2.1.3.5. For non-tidal wetlands, Harford County has a minimum buffer of 75 feet.

2.2. Wetlands of Special State Concern + 100 ft buffer

2.2.1. In Maryland certain wetlands with rare, threatened, endangered species or unique habitat receive special attention. The Code of Maryland Regulations (COMAR) Title 26, Subtitle 23, Chapter 06, Sections 01 & 02 identifies these Wetlands of Special State Concern (WSSC) and affords them certain protections including a 100 foot buffer from development. The Maryland Department of the Environment is responsible for identifying and regulating these wetlands. In general, the US Fish and Wildlife Service's National Wetlands Inventory wetlands provide the basis for identifying these special wetlands. Additional information, determined from field inspections, is used to identify and classify these areas.

2.2.2. Data layer: Harford_WSSC_100ft_buffers.shp

2.2.3. Methodology:

2.2.3.1. Downloaded WSSC.

2.2.3.2. Buffer 100 feet

2.3. Identify wetlands that have not been farmed, drained, ditched, or excavated.

2.3.1. Note: impounded wetlands (-b; -h) often provide good habitat

2.3.2. Note: filled (-s) may only be a small portion of the wetland, and this is not generally labeled consistently

2.3.3. ("CLASS" LIKE '%f') OR ("CLASS" LIKE '%d') OR ("CLASS" LIKE '%x')

2.4. Separate remaining wetlands into three different types: forested, shrub, emergent, and non-vegetated (e.g., mudflats; river bars). Open water falls under aquatic.

2.5. Compatible land cover includes unimpaired wetlands, forest patches, and open water.

2.6. Identify unimpaired wetlands (or portions of wetlands) that are at least 30 m from cleared or developed land, roads, railroads, ditches, or channelized streams.

2.7. Add 30 m buffers

2.8. Add WSSC's + 100 ft buffers (even if not all the land cover is natural).

3. Core Forest

3.1. Background:

3.1.1. Forest edges contain significant gradients of solar radiation, temperature, wind speed, and moisture between the forest patch interior and the adjacent land, especially if the adjacent land is developed. Increased solar radiation at the edge increases temperatures and decreases soil moisture and, with increased wind flow, decreases relative humidity, which can desiccate plants. Increased wind speed at a newly created edge commonly knocks down trees that are no longer buffered by adjacent canopy and not structurally prepared. This poses a problem especially for wetland trees, which have shallow roots and less stable soil. Wind can also carry dust or other small particles, which can adhere to vegetation. Noise from developed land disrupts natural activity in adjacent forest or marsh, by drowning wildlife cues for territorial boundary establishment, courtship and mating behavior, detection of separated young, prey location, predator detection, and homing. Sudden loud noises can also cause stress to animals. Changes in insolation and other physical parameters at created edges change plant and animal communities there, and processes like nutrient cycling.

3.1.2. Since the eastern U.S. was primarily unbroken forest prior to European colonization, many species are adapted to interior forest conditions. Edge habitat differs from interior forest in tree species composition, primary production, structure, development, animal activity, and propagule dispersal capabilities. The edge communities shift to more shade-intolerant, more xeric tree and shrub species, and early successional species. These then broadcast propagules that invade the forest interior. Edges can favor invasive species, which can then displace native species in adjacent areas. Opportunistic animals like raccoons, opossums, and cowbirds also colonize patch edges, and often invade the interior. These edge species often influence ecosystem dynamics by preying on, outcompeting, or parasitizing interior species. Cats and dogs from developed areas can also prey on or harass wildlife.

3.1.3. Age, structure, composition, disturbance history, etc. of forest is often more important to functions like wildlife habitat than patch size. This information was not readily available throughout the County.

3.1.4. Note: took too long to run computations at 1 m, so we ran at 3 m.

3.2. Forest patches with at least 1 acre of interior (>30 m from edges)

3.2.1. We decided that this would be the minimum patch size for consideration. Forest patches dominated by edge effects may not contain suitable conditions for forest obligates.

3.2.2. Identify tree canopy from HARF_24025_USGS.tif. This layer was missing data for Aberdeen Proving Ground. It was more spatially accurate than layer Vegetation_2013.

3.2.3. Identify orchards from layer Vegetation_2013.

3.2.4. Convert building polygons and parking lots to grid format.

3.2.5. Select impervious road surfaces (IMPERVIOUS = "YES") and convert polygons to grid format.

3.2.6. Convert 2014 impervious surfaces to grid format (a lot of redundancy with above layers but not 100%).

3.2.7. Select active railroads and buffer lines by 2 meters (based on aerial photos). Then convert polygons to grid format.

3.2.8. Buffer powerlines 10 meters (based on aerial photos) and convert polygons to grid format.
3.2.9. Convert road and railroad centerlines to grids so there are no artificial breaks as happenes when converting polygons to grids.
3.2.10. Subtract impervious surfaces, roads, railroads, powerline corridors, and or chards from tree canopy.
3.2.11. Identify interior forest (>30 m from nearest edge)
3.2.12. Identify contiguous groupings of at least 1 ac of interior forest, and add 30 m transition back.
3.2.13. Data layer: D:\Harford_GI\Harford_GI_GIS\forest\for_w_1ac_int
3.2.13.1. ESRI Grid format; cell size = 3 m

3.3. Forest paches with >100 ha (250 ac) of interior forest (>100 m from edges)
3.3.1. This patch size and depth is based on habitat requirements for forest interior birds (FIDS) in Maryland (Bushman and Therres, 1988).
3.3.2. There were only 5 such patches: one privately owned west of Abingdon along Haha Branch, one centered on Stoney Demonstration Forest, one privately owned along Gray's Run, and two near Lake Aaron Straus.

3.4. Key forest patches would best be identified from the ≥1 interior acre subset through presence of indicator species or surveys of forest quality. We lacked such data, though.

3.5. Calculate area of each forest patch with ≥1 acre of interior. Area calculated here includes the 30 m edge transition.

Patch area (ac)	% of patches	% of area
0 - 10	38%	5%
10 - 30	32%	12%
30 - 100	19%	22%
100 - 250	7%	24%
250 - 1092	4%	37%

3.6. From above, identify forest patches ≥100 acre (only 11% of patches, but 61% of area)

3.7. Add forest patches that overlap core aquatic areas, core wetlands, and BioNet Tiers 1-4.
3.7.1. 1106 out of 1649 forest patches met one or more of these four criteria.
3.7.2. These were designated core forest.

4. Core Grassland - unable to identify grassland habitat
4.1. Identify grasslands
4.1.1. From land cover (HARF_24025_USGS.tif), select Low Vegetation
4.1.2. From Cropland Data Layer (CDL; 12/12/2016 publication), select Pasture/Grass and Grassland Herbaceous
4.1.3. There wasn't any of the above mapped in Harford County.

5. Combine core areas. Remove developed land and add forest within these areas.
5.1. Convert polygons to rasters with value of 1.
5.1.1. Used same map extent and cell size (3 m) as the forest grid
5.2. Mosaic rasters together and remove areas outside the County or in APG.

5.3. Subtract impervious surfaces from fine-scale land cover and other data (see forest patch methodology)
5.4. Add adjacent tree cover
5.5. Remove areas only tenuously connected (<30 m wide) to core forest, wetland, or aquatic areas.
5.6. Remove areas <1 ac
5.7. Add core aquatic areas back in.
5.8. Resultant layer had some areas of questionable habitat value; e.g. lawns within floodplains. However, such areas may provide ecological services other than wildlife habitat, like flood attenuation.
5.9. Clip to County boundary, not including APG.

Hubs

1. Buffer core areas 100 m
2. Add small areas (<10 acres) within buffers
    2.1. 1 cell = 9 m2 = 0.00222395 acre.
    2.2. 10 acres = 4497 cells
3. Subtract major roads
    3.1. Data source: Centerline_August_2017
    3.2. Select speed ≥40 mph
    3.3. Also select interstate and state highways (shield = I or S)
    3.4. Save as Harford_major_roads.shp
    3.5. Convert to grid and subtract from core area buffers
4. Subtract areas within 30 m of buildings
5. Subtract parking lots
6. Add core areas back in
7. Remove areas only tenuously connected (<30 m wide) to core areas.
8. Clip to County boundary, not including APG.
9. Apply size threshold of 250 ac (112,444 cells)

Corridors

Had to run this at 10 m due to computer constraints.

Forest Corridors

1. Set environments and resample core forest
    a. Set projection (Maryland State Plane, NAD 1983, meters), snap, mask & cell size (10 m).
    b. Resample or re-rasterize data to this.

Forest movement impedance

1. Bridges
    a. Select bridges (from County data) over streams or other open water (field "OVER_"; some bridges are over other roads).
    b. Based on examination of data, buffer 20 meters
    c. From Hydrology_Lines, select FTYPE = stream/river, canal/ditch, artificial path
    d. From Hydrology_Polygons, select all except dam/weir
    e. From land cover, select water and wetlands
    f. Identify water within 20 meters of bridge points.
    g. Assign these areas the same code as Water in the land cover raster (1).

2. Water
    a. From Hydrology_Polygons, select ("DESCRIPTIO" = 'LAKE/POND') OR ("DESCRIPTIO" = 'STREAM/RIVER') OR ("DESCRIPTIO" = 'RESERVOIR') OR ("DESCRIPTIO" = 'CANAL/DITCH') OR ("DESCRIPTIO" = 'DITCH_CONC') OR ("DESCRIPTIO" = 'SPILLWAY')
    b. Assign these areas the same code as Water in the land cover raster (1).
    3. Assign buildings the same code as Structures in the land cover raster (7).
    4. Assign major roads a unique code (99)
    5. Assign roads and road lines the same code as Roads in the land cover raster (9).
    6. Assign parking lots the same code as Impervious Surfaces in the land cover raster (8).
    7. Assign railroads and rail lines the same code as Impervious Surfaces in the land cover raster (8).
8. Assign utility ROWs the same code as Low Vegetation in the land cover raster (5).
9. Assign orchards the same code as Shrubland in the land cover raster (4).
10. Overlay buildings, bridges, major roads, other roads, railroads, utility ROWs, and orchards over land cover data. Save as grid bldg_rd_rr_lc.
11. Based on tests while performing the Greater Baltimore Wilderness resiliency assessment, reclass modified land cover as follows (No Data = impassable for non-aerial forest animals):

Code	Description	Forest Corridor Impedance
1	Water	250
2	Wetlands	20
3	Tree Canopy	10
4	Shrubland	20
5	Low Vegetation	50
6	Barren	250
7	Structures	No Data
8	Impervious Surfaces	1250
9	Impervious Roads	1250
10	Tree Canopy over Structures	No Data
11	Tree Canopy over Impervious Surfaces	1250
12	Tree canopy over Impervious Roads	1250
13	Aberdeen Proving Ground	No Data
No Data	Outside County	No Data

    a. Give major roads an impedance of No Data (impassable except under bridges)
    b. Grid name: imp_lc_x5
6. Interior forest
    a. Reclass distance from forest edge (using grid tree_patches) as follows:

Distance from Forest Edge	Divide Impedance By:
> 100 m	3
30 - 100 m	2
< 30 m, or non-forest	1

    b. Saved divisor grid as imp_intfor.

7. Proximity to buildings and roads: Divide impedance by 2 within 30 m of buildings or roads
    a. Reclass road and building grids to 1 or No Data, and mosaic together.
    b. Reclass distance from roads and buildings as follows:

Distance from Nearest Road or Building	Divide Impedance By:
< 15 m (1 cell diag.)	3
15 - 30 m	2
> 30 m	1

    c. Saved divisor grid as near_rd_bldg.
8. Set impedance of offshore water (>30 m from shore) to NoData, so the program does not select forest corridors across large rivers or bays.
    a. Use water from land cover (specifically, grid bldg_rd_rr_lc, which reclassifies bridges as water)
    b. Save grid as imp_offshore
9. Protected lands
    a. We combined all available protected land layers (including easements and military land) in Harford County, and converted to a grid (grd_protected). The level of protection varied.
    b. Based on results from past projects, exclude paved surfaces and open water, using grid bldg_rd_rr_lc. Only trees, grass/shrubs, and bare earth receive a discount for being within a protected area.
    c. Reclass protected undeveloped land = 2; elsewhere = 1. Saved as imp_protect.
10. Combine
    a. Divide land cover impedance grid by interior forest impedance (i.e., lower impedance in forest interior), offshore water (i.e., no corridors >30 m from shore), protected land (i.e., lower impedance in undeveloped protected land), and proximity to roads and buildings (higher impedance near roads and buildings).
    b. Note that processing extent, cell size, etc. must align exactly between impedance and core area grids for the TMA tool to work.

Forest connectivity modeling

1. Created uncertainty grid for impedance layer, to be used with the new TMA version, such that each impedance value could vary but retain their rank order.

Impedance Value	Min. Value	Max. Value	Fractional Change to Min.	Fractional Change to Max.	Smallest Fractional Change	Final Min. Value	Final Max. Value
1	1	1	0.000000	0.000000	0.0000	1	1
2	2	2	0.000000	0.000000	0.0000	2	2
3	3	4	0.000000	0.333333	0.0000	3	3
5	4	7	0.200000	0.400000	0.2000	4	6
10	8	12	0.200000	0.200000	0.2000	8	12
15	13	17	0.133333	0.133333	0.1333	13	17
20	18	22	0.100000	0.100000	0.1000	18	22
25	23	27	0.080000	0.080000	0.0800	23	27
30	28	35	0.166667	0.166667	0.0666	28	32
40	35	45	0.125000	0.125000	0.1250	35	45
50	45	55	0.100000	0.100000	0.1000	45	55
60	55	67	0.083333	0.116667	0.0833	55	65
75	68	79	0.093333	0.053333	0.0533	71	79
83	79	91	0.048193	0.096386	0.481	79	87
100	92	112	0.080000	0.120000	0.0800	92	108
125	113	137	0.096000	0.096000	0.0960	113	137
150	138	200	0.080000	0.333333	0.0800	138	162
250	200	312	0.200000	0.248000	0.2000	200	300
375	313	437	0.165333	0.165333	0.1653	313	437
500	438	625	0.124000	0.124000	0.1240	438	562
750	625	1000	0.166667	0.333333	0.1666	625	875
1250	1000	1875	0.200000	0.500000	0.2000	1000	1500
2500	1875	3125	0.250000	0.250000	0.2500	1875	3125
3750	3125	4375	0.166667	0.166667	0.1666	3125	4375

2. Run TMA
    a. Impedance X5
    b. Maximum movement from start locations = 1,000,000
    c. Minimum pathway threshold = 1
    d. Maximum movement around pathway = 1000
        i. Equivalent to 40 m of bare earth or 200 m of grass (seems kind of high)
        ii. Through ag fields, width was ~60 - 80 m.
    e. Analysis iterations = 50
    f. Start location % = 1
    g. It took 3.5 hours.
3. Rank corridors (#1)
    a. Normalize the cost and accumulation grids (taking natural log).

b. Use TMA Corridor Importance Tool. The TMA Corridor Importance Tool sums the core area connected to each corridor as well as the movement impedance, and compares it to the entire study area. The final importance value for each corridor is calculated by multiplying the corridor cost ratio with the connected core area ratio. Corridors that have a high accumulated area and low corridor cost are more important.
c. Use the "Remove Cores from corridors" tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
d. Reclassify all output values from above tool to 1
e. Multiply above corridors by corridor importance values
f. Slice into ten equal-area increments.
g. Results were counterintutive.

4. Rank corridors (#2)
    a. As above, use the "Remove Cores from corridors" tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
    b. Reclassify all output values from above tool to 1
    c. Multiply above corridors by movement potential grid (which combines area connected and impedance)
    d. Slice into ten equal-area increments. 10 is best and 1 is worst.
    e. Output looked more logical than above.
5. Rank corridors (#3)
    a. Followed same procedure for corridor cost alone.
    b. In this case, 1 is best and 10 is worst.
    c. Decided to use #2 instead, since it includes area connected.

Wetland Corridors

Wetland movement impedance

1. First, identify core wetlands to connect
    a. Set processing extent same as forest impedance layer.
    b. Relatively unimpacted wetlands (ha_wet_unimp) within core areas (ha_core_areas)
    c. Note: All unimpacted wetlands fell within core areas.
    d. Save grid as core_wetl_10m
2. Bridges - same as for forest
3. Water - same as for forest
4. Assign buildings the same code as Structures in the land cover raster (7).
5. Assign major roads a unique code (99)
6. Assign roads and road lines the same code as Roads in the land cover raster (9).
7. Assign parking lots the same code as Impervious Surfaces in the land cover raster (8).
8. Assign railroads and rail lines the same code as Impervious Surfaces in the land cover raster (8).
9. Assign utility ROWs the same code as Low Vegetation in the land cover raster (5).
10. Assign orchards the same code as Shrubland in the land cover raster (4).
11. Assign DNR wetlands (other than farmed or open water) the same code as Wetlands in the land cover raster (2).
12. Overlay buildings, bridges, major roads, other roads, railroads, wetlands, utility ROWs, and orchards over land cover data. Save as grid lc_mod_wetl.

13. Reclass modified land cover as follows (No Data = impassable for non-aerial forest animals):

Code	Description	Forest Corridor Impedance
1	Water	20
2	Wetlands	10
3	Tree Canopy	20
4	Shrubland	35
5	Low Vegetation	50
6	Barren	250
7	Structures	No Data
8	Impervious Surfaces	1250
9	Impervious Roads	1250
10	Tree Canopy over Structures	No Data
11	Tree Canopy over Impervious Surfaces	1250
12	Tree Canopy over Impervious Roads	1250
13	Aberdeen Proving Ground	No Data
No Data	Outside County	No Data

a. Give major roads an impedance of No Data (impassable except under bridges)
b. Grid name: imp_lc_wetl

11. Core wetlands and other relatively unimpaired wetlands
a. Reclass as follows:

Wetland Context	Divide Impedance By:
Core wetlands	3
Other relatively unimpaired wetlands	2
Elsewhere	1

b. Saved divisor grid as imp_wetclass.

12. Floodplains
a. Reduce impedance of stream buffers and 1% floodplains, except for open water and impervious surfaces.
b. Reclassify to 2 = inside, 1 = outside. Save grid as imp_floodpln.

13. Proximity to buildings and roads: Same as for forest impedance

14. Set impedance of offshore water (>30 m from shore) to NoData, so the program does not select forest corridors across large rivers or bays. (Same as for forest impedance)

15. Protected lands: Same as for forest impedance

16. Combine
a. Divide land cover impedance grid by wetland impedance (i.e., lower impedance in core wetlands), floodplain impedance (i.e., lower impedance in floodplains), offshore water (i.e., no corridors >30 m from shore), protected land (i.e., lower impedance in undeveloped protected land), and proximity to roads and buildings (higher impedance near roads and buildings).
b. Set minimum impedance to 1 (cannot be less than this)

Wetland connectivity modeling

1. Created uncertainty grid for impedance layer, to be used with the new TMA version, such that each impedance value could vary but retain their rank order.

Impedance Value	Min. Value	Max. Value	Fractional Change to Min.	Fractional Change to Max.	Smallest Fractional Change	Final Min. Value	Final Max. Value
1	1	1	0.000000	0.000000	0.0000	1	1
2	2	2	0.000000	0.000000	0.0000	2	2
3	3	4	0.000000	0.333333	0.0000	3	3
5	4	5	0.200000	0.000000	0.0000	5	5
6	6	6	0.000000	0.000000	0.0000	6	6
7	7	7	0.000000	0.000000	0.0000	7	7
8	8	9	0.000000	0.125000	0.0000	8	8
10	9	11	0.100000	0.100000	0.1000	9	11
12	11	12	0.083333	0.000000	0.0000	12	12
13	13	14	0.000000	0.076923	0.0000	13	13
15	14	16	0.066667	0.066667	0.0666	14	16
17	16	18	0.058824	0.058824	0.0588	16	18
20	19	22	0.050000	0.100000	0.0500	19	21
25	23	25	0.080000	0.000000	0.0000	25	25
26	26	28	0.000000	0.000000	0.0000	26	26
30	28	32	0.066667	0.066667	0.0666	28	32
35	33	36	0.057143	0.028571	0.0285	34	36
37	36	38	0.027027	0.027027	0.0270	36	38
40	39	45	0.025000	0.125000	0.0250	39	41
50	45	51	0.100000	0.020000	0.0200	49	51
52	51	56	0.019231	0.076923	0.0192	51	53
60	56	61	0.066667	0.016667	0.0166	59	61
62	61	66	0.016129	0.064516	0.0161	61	63
70	66	71	0.057143	0.014286	0.0142	69	71
75	73	80	0.026667	0.066667	0.0266	73	77
100	88	103	0.120000	0.030000	0.0300	97	103
105	103	118	0.019048	0.123810	0.0190	103	107
125	115	127	0.080000	0.016000	0.0160	123	127
150	138	161	0.080000	0.073333	0.0733	139	161
187	169	200	0.096257	0.069519	0.0695	174	200
250	219	269	0.124000	0.076000	0.0760	231	269
375	313	407	0.165333	0.085333	0.0853	343	407
500	438	563	0.124000	0.126000	0.1240	438	562
750	625	812	0.166667	0.082667	0.0826	688	812
1250	1000	1375	0.200000	0.100000	0.1000	1125	1375
2500	1875	2750	0.250000	0.100000	0.1000	2250	2750
3750	3125	4375	0.166667	0.166667	0.1666	3125	4375

2. Run TMA
    a. Impedance X5
    b. Maximum movement from start locations = 1,000,000
    c. Minimum pathway threshold = 1
    d. Maximum movement around pathway = 1000
        i. Equivalent to 40 m of bare earth or 200 m of grass (seems kind of high)
        ii. Through upland fields, width was ~50 m.
    e. Analysis iterations = 50
    f. Start location % = 1
    g. It took 2.5 hours.
    h. Most (but not all) of the corridors were in floodplains.
3. Rank corridors (#1)
    a. Normalize the cost and accumulation grids (taking natural log).
    b. Use TMA Corridor Importance Tool. The TMA Corridor Importance Tool sums the core area connected to each corridor as well as the movement impedance, and compares it to the entire study area. The final importance value for each corridor is calculated by multiplying the corridor cost ratio with the connected core area ratio. Corridors that have a high accumulated area and low corridor cost are more important.
    c. Use the "Remove Cores from corridors" tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
    d. Reclassify all output values from above tool to 1
    e. Multiply above corridors by corridor importance values
    f. Slice into ten equal-area increments.
    g. Results were counterintutive.
4. Rank corridors (#2)
    a. As above, use the "Remove Cores from corridors" tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
    b. Reclassify all output values from above tool to 1
    c. Multiply above corridors by movement potential grid (which combines area connected and impedance)
    d. Slice into ten equal-area increments. 10 is best and 1 is worst.
    e. Output looked more logical than above.

Aquatic Corridors

Aquatic movement impedance

1. First, expand the study boundary by 50 m since Little Gunpowder Falls is the western County boundary and there are some positional discrepancies. Save as aqu_study_bnd.
2. Identify stream and river center lines within core aquatic areas.
    a. Give these an impedance of 1
3. All land has an impedance of NoData (if it's not water, it's impassable to fish).
4. Hydrology lines:

Value	Type	Impedance
1	Artificial Path	5
2	Stream/River	5
3	Canal/Ditch	100
4	Connector	No Data

5. Hydrology polygons:

Value	Description	Impedance
1	Lake/Pond	10
2	Stream/River	5
3	Dam/Weir	10000
4	Reservoir	10
5	Tunnel/Culvert	250
6	Rock/Island	No Data
7	Spillway	1250
8	Ditch_Conc	100
9	Swamp	250
10	Canal/Ditch	100

6. Fish blockages
    a. Buffer fish blockage points 15 m to account for positional uncertainty
    b. Multiply impedance by 100 (and by 1 elsewhere).
    c. We did not consider them totally impassable because some were probably culverts (presumably raised above the water level), and many (perhaps most) could be targeted for fish passage projects.
7. Proximity to buildings and roads: Same as for forest impedance
8. Protected lands: Same as for forest impedance
9. Combine
    a. Mosaic impedance of core streams and rivers on top, then hydrology lines, then hydrology polygons.
    b. Multiply by impedance of fish blockages and proximity to buildings and roads, and divide by impedance of protected lands.
    c. Upland areas have No Data (impassable).

Aquatic connectivity modeling

1. Created uncertainty grid for impedance layer, to be used with the new TMA version, such that each impedance value could vary but retain their rank order.

Impedance Value	Min. Value	Max. Value	Fractional Change to Min.	Fractional Change to Max.	Smallest Fractional Change	Final Min. Value	Final Max. Value
1	1	1	0.000000	0.000000	0.0000	1	1
2	2	2	0.000000	0.000000	0.0000	2	2
3	3	4	0.000000	0.333333	0.0000	3	3
5	4	6	0.200000	0.200000	0.2000	4	6
7	6	8	0.142857	0.142857	0.1428	6	8
10	9	12	0.100000	0.200000	0.1000	9	11
15	13	17	0.133333	0.133333	0.1333	13	17
20	18	25	0.100000	0.250000	0.1000	18	22
30	25	40	0.166667	0.333333	0.1666	25	35
50	40	75	0.200000	0.500000	0.2000	40	60
100	75	125	0.250000	0.250000	0.2500	75	125
150	125	175	0.166667	0.166667	0.1666	125	175
200	175	225	0.125000	0.125000	0.1250	175	225
250	225	275	0.100000	0.100000	0.1000	225	275
300	275	400	0.083333	0.333333	0.0833	275	325
500	400	750	0.200000	0.500000	0.2000	400	600
1000	750	1250	0.250000	0.250000	0.2500	750	1250
1500	1250	5750	0.166667	2.833333	0.1666	1250	1750
10000	5750	15000	0.425000	0.500000	0.4250	5750	14250
20000	15000	25000	0.250000	0.250000	0.2500	15000	25000
30000	25000	35000	0.166667	0.166667	0.1666	25002	34998

1. Run TMA
    a. Impedance X5
    b. Maximum movement from start locations = 1,000,000
    c. Minimum pathway threshold = 1
    d. Maximum movement around pathway = 1000
    e. Analysis iterations = 50
    f. Start location % = 1
    g. It took 2.5 hours.
2. Separate corridors from core areas
    a. Use the "Remove Cores from corridors" tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
    b. Reclassify all output values from above tool to 1
    c. There were very few, and they all fell within core areas.

Combine corridors

Method #1

1. Add sliced forest movement potential corridors to sliced wetland movement potential corridors (with background = 0). Aquatic corridors all fell within core areas.
2. Reclassify 0 to No Data (i.e. remove non-corridors)
3. Use the "Remove Cores from corridors" tool to remove core areas and areas that do not connect at least two core areas (they may connect different parts of the same core area, or function as buffers, or, in some cases, act as dead ends.)
4. Had to manually remove (mask out) corridors that did not link core areas; not all were removed by above step. Save grid as corr_sep2.
5. Slice into ten equal-area increments. 10 is best and 1 is worst. Save as ha_corridors.
6. Reclass to 1, No Data and convert to shapefile ha_corridors_poly.
7. Output did not include some forest patches because they had been removed in the forest corridor steps. These should not have been omitted.

Method #2

1. After examining output from combined corridor model, decided not to remove core areas (they were added back in after running the "Remove Cores from corridors" tool.
2. For forest corridors, use the "Remove Cores from corridors" tool to remove core forest and areas that do not connect at least two core forest patches (they may connect different parts of the same patch, or function as buffers, or, in some cases, act as dead ends). Output grid = for_corr_sep.
3. Combine core forest and forest corridors from above step (output grid = for_core_corr) and multiply by the movement potential grid (for_move_pot). Output grid = for_cc_mvpot.
4. There was some core forest not included in this, an artifact of the program. After examining the spread of movement potential data within core forest, we gave that a value of the mean (0.935366) minus one standard deviation (0.056694), or 0.878672. Mosaic for_cc_mvpot on top of this. Output grid = for_cc_mvpot2.
5. For wetland corridors, use the "Remove Cores from corridors" tool to remove core wetlands and areas that do not connect at least two core wetlands. Output grid = wet_corr_sep.
6. Combine core wetlands and wetland corridors from above step (output grid = wet_core_corr) and multiply by the movement potential grid (wt_move_pot). Output grid = wet_cc_mvpot.
7. There was some core wetland area not included in this, an artifact of the program. After examining the spread of movement potential data within core wetlands, we gave that a value of the mean (0.929924) minus one standard deviation (0.051099), or 0.878825. Mosaic wet_cc_mvpot on top of this. Output grid = wet_cc_mvpot2.
8. There were very few aquatic corridors, and they all fell within core areas.
9. Add forest and wetland movement potential grids after converting NoData values to 0: add_movpot = Con(IsNull("for_cc_mvpot2"), 0, "for_cc_mvpot2") + Con(IsNull("wet_cc_mvpot2"), 0, "wet_cc_mvpot2")
10. Convert values of 0 back to No Data: comb_movpot = Con("add_mvpot" > 0,"add_mvpot")

APPENDIX E: Landscape Ranking Factors

Table E-1. Factors used to rank unprotected land for natural resource conservation importance, and their relative weighting.

Level 2	Level 2 weight	Level 3	Level 3 weight	Level 4	Level 4 weight	Level 5	Level 5 weight	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
Mandatory criteria		Not developed						(Mandatory)	Impervious surfaces	1	0	step
		Not open water						(Mandatory)	Open water	1	0	step
		Not already protected (with fee simple or easement restrictions)						(Mandatory)	Protected land (with fee simple or easement restrictions on land conversion)	1	0	step
Statewide Green Infrastructure	0.33	State Designated Ecological Significance	0.6	Statewide Green Infrastructure Hubs	0.2			0.040	Statewide hubs	1	100	step
				Statewide Green Infrastructure Corridors	0.1			0.020	Statewide corridors	1	100	
				Targeted Ecological Areas	0.2			0.040	All TEA sites	1	100	step
				BioNet Significance	0.3			0.060	Tier 1 – Critically Significant for Biodiversity Conservation	1	100	step
									Tier 2 – Extremely Significant for Biodiversity Conservation	2	80	
									Tier 3 – Highly Significant for Biodiversity Conservation	3	60	
									Tier 4 – Moderately Significant for Biodiversity Conservation	4	40	
									Tier 5 – Significant for Biodiversity Conservation	5	20	

Level 2	Level 2 weight	Level 3	Level 3 weight	Level 4	Level 4 weight	Level 5	Level 5 weight	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
				Wetlands of Special State Concern + 100 ft buffer	0.2			0.040	All WSSC + 100 foot buffers	1	100	step
		Watershed Characteristics (DNR 12-digit)	0.4	Forest Cover by Watershed	0.25			0.033	% forest cover in watershed (see "Maryland's Forests for Healthy Watersheds")	0-78%	0-100	val/max * 100
				Impervious Surface by Watershed	0.25			0.033	Able to support sensitive species and stable stream banks (source: MD DNR)	0-5%	100	step
									Most sensitive species absent, some erosion and pollution	5-10%	50	
									Only tolerant species, obvious erosion	10-20%	25	
									Severely impaired	>20%	0	
				Forests of Recognized Importance	0.25			0.033	100 foot buffers of Stronghold Watershed streams, trout bearing streams, streams feeding municipal drinking water reservoirs, and Tier II High Quality Waters	1	100	step
County Scale Resource Features	0.33	Natural resource features	0.33	Wetlands and floodplains	0.5	Wetlands + buffers	0.5	0.028	Wetlands + 75-100 foot buffer	1	100	step
						Streams + buffers and 1% (100 year) floodplains	0.5	0.028	Streams + 75-150 foot buffer + 1% (100 year) floodplain	1	100	step
				Forest	0.25	Forest patches with at least 1 acre of interior	1.0	0.028	Forest patches with at least 1 acre of interior	1	100	step
				Highly erodible	0.15	Highly	1.0	0.017	Soils on slopes >15%,	1	100	step

Level 2	Level 2 weight	Level 3	Level 3 weight	Level 4	Level 4 weight	Level 5	Level 5 weight	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
				soils		erodible soils			or soils with K > 0.35 on slopes > 5%			
		County green infrastructure network	0.67	Core areas	0.5			0.112	Core areas	1	100	step
				Hubs	0.125			0.028	Hubs	1	100	step
				Aquatic movement importance	0.125			0.028	Movement potential for aquatic organisms (area linked + linkage suitability)	1	0-100	equal area slice
				Forest movement importance	0.125			0.028	Movement potential for forest organisms (area linked + linkage suitability)	1	0-100	**equal area slice**
				Wetland movement importance	0.125			0.028	Movement potential for wetland organisms (area linked + linkage suitability)	1	0-100	equal area slice
Community/Equity Considerations	0.33	Demographics for populations more vulnerable to storms	0.40	Population Density	0.25			0.033	# of people/mi2	0-20522	0-100	equal area slice
				Household Income	0.25			0.033	% Population with income below poverty (12mo)	0-100%	0-100	none
				Ethnicity/Minority	0.25			0.033	% Population of non-proficient English speakers	0-100%	0-100	none
				Age	0.25			0.033	% Population <18 or >= 65 years of age	0-100%	0-100	none
		Distance to Parks	0.10		1			0.033	Distance in meters to nearest state or County park	0-7088	0-100	equal area slice
		Ecosystem Service Value (sum of air pollution removal, carbon sequestration, groundwater recharge, nutrient uptake, stormwater mitigation, wildlife habitat and biodiversity, and surface water protection benefits)	0.50		1			0.167	$ per 30 m pixel per year	0-1124	0-100	equal interval slice

Table E-2. Factors used to rank areas for siting new stormwater treatment BMPs, and their relative weighting.

Level 2	Level 2 weight	Level 3	Level 3 weight	Level 4	Level 4 weight	Level 5	Level 5 weight	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
Mandatory criteria		Suitable BMP site						(mandatory)	Identified using EPA criteria for bioretention, constructed wetland, dry pond, grassed swale, infiltration basin, infiltration trench, porous pavement, sand filter (both surface and non-surface), vegetated filter strip, and/or wet pond	1	1	step
		Existing BMP location?							yes	1	0.33	step
									no	No Data	1	
Land ownership	0.20							0.200	Publicly owned (excluding APG)	1	100	step
									Privately owned with easement	1	25	
									Privately owned, no easements		0	
Area of impervious surface draining to site	0.20							0.200	Acres of impervious surface draining to site (maximum impervious flow accumulation)	<0.5	0	step
										0.5 - 2	20	
										2 - 5	40	
										5- 10	60	
										10 - 25	80	
										>25	100	
Watershed characteristics	0.30	Watershed Characteristics (DNR 12-digit)	0.4	Forest Cover by Watershed	0.5			0.060	% forest cover in watershed (see "Maryland's Forests for Healthy Watersheds")	0-78%	0-100	equal interval slice, then subtract from 100
				Impervious Surface by Watershed	0.5			0.060	Able to support sensitive species and stable stream banks (source: MD DNR)	0-5%	0	step
									Most sensitive species absent, some erosion and pollution	5-10%	50	
									Only tolerant species, obvious erosion	10-20%	100	
									Severely impaired	>20%	100	

Level 2	Level 2 weight	Level 3	Level 3 weight	Level 4	Level 4 weight	Level 5	Level 5 weight	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
		Development preceding stormwater regulations (by NHD catchment)	0.2		1			0.060	% of NHD catchment developed in 1992 (closest available land cover to 1984, when local ordinances were implemented)	0-100%	0-100	none
		Nutrient loading (NHD catchment)	0.4	Incremental TN flux attributable to undifferentiated urban sources	0.5			0.060	TN_MEAN_PLOAD_INC_URBAN (kg N/year)	0-7800	0-100	% of maximum
				Incremental TP flux attributable to undifferentiated urban sources	0.5			0.060	TP_MEAN_PLOAD_INC_URBAN (kg P/year)	0-826	0-100	% of maximum
County/Local Scale Resource Features	0.15	Floodplains, erodible soils, and steep slopes	1.00	Floodplains	0.5	1% (100 year) floodplains	0.83	0.062	1% (100 year) floodplains	1	100	step
						0.2% (500 year) floodplains	0.17	0.012	0.2% (500 year) floodplains	1	100	step
				Erodible soils	0.5	Soil erodibility (K factor). (note: some areas lacked data)	0.5	0.038	kwfact (An erodibility factor which quantifies the susceptibility of soil particles to detachment and movement by water. This factor is adjusted for the effect of rock fragments)	.02-.55	0-100	equal area slice
						Slope	0.5	0.038	% slope	0 - >100	0-100	equal area slice
Community/Equity Considerations	0.15	Demographics for populations more vulnerable to storms	1.00	Population Density	0.25			0.038	# of people/mi2	0-20522	0-100	equal area slice
				Household Income	0.25			0.038	% Population with income below poverty (12mo)	0-100%	0-100	none
				Ethnicity/Minority	0.25			0.038	% Population of non-proficient English speakers	0-100%	0-100	none
				Age	0.25			0.038	% Population <18 or >= 65 years of age	0-100%	0-100	none

Table E-3. Factors used to rank preservation of natural features for coastal defense, and their relative weighting.

Level 2	Level 2 weight	Level 3	Combined weight	Classification	Numeric Value	Reclassified Value (0-100)	Reclass function
Mandatory criteria		Not developed	(Mandatory)	Impervious surfaces	1	0	step
		Not already protected (with fee simple or easement restrictions)	(Mandatory)	Protected land (with fee simple or easement restrictions on land conversion)	1	0	step
		Within storm surge zone	(Mandatory)	Within storm surge zone (Categories 1-4)	1	1	step
		Existing natural features within storm surge zone (forest, wetlands, or underwater grass)	(Mandatory)	Within storm surge zone, forest >1 ac and >=120 ft wide, DNR wetlands, and 2015 SAV with at least 40% cover	1	1	step
Blue Infrastructure shoreline segments	0.333333	(Allocate to nearest natural features in storm surge zone)	0.333	Total rank	0 - 165	0-100	Equal interval slice
Maryland Coastal Resiliency Assessment - Habitat Role in Hazard Reduction	0.666667	(Allocate to nearest natural features in storm surge zone)	0.667	Tier I Shorelines (Shorelines with a high habitat role, OR shorelines that transition to High Hazard when habitats are removed.)		100	step
				Tier II Shorelines (Shorelines with moderate habitat role, OR shorelines that transition to Moderate Hazard when habitats are removed.)		25	
				Neither Tier I nor Tier II		0	

APPENDIX F: Forest Assessment and Model Validation

Purpose

We wanted to know if the green infrastructure modeling was indeed useful for identifying high quality natural resources in Harford County; specifically, if areas inside the green infrastructure network were in better condition than areas outside the network. The Maryland Department of Natural Resources has been surveying Harford County streams for two decades. We therefore focused our attention on terrestrial resources; specifically, forest, which covers much more area in the County than wetlands. We were interested in five questions:

Q1: What is the range of forest conditions in the County?
Q2: Is core forest, on average, in better overall condition than forest outside core areas?
Q3: What is the average cover percentage of invasive exotic species?
Q4: Do core areas, on average, have fewer invasive species than forest outside core areas?
Q5: Do any other factors (e.g., distance to edge, road or trail proximity, stand age, or soil moisture) affect invasive species coverage?

Methodology

Plot design

We used a rapid forest assessment protocol and data sheet developed for various other projects (e.g., Weber, 2011; Weber and Allen. 2010; Weber and Boss, 2009) and modified it slightly. We assessed hydrology, disturbances, vegetation structure and composition, forest maturity, and wildlife value within a 50 m radius circle around each random point (see Appendix F-1).

Plot locations

For access purposes, we performed our surveys in County parks. We first identified all County parks containing both core forest and non-core forest. We then generated random points in ArcGIS (using the Create Random Points tool), with the following constraints and stratification:

- Within each park, we picked 2 core forest patches and 2 non-core forest patches, picking the largest two in each category. If there was only one core patch or one non-core patch, then we selected one of each. The idea of picking the largest was to represent the most overall area.
- Points were generated randomly, one point per patch, given the following additional constraints.
- Plots had to be entirely within the park (center point therefore >50 m from park boundary).
- Plot center points had to be under tree canopy (using tree areas other than orchards from 2013 County polygons). The entire plot might not be forested, just part of it, but the center point had to fall under tree canopy. Only the forest patch containing the center point was to be assessed.
- Core forest plots had to fall entirely within core forest (center point therefore >50 m from core edge).
- Non-core plots had to fall entirely outside core forest (center point therefore >50 m from core forest).
- Plots had to be accessible by foot.

Resulting plot locations

The following parks contained random core and non-core points:

Park Name	# of Points
Benson Fields (Edgeley Grove)	4
Deer Creek Conservation Area Sandy Hook	4
Dublin Park	4
Eden Mill Nature Center & Park	4
Edgeley Grove Farm	4
Eleanor & Millard Tydings Park	4
Forest Greens	4
Harford Glen	4
Perryman Park	4
Saddleview Conservation Area	4
Scarboro Hills Disc Golf Course	4
Swan Harbor Farm	4
Willoughby Beach Park	4
Winters Run Conservation Area (Singer Road Park)	4
Anita C. Leight Estuary Center	2
Cedar Lane Park Regional Field Sports Complex	2
Churchville Recreation Complex	2
Forest Hill Recreation Complex	2
Havre De Grace Community Center	2
Schucks Road Regional Sports Complex	2
Winters Run Greenway Philadelphia Road	2
Winters Run Greenway Winters Run Manor	2

From this, we picked Deer Creek Conservation Area and Swan Harbor Farm, because we were also monitoring these for wildlife. From the others, parks with 4 points were preferable to 2 points only, passive recreation sites were preferable to active recreation sites, geographic diversity was important, and accessibility was a key factor. Not all random points were readily accessible.

Results

We examined 24 random plots (12 core, 12 non-core) in 9 different County parks:

Point ID	Park Name	Core	Distance to Edge (m)	Invasive Plant % of Area	Total Score	Moisture (wet/mesic /dry)	Successional Stage
3	Anita C. Leight Estuary Center	no	30	40	262	wet/mesic	mid
6	Anita C. Leight Estuary Center	yes	90	0	380	dry	late
11	Deer Creek Conservation Area Sandy Hook	no	30	75	172	mesic	early
28	Deer Creek Conservation Area Sandy Hook	yes	60	60	207	mesic	early
9	Dublin Park	no	15	90	153	wet	early
26	Dublin Park	yes	85	50	332	wet	mid
8	Eden Mill Nature Center & Park	no	75	45	112	dry	early
22	Eden Mill Nature Center & Park	yes	80	30	284	mesic	late
1	Edgeley Grove Farm	no	25	55	180	wet	early
2	Edgeley Grove Farm	no	20	75	137	mesic	early
4	Edgeley Grove Farm	yes	110	5	244	mesic	early
5	Edgeley Grove Farm	yes	50	80	305	mesic/wet	late
20	Eleanor & Millard Tydings Park	no	15	90	202	wet	early
32	Eleanor & Millard Tydings Park	yes	70	15	179	mesic	early
15	Perryman Park	no	20	75	177	mesic	early
16	Perryman Park	no	25	75	240	mesic	mid
33	Perryman Park	yes	75	25	346	mesic	mid
12	Scarboro Hills Disc Golf Course	no	20	75	242	wet	early
23	Scarboro Hills Disc Golf Course	yes	80	0	430	dry	late
24	Scarboro Hills Disc Golf Course	yes	70	5	276	mesic	mid
17	Swan Harbor Farm	no	35	80	242	mesic/wet	early
18	Swan Harbor Farm	no	20	75	190	mesic/wet	mid
29	Swan Harbor Farm	yes	80	40	325	mesic	mid
30	Swan Harbor Farm	yes	290	0	445	mesic	late

Examining the table, only 3 of 24 plots had no invasive exotic plants. All three were in late-successional core forest, and were at least 80 m from the nearest edge. Two were dry forest communities and one was mesic.

Two more plots had only small numbers of invasive plants (5% or less). Both were in core forest, both were mesic. One was early successional and one was mid-successional. All plots with <40% invasives were in core forest. Only 3 of 12 plots in core forest had >40% invasives.

We then analyzed the data in R (version 3.2.1). Total scores were normally distributed, but invasive species coverage and distance to nearest edge were not:

```
> shapiro.test(point_summary_data$`% invasives`)
        Shapiro-Wilk normality test

data:  point_summary_data$`% invasives`
W = 0.88858, p-value = 0.01242
        Non-normal

> shapiro.test(point_summary_data$`Total score`)
        Shapiro-Wilk normality test

data:  point_summary_data$`Total score`
W = 0.95544, p-value = 0.3538
        Can assume normal

> shapiro.test(point_summary_data$`distedge_m`)
        Shapiro-Wilk normality test

data:  point_summary_data$distedge_m
W = 0.67142, p-value = 4.317e-06
        Non-normal
```

The percent area covered by invasive plants was significantly higher in non-core forest than core forest:

```
> mean(subset(point_summary_data$`% invasives`, point_summary_data$core == 1))
[1] 25.83333
> mean(subset(point_summary_data$`% invasives`, point_summary_data$core == 0))
[1] 70.83333

> wilcox.test(point_summary_data$`% invasives` ~ point_summary_data$core,
alternative = c("greater"))
        Wilcoxon rank sum test with continuity correction

data:  point_summary_data$`% invasives` by point_summary_data$core
W = 129, p-value = 0.0004957
        alternative hypothesis: true location shift is greater than 0
```

Total score was significantly higher in core forest than non-core forest:

```
> t.test(point_summary_data$`Total score` ~ point_summary_data$core, alternative =
c("less"))
        Welch Two Sample t-test

data: point_summary_data$`Total score` by point_summary_data$core
t = -4.4289, df = 17.502, p-value = 0.0001724
        alternative hypothesis: true difference in means is less than 0
95 percent confidence interval:
        -Inf -73.14614
sample estimates:
mean in group 0 mean in group 1
        192.4167        312.7500
```

Plots closer to the forest edge had significantly more invasive species than plots further from the edge. However, plots further from the edge were also significantly more likely to be in core forest; not surprising, since by definition core forest had more interior area than non-core forest.

```
> cor.test(point_summary_data$distedge_m, point_summary_data$`% invasives`,
method = "spearman")
        Spearman's rank correlation rho

data: point_summary_data$distedge_m and point_summary_data$`% invasives`
S = 4196.6, p-value = 7.219e-07
        alternative hypothesis: true rho is not equal to 0
sample estimates:
       rho
-0.8246039

> wilcox.test(point_summary_data$`distedge_m` ~ point_summary_data$core,
alternative = c("less"))
        Wilcoxon rank sum test with continuity correction

data: point_summary_data$distedge_m by point_summary_data$core
W = 4.5, p-value = 5.131e-05
        alternative hypothesis: true location shift is less than 0

> mean(subset(point_summary_data$'distedge_m', point_summary_data$core == 0))
[1] 27.5
> mean(subset(point_summary_data$'distedge_m', point_summary_data$core == 1))
[1] 95
```

Plots >50 m from the edge had significantly fewer invasive plants than plots ≤50 m from the edge:

```
>wilcox.test(point_summary_data_w_numerics$`%invasives`~point_summary_data_w_
numerics$distgt50m, alternative = c("greater"))
        Wilcoxon rank sum test with continuity correction
```

data: point_summary_data_w_numerics$`% invasives` by point_summary_data_w_numerics$distgt50m
W = 139.5, p-value = 4.713e-05
alternative hypothesis: true location shift is greater than 0

> mean(subset(point_summary_data_w_numerics$`% invasives`, point_summary_data_w_numerics$distgt50m == 1))
[1] 22.91667
> mean(subset(point_summary_data_w_numerics$`% invasives`, point_summary_data_w_numerics$distgt50m == 0))
[1] 73.75

Moister sites appeared to have more invasive plants:

> kruskal.test(point_summary_data_w_numerics$`% invasives`, point_summary_data_w_numerics$moist_num)

Kruskal-Wallis rank sum test

data: point_summary_data_w_numerics$`% invasives` and point_summary_data_w_numerics$moist_num
Kruskal-Wallis chi-squared = 9.4684, df = 3, p-value = 0.02367

Means: dry = 15, mesic = 40, mesic/wet = 69, wet = 72

There was a relationship between invasive plants and successional stage, but it was not strong (p = 0.06):

> kruskal.test(point_summary_data_w_numerics$`% invasives`, point_summary_data_w_numerics$succ_num)

Kruskal-Wallis rank sum test

data: point_summary_data_w_numerics$`% invasives` and point_summary_data_w_numerics$succ_num
Kruskal-Wallis chi-squared = 5.5878, df = 2, p-value = 0.06118

Means: early = 62, mid = 44, late = 22

Just comparing late successional to mid and early, the difference was significant ($p<0.05$).

Discussion

Invasive exotic plants were a problem at all County parks, dominating the ground and shrub cover in half the plots. However, core forest had, on average, significantly fewer invasive plants than non-core forest. All plots with <40% invasives were in core forest. Only 3 of 12 plots in core forest had >40% invasives. Core forest also had higher total scores than non-core forest.

Invasive plants were more common near forest edges than when >50 m from the edge. Wetter soils tended to have more invasives than dryer soils, and younger forest tended to have more invasives than older forest. A few of the plots (12.5%) had no invasive plants. All of these were in late-successional core forest, and were at least 80 meters from the nearest edge. Two were dry forest communities and one was mesic.

Many of the sites had little native groundcover (especially herbaceous plants). In the case of mesic sites, this might have been from deer overbrowsing, and we did spot a lot of deer or signs of deer (browsed plants, hoof prints, or droppings). Some sites dominated by invasives had few native plants, but some had many. At sites with too many deer, population control, coupled with fencing and restoration, might benefit forest understory composition.

Future steps could include additional sampling, perhaps including random sites outside County parks. With more data, more sophisticated analyses could be performed (e.g. multivariate analyses).

Alternatively, remediation strategies could be compared in a pilot study. For example, native plant recovery in plots grazed by goats could be compared to plots where conventional weeding with glyphosate application was used. Financial costs could also be compared, and the level of volunteer engagement.

Literature Cited

Weber, T. C. 2011. Maximum entropy modeling of mature hardwood forest distribution in four U.S. states. Forest Ecology and Management 261:779-788.

Weber, T. C. and W. L. Allen. 2010. Beyond on-site mitigation: An integrated, multi-scale approach to environmental mitigation and stewardship for transportation projects. Landscape and Urban Planning 96:240-256.

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Appendix F-1: Forest Rapid Field Assessment Data Form

FOREST RAPID FIELD ASSESSMENT
(VERSION 2018-05)

Site name _____ Sample point ID _____

Latitude _____ Longitude _____ Date _____

Investigators _____ Photos taken (yes/no) 1-N; 2-E; 3-S; 4-W

Forest patch size _____ ac Distance to forest edge _____ m

Known site history:

Current site management:

Predominant community type:

Within the community being sampled, describe any other embedded smaller communities (e.g., clearings, younger or older tree stands, etc.) and their approximate size:

Forest obligate species (e.g., forest interior birds) observed (seen or heard):

Rare species (plant or animal) or unique communities observed?

Is the community subject to repeated natural disturbances or stresses (yes/no)? (Examples are communities on river scours, beaches, ridge tops, rocky soil, etc.)

If natural disturbances or stresses are present, describe:

Signs of past history and other notes:

SOIL DESCRIPTION

Series name (from soil survey):

Texture class: Drainage class:

Hydric? (yes/no) Characteristics_____

Hydrologic regime ("U" for upland; if wetland, enter Cowardin code): _____
(If this is a wetland, please fill out the wetland field form)

SURFACE WATER WITHIN THE COMMUNITY

Parameter	Description of feature	Parameter value	Score
Presence of streams		Perennial stream present	50
		Intermittent stream (no perennial) present	20
		Ephemeral stream/drainage swale only present	10
		None of the above present	0
Presence of headwaters, springs, seeps		Present	20
		Absent	0
Presence of wetlands		Seasonally, tidally, or semi-permanently flooded wetlands (including vernal pools)	50
		Temporarily flooded or saturated wetlands only	20
		No wetlands present	0

HUMAN DISTURBANCES WITHIN THE COMMUNITY

Type of disturbance	Area affected					
	None	Present, but <5% of site	5-10% of site	11-25% of site	26-50% of site	51-100% of site
No disturbance, or minor natural disturbances only	N/A	N/A	N/A	N/A	N/A	0.00
Roads, powerlines, or trails						
Paved road or railroad	0.00	0.19	0.37	0.56	0.74	0.93
Powerline or other utility corridor (canopy broken)	0.00	0.16	0.31	0.47	0.63	0.79
Unpaved or logging road (canopy broken)	0.00	0.14	0.29	0.43	0.57	0.71
Unpaved or logging road (canopy unbroken)	0.00	0.10	0.20	0.30	0.40	0.50
Paved trail	0.00	0.11	0.23	0.34	0.46	0.57
Gravel trail	0.00	0.10	0.20	0.30	0.40	0.50
Unimproved trail	0.00	0.03	0.06	0.09	0.11	0.14
Vegetation alteration						
Managed for pine production	0.00	0.16	0.31	0.47	0.63	0.79
Recent clearcut (<5 years)	0.00	0.14	0.29	0.43	0.57	0.71
Logging within 30 years, but not clearcut <5 years	0.00	0.11	0.23	0.34	0.46	0.57
Mowing	0.00	0.09	0.17	0.26	0.34	0.43
Used for livestock grazing	0.00	0.07	0.14	0.21	0.29	0.36
Understory removal	0.00	0.11	0.23	0.34	0.46	0.57
Burning	0.00	0.11	0.23	0.34	0.46	0.57
Hydrologic alteration that affects community structure, composition, and/or function						
Ditches or channelized streams that provide effective drainage, and levees present	0.00	0.19	0.37	0.56	0.74	0.93
Ditches or channelized streams that provide effective drainage, but no levees	0.00	0.17	0.34	0.51	0.69	0.86
Unmaintained ditches or prior stream channelization are present, but they are no longer effective, and will in most instances not have the ability to drain water (i.e., ditches have become filled with debris and are not maintained)	0.00	0.06	0.11	0.17	0.23	0.29

Type of disturbance	Area affected					
	None	Present, but <5% of site	5-10% of site	11-25% of site	26-50% of site	51-100% of site
Tile draining	0.00	0.11	0.23	0.34	0.46	0.57
Excavation of substrate or impoundment of water (dams, dikes, weirs, etc.)	0.00	0.14	0.29	0.43	0.57	0.71
Deposition of fill or spoil, other than levees	0.00	0.07	0.14	0.21	0.29	0.36
Stream or floodplain constricted, but not dammed (bridge, culvert, road bed, etc.)	0.00	0.10	0.20	0.30	0.40	0.50
Microtopography alteration						
Grading	0.00	0.11	0.23	0.34	0.46	0.57
Bedding	0.00	0.11	0.23	0.34	0.46	0.57
Windrows	0.00	0.11	0.23	0.34	0.46	0.57
Skidder tracks	0.00	0.09	0.17	0.26	0.34	0.43
Pollution						
Point source pollution (e.g., pipes carrying effluent)	0.00	0.09	0.17	0.26	0.34	0.43
Non-point source pollution	0.00	0.10	0.20	0.30	0.40	0.50
Stormwater piped in	0.00	0.10	0.20	0.30	0.40	0.50
Trash dumping	0.00	0.07	0.14	0.21	0.29	0.36
Hazardous materials	0.00	0.11	0.22	0.33	0.43	0.54
Diseases, pests, or excessive herbivory						
Tree diseases or pests causing significant mortality, multiple species	0.00	0.13	0.26	0.39	0.51	0.64
Tree diseases or pests causing significant mortality, one species	0.00	0.07	0.14	0.21	0.29	0.36
Tree diseases or pests causing stress	0.00	0.01	0.03	0.04	0.06	0.07
Excessive herbivory (e.g., deer overbrowsing)	0.00	0.04	0.09	0.13	0.17	0.21
Non-human facilitated						
Loss of canopy trees to wind or ice damage	0.00	0.07	0.14	0.21	0.29	0.36

Invasive exotic species % ground covered by exotic species: _____	**Extent of invasive exotic species**				
	Absent	Present, but uncommon	Common but not dominant	Dominant	Site overrun
	0.00	0.14	0.21	0.29	0.36
List the most common invasive species observed:					

TOTAL DISTURBANCE SCORE: _____
(In the office, add above numbers; subtract this sum from 1.0; if negative, set to to 0.0; and multiply by 175)

Would the forest community benefit from active management such as invasive species control or tree planting?

VEGETATION STRUCTURE AND DOMINANT SPECIES

Stratum (note: not all strata may be present)	**Height at top of stratum (m)**	**% cover**	**Species making up 50% of stratum (put additional important species in parentheses)**
Canopy layer			
Upper subcanopy (>10m; below canopy)			
Lower subcanopy (3-10m)			
Shrub layer (1-3m)			
Ground layer (<1 m)	N/A		

Community type (Ecological Community Group if known) _____
Approx. forest age _____yrs. (Tree rings___ Tree core___ Tree size & spp.___ Aerial photo___ Other_____)

FOREST MATURITY AND WILDLIFE VALUE

Parameter	**Parameter value**	**Score**
Successional stage	Late	50
	Mid	25
	Early	0
Wildlife value of dominant trees	Canopy dominated by oaks, hickories/walnuts, and/or beeches (>50%)	30
	Tulip poplar, maple, sweetgum, pine, or other dominant in canopy; but oaks, hickories/walnuts, and/or beeches co-dominant (20-50%)	15
	Few or no oaks, hickories/walnuts, and/or beeches in canopy (<20%)	0
Berry-producing plants	≥25% of area	15
	<25% of area	0
Size class of canopy species	>16" (40.6 cm) dbh	50
	9-16" (22.9-40.6 cm) dbh	25
	4-9" (10.2-22.9 cm) dbh	10
	<4" (10.2 cm) dbh (saplings)	0
Height at top of canopy layer	>85 ft (>26 m)	50
	60-85 ft (18.5-26.0 m)	25
	<60 ft (<18.5 m)	0
Stand stratification (canopy, top subcanopy, lower subcanopy, shrub, and ground layers)	≥5 layers present with >25% areal coverage	20
	4 layers present with >25% areal coverage	15
	2-3 layers present with >25% areal coverage	10
	0-1 layers present with >25% areal coverage	0
Standing dead trees >8" (20 cm) dbh (within 11.5m of observation point)	Present, but <25% of boles	20
	Absent or ≥25% of boles	0
Downed logs (>20	Present	N/A

Parameter	**Parameter value**	**Score**
cm dbh)	Absent	N/A
Trees (live or dead) with cavities	Present	20
	Absent	0
Pit and mound structure	Present	20
	Absent	0
Vines on trunks	<10%	15
	10-25%	8
	>25%	0
Tree seedling recruitment (note: abundant is defined as >10 seedlings within a 5m radius center plot)	Seedlings of nut-producing trees (oaks, hickories, beech) abundant	30
	Seedlings of other late successional trees (bald cypress, hemlock, dogwood, etc.), except sugar maple, abundant.	20
	Seedlings of nut-producing trees (oaks, hickories, beech) present, but not abundant	15
	Seedlings of other late successional trees present, but not abundant. Seedlings dominated by pioneer trees, sugar maples, or few seedlings of any type.	10
	Seedlings of only pioneer trees (e.g., pines, red cedar, sumac, sweetgum, sycamore, tulip poplar, red maple) or sugar maple present	5
	No seedlings present	0
	Only exotic seedlings present	-10

TOTAL SCORE _____
Rating (Excellent / Good / Fair / Poor)
(based on score; adjusted if adapted to repeated natural disturbance

APPENDIX G: Wildlife and Habitat Survey Information

Wildlife Habitat Assessments For Harford County Government Green Infrastructure Plan

Wildlife habitat assessments were conducted at four sites throughout the County. Special attention was paid to the presence of amphibians, which are more sensitive to poor-quality habitat. Seasonal wetlands (vernal pools) were sought out during the spring surveys to capture the brief breeding season of frogs, toads, and salamanders. Observations included listening for calls, lifting debris, searching for egg masses, and visual encounters around wetlands.

Water samples were taken at one isolated wetland per site to record the dissolved oxygen, nitrogen, and pH. Other wildlife species recorded during surveys included mammals (including tracks and scat), birds, reptiles, and a subset of insects. Fish, mollusks, and crustaceans were not specifically targeted due to existing extensive stream surveys previously performed by the State. High resolution trail cameras with nighttime infrared illumination were placed at each site for a period of at least two weeks to record the diversity and density of species that might be nocturnal, wary of humans, or otherwise not encountered during the on-site visits. Camera locations were selected based on animal signs, trails, or significant natural features of the site such as habitat transition zones.

Mariner Point Park in Joppa, MD

Overview: Members of the Susquehannock Wildlife Society (SWS), including a master naturalist, professor of biology, and field researchers surveyed the county property within a GI hub/corridor to determine both wildlife habitat and document any wildlife present during multiple visits during both spring and summer seasons in 2018.

Methods: Strategic placement of digital trail cameras, visual surveys, review of recent historic data for adjoining and nearby sites.

Habitat Types with Species: The property exhibits a unique variety of habitat zones that support the needs of many wildlife species despite being an actively used recreation space and being mostly isolated from other land areas by development.

Forest: The forest appears to be fairly sparse in many areas of the park with some of the buffer along the shoreline having somewhat more diversity. Some areas with previously planted reforestation trees appears to be doing well. Invasive plant presence is noticeable in areas along the shoreline and understory where mowed grass isn't present.

Along the forest floor there aren't many logs or rocks to provide cover for amphibians such as toads and salamanders habitat for hiding. Some of the interior areas have well established older trees but due to mowing practices, no replacement trees are growing in the understory. The forest, especially along the Gunpowder river does support edge habitat for eastern box turtles, hawks, a variety of song birds, woodpeckers, red fox, white-tailed deer, gray squirrel, opossum, striped skunk, raccoon, and other species that are tolerant of human activities.

Open Space & Sediment Pond: While no significant wetlands were discovered within the land areas, a sediment point that receives dredge materials may hold water and provide habitat from time to time. During surveys the pond was mostly dry. Pond was subject to invasive plants due to characteristics and habitat where little else can grow. Many areas of park are grass and paved walkways. These areas may allow wildlife to move from one area to another but only for species that are tolerant of human activity and not threatened by moving in open areas.

Tidal Marsh and River: The surrounding edge of the property borders the Gunpowder River as it transitions to the Chesapeake Bay, a freshwater tidal area. The main connecting corridor of this site is the waterfront where species that can swim may move to and from this park to other protected areas such as the nearby state park. This area provides adequate habitat for species that are accepting of open water. Some of the species using this area may include wood ducks, beaver, muskrat, river otter, mink, great blue heron, eastern painted turtles, northern red-bellied turtles, eastern snapping turtles, green frogs, bullfrogs, southern leopard frogs, Cope's gray tree frogs, spring peepers, northern water snakes, several species of fish, mollusks, crustaceans, and many insects.

Trail Camera Survey Species Confirmation (On site):

Red fox	Raccoon	White-tailed deer

Observed Survey Species Confirmation (On site):

American bullfrog	Cedar waxwings	Great blue heron	Red-bellied cooter
American goldfinch	Common grackle	Green frog	Red-bellied woodpecker
American robin	Cooper's hawk	House sparrow	Red-eared slider
Black racer	Cope's gray tree frog	Mallard	Red-shouldered hawk
Blue gray gnatcatcher	Double-crested cormorant	Mourning dove	Red-winged blackbird
Blue jay	Eastern cottontail	Muskrat	Ringbilled gull
Blue jay (nesting material)	Eastern garter snake	Muskrat lodges	Roby-crowned kinglet
Canada goose	Eastern painted turtle	Myrtle warbler	Tree swallow
Carolina chickadee	Eastern rat snake	Northern cardinal	Tufted titmouse
Carolina wren	Gray catbird	Northern Rough-winged swallow	Turkey vulture
Caspian tern	Gray squirrel	Osprey	White-throated sparrow

Species Confirmation (Additional & previous records by SWS at Swan Harbor and nearby sites): Additional species have been discovered at Mariner Point Park and nearby sites by SWS that add to diversity of this site as a high quality wildlife hub. More comprehensive biodiversity records have been done, predating this survey effort, and potentially include rare, threatened and endangered species that are not captured in this public report due to the sensitivity of these populations but will be utilized for discussions, habitat enhancements, or restoration as well as to form connectivity between hubs and corridors.

Basic Plant Overview: The forest contains mixed hardwoods with most age classes being on the older side. Deer grazing is prevalent in many locations at this site and continued or enhanced management of deer is recommended to maintain a healthy understory and a healthy deer population. There are high invasive understory diversity in areas, especially along river and forest edge such as multiflora rose, Japanese stiltgrass, English ivy and Japanese honeysuckle. Tidal wetland areas and sediment pond include cattails and invasive phragmites.

Wetland Water Quality Test:

Location: This site did not have any standing water wetlands that could be tested for the survey.

Recommendation: Due to the location as part of the ecologically valuable Gunpowder River ecosystem, the Susquehannock Wildlife Society strongly recommends that any connected properties and corridors be protected and enhanced so that it may continue to provide a much needed refuge for species moving along the Gunpowder corridor. We noticed a fair amount of human traffic at the site that while not possible to restrict, some actions may be able to prevent with signage and enforcement. The feeding of wildlife, which is common at this park, and availability of food via the outdoor trash cans pose a threat to the health and survival of wildlife. We recommend more active enforcement of wildlife feeding policies and wildlife proof trash cans. We recommend that some of the green grass mowing areas be converted into a native wildflower meadow to create more habitat diversity and prevent additional sediment or runoff into the Gunpowder. Additional trees should be planted in different areas to provide an understory and create some diversity of species. Increased use, a substantial increase in traffic or other destructive change of this property would be a major loss for local conservation. We recommend that invasive species be kept in check and if deer herds are being managed then it should continue.

Parker Conservation Area in White Hall, MD

Overview: Members of the Susquehannock Wildlife Society including a master naturalist, professor of biology, and field researchers surveyed the county property within hub/corridor network to determine both wildlife habitat and document any wildlife present during multiple visits during both spring and summer seasons in 2018.

Methods: Strategic placement of digital trail cameras, visual surveys, review of recent historic data for adjoining and nearby sites.

Habitat Types with Species: The property exhibits a unique variety of habitat zones that support the needs of many wildlife species despite being a somewhat narrow corridor following Deer Creek.

Forest: Forest is the main feature of this area with half being in the floodplain of Deer Creek and the other half being steep hillside slope scattered with rock outcrops. The forest appears to be healthy overall with some diversity of tree species in different age classes. Invasive plant presence is noticeable in areas along the floodplain but has not yet overtaken. Along the forest floor many logs and rocks were found that provide cover for amphibians such as toads and salamanders as well as snakes and insect species. A prominent feature of this landscape is the large rock outcrops which may also provide dens for snakes and mammals. The forest provides an adequate expanse that will support eastern box turtles, several native owl species, a variety of song birds, woodpeckers, red fox, white-tailed deer, gray squirrel, chipmunks, opossum, striped skunk, raccoon, and other species.

Creek, Spring Seeps and vernal pools: Deer Creek certainly has some sedimentation but appears to be relatively clean and fairly well buffered throughout Parker Conservation Area. The creek provides water for woodland birds and mammals, including mink and otters as well as habitat for a variety of fish. There are several spring seeps and small tributaries that provide additional habitat, a water source, and saturated soil that can support additional plant and animal species. This site provides opportunity for spring amphibian breeding and egg laying for red salamanders and other spring-head focused species. There are several spring-head areas clustered in one area of the park that serve as vernal pools that we confirmed wood frogs, spring peepers, and eastern red-spotted newts using to breed and go through their metamorphosis.

Trail Camera Survey Species Confirmation (On site):

Gray squirrel	Raccoon	White-tailed deer
Great blue heron	Red fox	

Observed Survey Species Confirmation (On site):

American toad	Eastern chipmunk	Katydid	Wood frog
Bald eagle	Eastern snapping turtle	Louisiana waterthrush	Spring peeper
Beaver (track)	Green frog	Millipede	Stonefly larva
Black-tip hogsucker	Fishing spider	Northern water snake	Tiger swallowtail
Bumble bee	Freshwater mollusk	Pickerel frog	Turkey vulture
Crayfish	Gray squirrel	Raven	Water strider
Dobsonfly	Gray tree frog	Red-eyed vireo	White-tail deer
Dragonhunter dragonfly	Ebony jewelwing dragonfly	Red-legged grasshopper	Six spotted tiger beetle
Eastern red-spotted newt	Hummingbird clearwing moth	Rough-wing swallow	Wood frog (eggs & tadpoles)
Eastern phoebe	Huntsman spider	Ruby crowned kinglet	

Species Confirmation (Additional & previous records by SWS at Swan Harbor and nearby sites): Additional species have been discovered at Parker Conservation Area and nearby sites by SWS that add to diversity of this site as a high quality wildlife hub. More comprehensive biodiversity records have been done, predating this survey effort, and potentially include rare, threatened and endangered species that are not captured in this public report due to the sensitivity of these populations but will be utilized for discussions, habitat enhancements, or restoration as well as to form connectivity between hubs and corridors.

Basic Plant Overview: Fairly diverse forest in floodplain with mixed hardwoods that includes an understory of mountain laurel, witch hazel, and several fern species as well as younger age classes of oak and other canopy species. Deer grazing is less prevalent at this site than others. Spring-fed wetland areas have skunk cabbage and arrow arum. Invasive plants are present, especially along creek and forest edge such as barberry, mile-a-minute, multiflora rose, and Japanese stiltgrass but still at a manageable level.

Wetland Water Quality Test: Location: Woodland vernal pool

Results: Dissolved oxygen - 1.2 mg/L, pH - 6.2, nitrates 0.0 mg/L
Our finding was that the dissolved oxygen was low but that is common given the time of the year sampled and vernal pools fluctuate depending on rainfall. The pH is a little low but still close to the optimal range of between 6.5 and 9. Nitrates above 3 would indicate pollution or fertilizer contamination but with the level not registering above zero in our tests we believe this pool is healthy and functioning as it should for wildlife.

Recommendation: Due to the location as part of the ecologically valuable Deer Creek valley, habitat and species diversity, a manageable number of invasive species, core forest, and high agricultural use in surrounding areas, the Susquehannock Wildlife Society strongly recommends that any connected properties and corridors be protected and enhanced so that it may continue to provide a much needed refuge for species moving along the Deer Creek corridor. We noticed a fair amount of human traffic on our trail cameras that included some swimming and fishing but most concerning was a fire ring and some graffiti in a location so remote. We recommend more active enforcement of park hours and uses limited to hiking which is likely to be minimal due to lack of parking which helps maintain some of the more wild characteristics of the property. Increased use, a substantial increase in traffic or other destructive change of this property would be a major loss for local conservation. We recommend that invasive species be kept in check and if deer herds are being managed then it should continue.

Swan Harbor Farm in Havre de Grace, MD

Overview: Members of the Susquehannock Wildlife Society including a master naturalist, professor of biology, and field researchers surveyed the county property within hub/corridor network to determine both wildlife habitat and document any wildlife present during multiple visits during both spring and summer seasons in 2018.

Methods: Strategic placement of digital trail cameras, visual surveys, recent historic data for adjoining and nearby sites.

Habitat Types with Species: The property exhibits a unique variety of habitat zones that support the needs of many wildlife species despite being highly altered and utilized for human activities and agriculture.

Forest: The forest appears to be healthy overall with some diversity of tree species in different age classes. Invasive plant presence is high in some locations on the property, especially along the stream buffer and forest edges. Along the forest floor many logs were found that provide cover for amphibians such as toads and salamanders as well as insect species. The forest provides an adequate expanse that will support eastern box turtles, several native owl species, a variety of song birds, woodpeckers, red fox, white-tailed deer, gray squirrel, opossum, striped skunk, raccoon, and other species. Transitional zone between stream valley of forest and agricultural area includes steep hillside with potential for mammal dens.

Creek, Spring Seeps and vernal pools: Gashey's Creek certainly has some sedimentation but appears to be relatively clean and fairly well buffered throughout Swan Harbor. The creek provides water for woodland birds and mammals as well as habitat for salamanders and variety of fish. There are several spring seeps that may provide additional habitat, a water source, and saturated soil that can support additional plant and animal species. This site provides opportunity for spring amphibian breeding and egg laying for red salamanders and other spring-head focused species. There are several vernal pools scattered throughout the forest areas that allow for species of amphibians, especially spotted salamanders, spring peepers, and wood frogs to breed and go through their metamorphosis.

Tidal Marsh: The eastern portion of the property borders the Susquehanna River as it transitions to the Chesapeake Bay, a freshwater tidal area. This area provides adequate habitat including some sheltered coves. Some of the species using this area include wood ducks, beaver, muskrat, river otter, mink, great blue heron, eastern painted turtles, northern red-bellied turtles, eastern snapping turtles, green frogs, bullfrogs, southern leopard frogs, Cope's gray tree frogs, spring peepers, northern water snakes, several species of fish, mollusks, crustaceans, and many insects.

Agricultural Field: The agricultural field itself does not provide much wildlife habitat although it allows an important stop for birds, but if left to grow native grasses and vegetation, even in selected areas or as a buffer, it would provide ideal habitat and food for species like the white-tailed deer, eastern coyote, striped skunk, red fox, groundhog, northern black racer, eastern garter snake, rodent species, as well as hawks, eagles, owls, and falcons that might just otherwise pass through. Open areas are important as transitional zones between forest and meadow wildlife habitat that will be used for feeding, hunting, and hiding. The eastern box turtle in particular uses these areas for egg laying due to the direct sunshine that aids in incubation.

Trail Camera Survey Species Confirmation (On site):

Eastern coyote	Great blue heron	Raccoon	White-tailed deer
Gray squirrel	Opossum	Red fox	

Observed Survey Species Confirmation (On site):

American crow	Eastern box turtle	Monarch	Rusty blackbird
American toad	Eastern garter snake	Mosquito larvae	Spider mite
Bald eagle	Ebony jewelwing dragonfly	Myrtle warbler	Spring peepers
Banded killifish	Evergreen bagworm	Northern cricket frog	Sulfur butterfly
Belted kingfisher	Fowler toad	Painted turtle	Swamp sparrow
Black racer	Goldfinch	Palm warbler	Tree swallow
Blue gray gnatcatcher	Gray squirrel	Pickerel frog	Turkey vulture
Bluebird	Great blue heron	Raccoon (tracks)	Water strider
Bluegill	Green frog	Red fox (tracks)	White-tailed deer
Canada goose	Green sunfish	Red-shouldered hawk	Wood duck
Cope's gray tree frog	Huntsman spider	Red-tailed hawk	Wood frog (egg mass)
Creek chub	Japanese beetle	Red-winged blackbird	

Species Confirmation (Additional & previous records by SWS at Swan Harbor and nearby sites): Additional species have been discovered at Swan Harbor Farm and nearby sites by SWS that add to diversity of this site as a high quality wildlife hub. More comprehensive biodiversity records have been done, predating this survey effort, and potentially include rare, threatened and endangered species that are not captured in this public report due to the sensitivity of these populations but will be utilized for discussions, habitat enhancements, or restoration as well as to form connectivity between hubs and corridors.

Basic Plant Overview: Fairly diverse understory in uplands with mixed hardwoods that includes an understory with pawpaw trees and a variety of wildflowers and groundcover including mayapple, trout lily, fern species, and skunk cabbage. Deer grazing is prevalent in many locations at this site and continued or enhanced management of deer is recommended to maintain a healthy understory and a healthy deer population. High invasive understory diversity in areas, especially along creek and forest edge such as barberry, multiflora rose, Japanese stiltgrass, and blackberry. Open wetland areas include cattails and grasses but also invasive purple loosestrife. Edge of agricultural area has patches of Indian hemp and milkweed that can support some insect diversity.

Wetland Water Quality Test:

Location: Cattail wetland in agricultural field

Results: Dissolved oxygen - 7.4 mg/L, pH - 6.4, nitrates - 0

Our finding was that the dissolved oxygen was well above the range of concern. Organisms become stressed or sick in areas with low oxygen levels but this was not the case here. The pH is a little low but still close to the optimal range of between 6.5 and 9. Nitrates above 3 would indicate pollution or fertilizer contamination but with the level not registering above zero in our tests we believe this pool is healthy and functioning as it should for wildlife.

Recommendation: Due to the location along a geographical transition zone, habitat and species diversity, a manageable number of invasive species, core forest, and highly developed surrounding areas, the Susquehannock Wildlife Society strongly recommends that any connected properties and corridors to the north be protected and enhanced so that it may continue to provide a much needed refuge for species in the coastal plain of Harford County. Increased use, a substantial increase in traffic or other destructive change of this property would be a major loss for local conservation in a highly fragmented region of the county. We recommend that invasive species be kept in check and deer herds be managed more effectively to maintain a healthy forest. Native trees, grasses, and wildflowers should be planted in at least a portion of the agricultural space or transition area between forest and agricultural fields.

Bynum Run Conservation Area in Abingdon, MD

Overview: Members of the Susquehannock Wildlife Society including a master naturalist, professor of biology, and field researchers surveyed the county property within hub/corridor network to determine both wildlife habitat and document any wildlife present during multiple visits during both spring and summer seasons in 2018.

Methods: Strategic placement of digital trail cameras, visual surveys, review of recent historic data for adjoining and nearby sites.

Habitat Types with Species: The property exhibits a unique variety of habitat zones that support the needs of many wildlife species despite being a somewhat narrow corridor following Bynum Run.

Forest: Forest is the main feature of this area with half being in the floodplain of Bynum Run and the other half being steep hillside slope scattered with rock outcrops. The forest appears to be healthy in sections with some diversity of tree species in different age classes but many stretches are dominated by beech trees and much is grazed heavily by deer. Invasive plant presence is noticeable in areas along the floodplain but has not yet overtaken. Along the forest floor many logs and rocks were found that provide cover for amphibians such as toads and salamanders as well as snakes and insect species. The forest provides an adequate expanse that acts as a corridor between other protected areas such as Bush Declaration Natural Resource Area to the south that will support eastern box turtles, several native owl species, a variety of song birds, woodpeckers, red fox, white-tailed deer, gray squirrel, chipmunks, opossum, striped skunk, raccoon, and other species.

Creek, Spring Seeps and vernal pools: Bynum Run certainly has some sedimentation but appears to be relatively clean and fairly well buffered throughout Bynum Run Conservation Area. The creek provides water for woodland birds and mammals, including mink and otters as well as habitat for a variety of fish. There are several spring seeps and small tributaries that provide additional habitat, a water source, and saturated soil that can support additional plant and animal species. This site provides opportunity for spring amphibian breeding and egg laying for red salamanders and other spring-head focused species. There are several spring-head areas and a few vernal pools that we confirmed wood frogs, spring peepers, and spotted salamanders using to breed and go through their metamorphosis.

Trail Camera Survey Species Confirmation (On site):

Eastern coyote	Great blue heron	Raccoon	River otter
Gray squirrel	Opossum	Red fox	White-tailed deer

Observed Survey Species Confirmation (On site):

American crow	Cooper's hawk	Nothern flicker	Spotted salamander (eggs)
American robin	Cope's gray tree frog	Nothern hogsucker	Summer tanager
American toad (egg)	Downy woodpecker	Pickerel frog	Swamp sparrow
Barred owl	Eastern phoebe	Pickerel frog (egg)	Turkey vulture
Blue gray gnatcatcher	Eastern towhee	Raccoon (tracks)	Two-lined salamander
Blue jay	Gray catbird	Red tail	Water strider
Cardinal	Green frog	Redback salamander	White-breasted nuthatch
Carolina Chickadee	Louisiana waterthrush	Red-bellied woodpecker	White-tailed deer (tracks)
Caroline wren	Mallard	Red-tailed hawk	Wood duck
Common grackle	Myrtle warbler	Red-winged blackbird	Wood frog (larva)
Common yellow-throat	Nothern cardinal	Ruby-crowned kinglet	Wood thrush

Species Confirmation (Additional & previous records by SWS at Swan Harbor and nearby sites): Additional species have been discovered at Bynum Run Conservation Area and nearby sites by SWS that add to diversity of this site as a high quality wildlife hub. More comprehensive biodiversity records have been done, predating this survey effort, and potentially include rare, threatened and endangered species that are not captured in this public report due to the sensitivity of these populations but will be utilized for discussions, habitat enhancements, or restoration as well as to form connectivity between hubs and corridors.

Basic Plant Overview: Much of the forest is dominated by beech trees away from the creek with little understory other than some groves of pawpaw trees. Due to deer grazing there are a fair number of invasive plants present, especially along creek and forest edge such as mile-a-minute, multiflora rose, and Japanese stiltgrass. Spring-fed wetland areas have skunk cabbage and jack-in-the-pulpit.

Wetland Water Quality Test:

Location: Woodland vernal pool

Results: Dissolved oxygen - 1.2 mg/L, pH - 6.2, nitrates – 0

Our finding was that the dissolved oxygen was low but that is common given the time of the year sampled and vernal pools fluctuate depending on rainfall. The pH is a little low but still close to the optimal range of between 6.5 and 9. Nitrates above 3 would indicate pollution or fertilizer contamination but with the level not registering above zero in our tests we believe this pool is healthy and functioning as it should for wildlife.

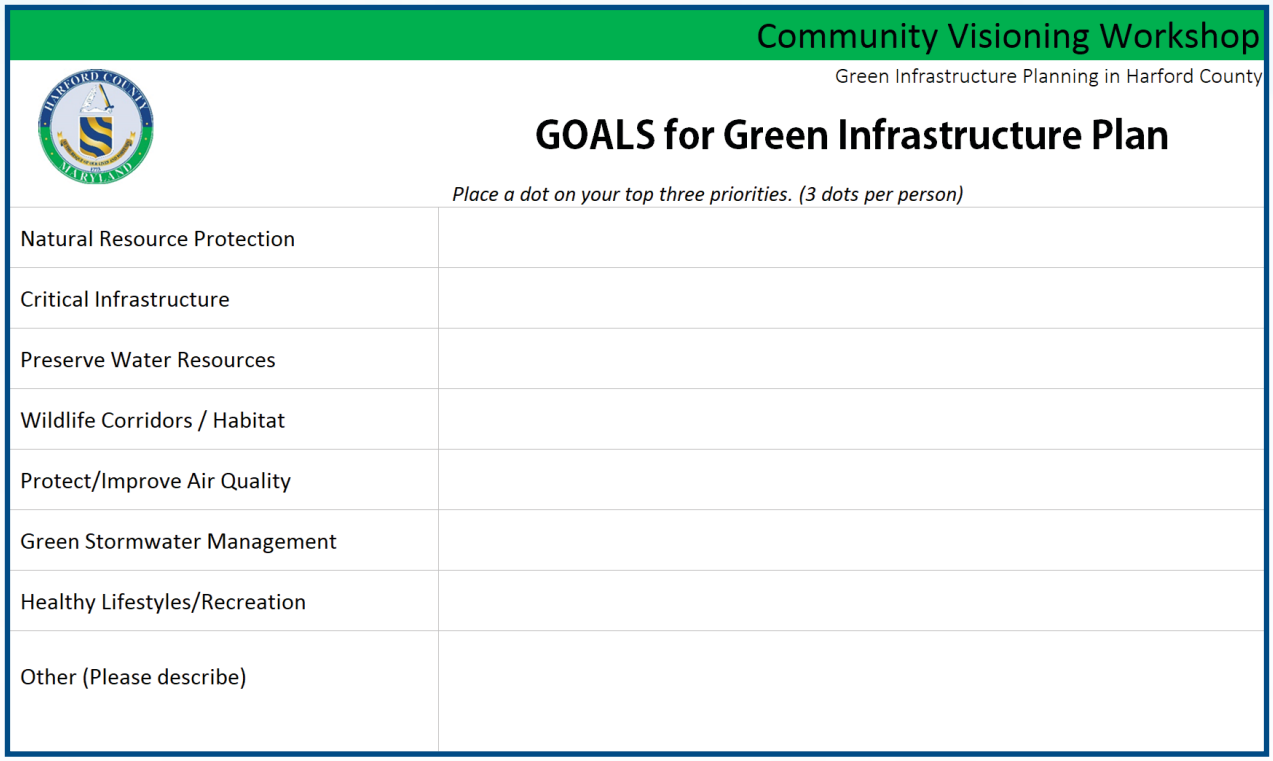
Recommendation: Due to the location as part of the ecologically valuable Bynum Run valley, habitat and species diversity, a manageable number of invasive species, connectivity to other preserved areas, and highly developed areas surrounding this corridor, the Susquehannock Wildlife Society strongly recommends that any connected properties and corridors be protected and enhanced so that it may continue to provide a much needed refuge for species moving along the Bynum Run corridor. We noticed a fair amount of human traffic on our trail cameras that included some metal detecting and fishing but most concerning was vehicle traffic from trucks, Jeeps, ATVs, and tractors, likely by those in the surrounding communities. We recommend more active enforcement of park hours and uses limited to hiking. Increased use, a substantial increase in traffic or other destructive change of this property would be a major loss for local conservation. We recommend that invasive species be kept in check and if deer herds are being managed then it should continue. Native trees and plants should be introduced where possible.

APPENDIX H: Public Response

Open House Community Meetings

February 8, 2018

On February 8, on the Harford Community College campus, Harford County and other members of its Green Infrastructure project team conducted an open house meeting to initiate the broader outreach regarding green infrastructure planning in the community. Display boards illustrated several resource maps for the County and solicited feedback on priorities for green infrastructure goals and strategies.



Community Visioning Workshop

Green Infrastructure Planning in Harford County

GOALS for Green Infrastructure Plan

Place a dot on your top three priorities. (3 dots per person)

Natural Resource Protection	
Critical Infrastructure	
Preserve Water Resources	
Wildlife Corridors / Habitat	
Protect/Improve Air Quality	
Green Stormwater Management	
Healthy Lifestyles/Recreation	
Other (Please describe)	

Figure A-1: Display Board of Goals for Group Dot Ranking Exercise.

A fact sheet handout provided the green infrastructure information through a frequently asked question and answer format. Over 60 participants attended to hear the presentation about the GI Plan's scope and timeline, mapping approaches for the four resilient strategies, and results from the Gunpowder Watershed GI pilot Project. The open house presentation also emphasized the importance of public participation to help guide the planning process and ensure its accurate representation of values and goals for the County and its HarfordNEXT implementation.

The community open house engaged participants through a series of group and individual exercises. Participants were asked to share their perspectives on the GI Plan's goals and importance of different implementations strategies. Input was also gathered regarding potential County park sites for GI demonstration projects.

The first activity requested participants to rank their priority for Green Infrastructure goals. This task involved numbering a list of goals compiled from HarfordNEXT. Ranking cards were distributed to each participant with a list of goals and space for an additional goal as "other" if a missing goal was needed for consideration. Using "1" as the highest priority, participants ranked their choices (1 through 7 unless "other" was used, adding an 8th choice). The list of goals included Natural Resource Protection, Critical Infrastructure Protection, Preserve Water Resources, Wildlife Corridors/Habitat, Protect/Improve Air Quality, Green Stormwater Management, Healthy Lifestyles/Recreation and Other. The most important "1" ranking was tabulated to reveal the most important goals, as shown in Figure A-2 below. Two other goals - "Urban Planning" and "Heritage" - were also added by citizen feedback. Natural Resource Protection far outweighed all other listed goals.

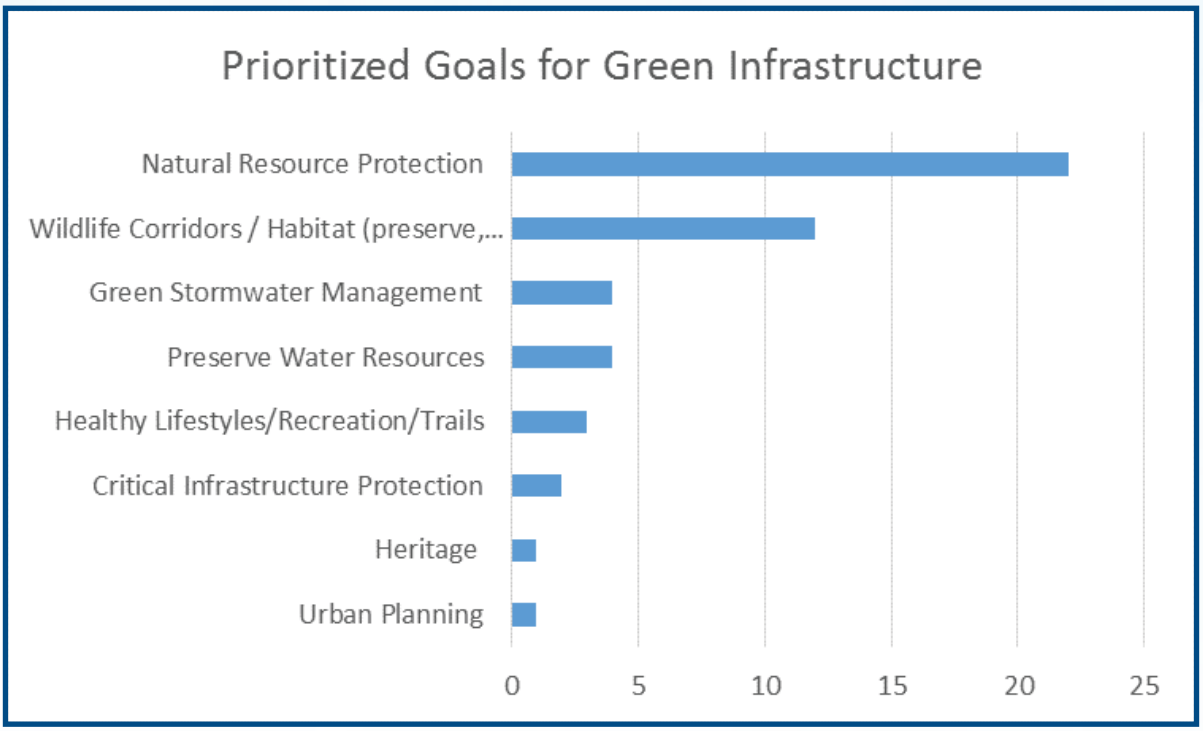


Figure A-2: Prioritized Goals Identified by Participants at February 8th Community Open House.

The second activity for participants requested their ranking of strategies for implementation of a green infrastructure program by prioritizing a list of potential actions to be taken by the County and others. The list of strategies included Acquire key natural areas, acquire strategic connecting corridors, Plant riparian buffers, Enhance tree canopy, Add multi-benefit green stormwater projects, Reduce impervious surfaces, Connect greenway trails, Expand coastal protection projects, and a space to add "Other implementation strategy". Once again, the ranking value applies "1" as the highest priority. As illustrated in Figure A-3 below, acquiring key natural areas was by far the highest priority identified by meeting participants.

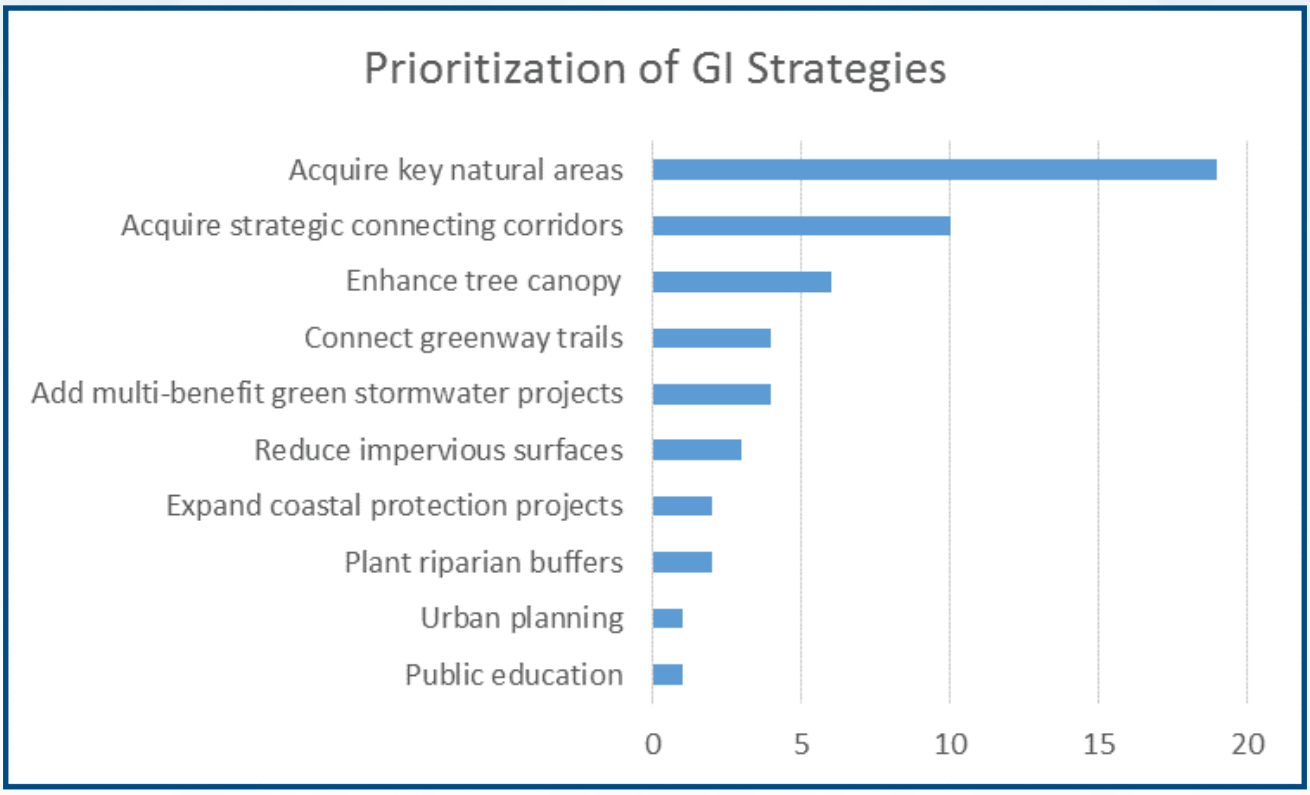


Figure A-3: Prioritized Strategies Identified by Participants at February 8th Community Open House.

The final activity conducted during the community open house provided a format for participants to indicate a demonstration project type and a suggested County park property where the GI strategies could be implemented. As background, the workshop leaders shared that the County's Land Preservation, Parks, and Recreation Plan (LPPRP) was being updated and the 2018 draft plan was currently under review. Several of the existing (2013) LPPRP policy recommendations directly related to green infrastructure including:

> *PR-1 Acquire additional recreation land, including waterfront properties, to help meet the needs of current and future residents.*
>
> *PR-2 Develop integrated greenway/trail systems with both public and private segments.*
>
> *PR-7 Incorporate sustainable development and conservation practices in all Parks and Recreation parks and facilities.*

Instructions for Task #3: "Consider your personal knowledge of County parks and where you think a GI demonstration project could be beneficial."

Four specific project types were listed (Plant riparian buffers, Enhance existing tree canopy, Add Multi-Benefit Green Stormwater Projects, and Reduce impervious Surfaces) as well as a line for "Other" implementation strategy. Participants who were familiar with specific County parks provided their suggestions based on their local knowledge of the sites and the project types.

County Park Green Infrastructure Demonstration Project - Suggestions from Feb 8th Comments				
Riparian buffers	Enhanced tree canopy	Multi-benefit green stormwater projects	Reduced impervious surfaces	Other implementation strategy
Copenhaver Park	Shamrock Park	Havre de Grace Activity Ctr (3)	Mariner Point Park	Reduce mowing areas thru-out
Swan Harbor Farm (2)	Edgewood	Friends Park	Copenhaver Park	Remove invasives
Eden Mill (2)	Ma & Pa Trail (2)	Mariner Point Park (2)	Friends Park	Make trail connections
Alfred B. Hilton Park	Swan Harbor Farm	Swan Harbor Farm	Forest Hill/Hickory Activity Ctr	Signage
Alice & Wm Longley Park	Fallston Rec Complex	Anita Leight Park	Swan Harbor Farm	Plant a meadow
Anita Leight Park	Mullins Park (2)	Perryman Park	Fallston Rec Complex	Develop "green line" - cons/dev.
	All ball fields	Willoughby Beach Park	Otter Point	Rain Garden (Leight)
	Tudor Hall	Otter Point Landing (2)	Broad Creek Landing	
		All rec. fields	Churchville Rec Complex	
			All parks	

Figure A-4: Community Suggestions for Demonstration Project Types in County Parks.

Enhancing tree canopies and adding multi-benefit green stormwater projects showed a stronger preference as demonstration projects for consideration in County parks compared to planting riparian buffers and reducing impervious surfaces.

In addition to the three organized tasks, participants were encouraged to fill out comment cards to share their thoughts and ideas about Harford County's green infrastructure plan. Over 30 comment cards were received containing suggestions and considerations. The submitted comments contained expressed support of green infrastructure with numerous suggestions and ideas on ways to help implement strategies and promote coordination and partnerships. A frequently expressed concept encouraged extending greenways along the Gunpowder, Little Gunpowder and connecting green spaces/greenways to neighborhoods and public transit (Harford Link). Connections for walking, biking and insect pollinators were included with the need for extended greenways and wildlife corridors. Some suggestions for potential project demonstration sites included Harford Community College, Harford County schools, and the Ma & Pa trail corridor. A few individuals expressed concern about green infrastructure being implemented without allocated funding or additional regulations. Some comments encouraged greater communication during the planning process to facilitate coordination. Overall, the comments were positive and indicated a desire to see green infrastructure implemented in a variety of ways including beyond the public realm. Actual comments are listed below.

September 27, 2018

On September 27, 2018, the draft plan's findings and recommendations were presented in a second community open house to share the planning process and its preliminary results and to reengage public feedback on aspects of the County's green infrastructure network.

The second open house displayed maps of the identified green infrastructure network, best locations for specific beneficial stormwater practices and high priority lands for conservation to enhance the green infrastructure network. At least 33 participants viewed the presentation about the mapping and wildlife validation surveys and the summary of public feedback from the February green infrastructure community meeting.

Harford County and consulting members of its Green Infrastructure project team conducted this second meeting to present highlights from the planning results. The County was able to share its current efforts to provide a public on-line green infrastructure mapping website where individuals could explore their properties and other lands in the county relative to their core habitat values, corridor and hub identification and stormwater best management practice feasibility. The online mapping service was estimated to be ready for public use by the end of October

Participants were asked to weigh in on their priorities by "voting" on relative importance of different implementation strategies. These strategies included actions that the County could be responsible for, as well as green infrastructure network enhancement activities that would be outside of county action, such as those listed below:

- Practice stewardship by actively applying green infrastructure and stormwater practices on county-owned lands
- Engage additional efforts to preserve high-value green infrastructure lands (fund new passive parks)
- Initiate outreach and education programs on the benefits of preserving green infrastructure lands
- Create links and connections for trails, greenways and wildlife corridors
- Encourage private land owners and conservation groups to implement green infrastructure practices
- Support & enhance agricultural programs that benefit green infrastructure on farmland
- Other (Please describe)

Cards were provided with the six (6) listed strategies (both county and non-county actions) and a column for ranking their importance from 1-6, with 1 being the most important. A seventh space was provided for any "other" strategies that could be suggested and included in the ranking. Results from the exercise are illustrated in Figure A-5 below.

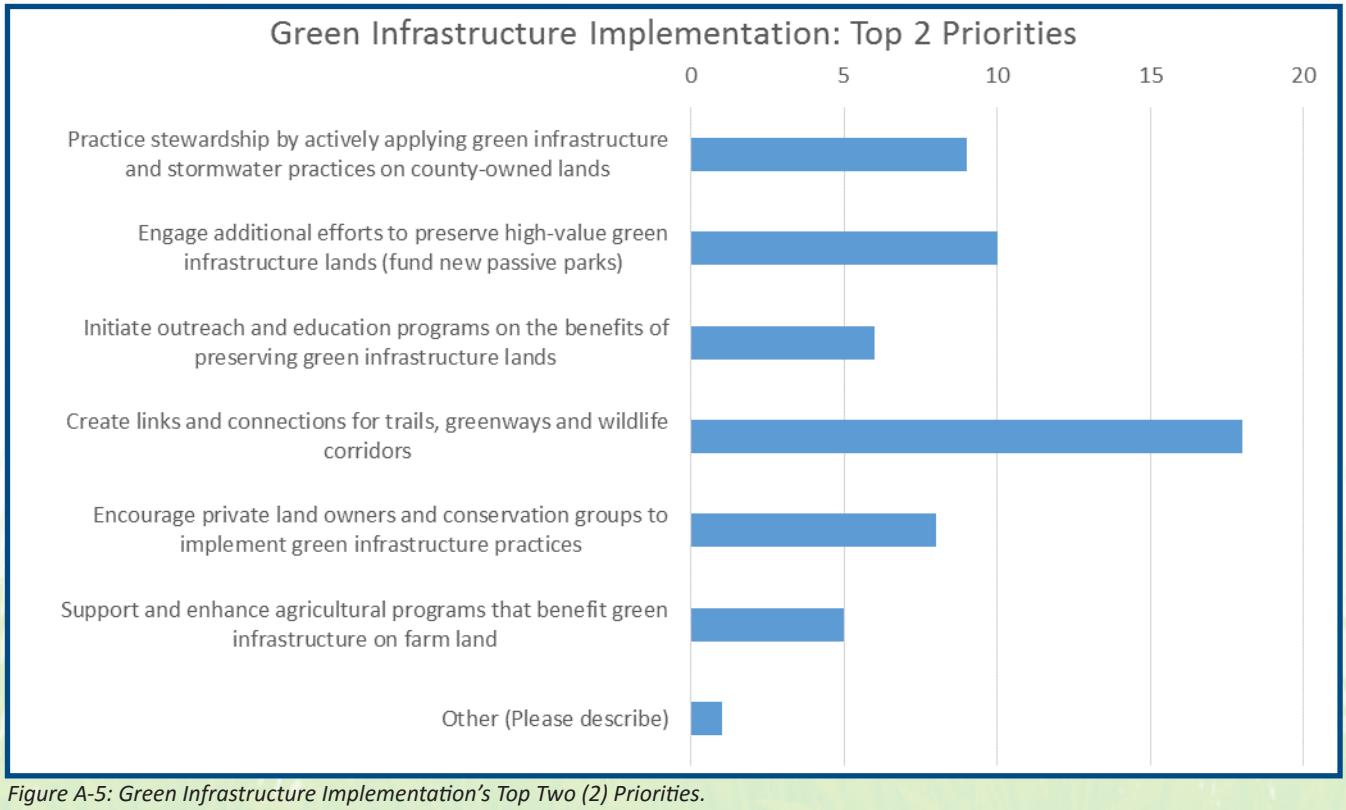
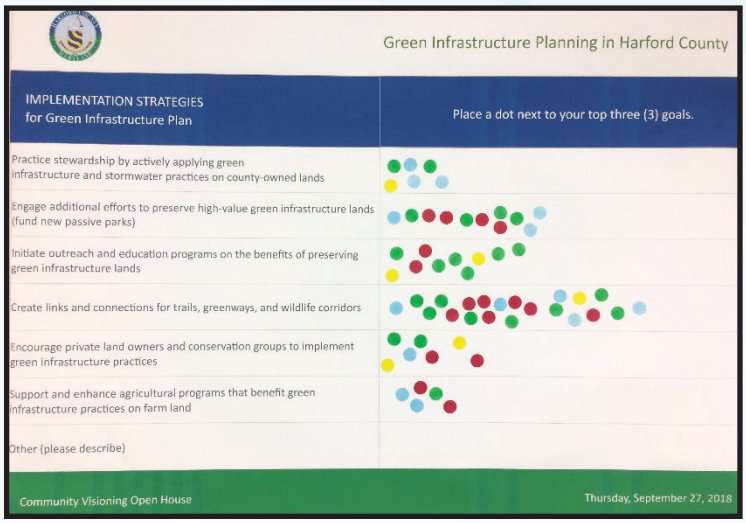


Figure A-5: Green Infrastructure Implementation's Top Two (2) Priorities.

As shown in Figure A-5 (previous page), the two highest ranking priorities among the second meeting participants were connecting greenways and acquiring more high-value conservation lands. The strategy gathering the most #1 rank was, "Create links and connections for trails, greenways and wildlife corridors."

The cards reflected similar results to the display board that depicted the identical list of strategies for prioritization. Participants were given three (3) dots upon entering the meeting venue for "casting their vote" for their three highest priority strategies. The strategy to connect greenways for both trails and wildlife was clearly the highest priority among approximately two-thirds of the meeting attendees, garnering 21 dots (10 more than any other strategy).



Comment cards were also provided for attendees to record their ideas, thoughts and concerns relative to the green infrastructure network and the county planning effort. Those comments are listed below, along with comments from the February meeting.

COMMENT CARDS

Green Infrastructure Plan - February 8, 2018

At the City of Havre de Grace I am the permit coordinator and green infrastructure is top most in daily activities/work.

Look forward to seeing this implemented. Excited to help with the outreach and home/small site BMP's

I think this activity tonight is a wonderful way to move green initiatives forward and garner support! I met like-minded folks who are excited to work on the goals and strategies, which gave me some HOPE – a rare and precious thing in this day and age under the "current administration."

Incentivize or regulate – Need summary/date on ideas generated at the workshop.

Lots of groups with related goals that can contribute to green infrastructure - but they are mostly independent. Need some way to bring them together for joint projects or complementary projects. Maybe hold a coordination meeting that involves interested groups so they can work with the GIP framework to exchange ideas and find partnership opportunities.

There seems to be wide interest in acquiring areas for natural resource/wildlife habitat purposes. Is there interest in a very large Harford County Natural Park/Conservation Area?

Creation of such a park/area might be an excellent economic and environmental long-term strategy and set an example for surrounding counties.

You have the folks heavily invested here now in Feb 2018. Sept 2018 for a "NEXT" gather is too late!
Newsletter "Bi-Monthly" updates – include Park Features!

Join information on the County's efforts to improve the environment

Develop Gunpowder Greenway to connect to Marshy Point – then upriver to Jerusalem Mill.

We want to be the demonstration project – We have the area – no land needs to be purchased just need planning – enforcement – parks cooperation and storm water retrofit by Storm Water Management Academy.

We'd like to see the entire length of the Little Gunpowder have green space and dirt hiking trails for pedestrians.

Buses (Harford Link) should have stops at parks, estuary center, Eden Mill, etc.

We work towards a lot of the same goals. Great Open House.

Great public workshop. No recommendations.

I enjoyed being a part of building up what looks like great planning.

How is any of this going to happen without affecting funding or regulations? Is it just an exercise?

After all, Harford Next is "just a vision", not regulatory or required, as we are repeatedly reminded by elected officials.

Increase use of green energy on all public/community buildings – saves money long term and removed dependence on polluting fossil fuels.

Paths connecting neighborhoods to public/common walks – allowing walking/biking rather than car travel.

Sidewalks on stretches currently unwalkable – would enable walk rather than car.

Workshop was great. Very informative. It's wonderful to see the County concerned about green space.

I would be interested in hearing about plans for promotion of the green infrastructure plan.

Commend H. C. Government for spending time to develop the plan. Kudos!
Purpose and outcomes could be better defined
It seems that only County lands will be affected now. Could this drive incentives and funding for private landowners too?
How does this overlay with preservation programs, project open space, etc?
Let me know how Harford Land Trust can help!!

"Maybe" encourage introductions at beginning of mtg.
More details on actions required to implement.
Impressed with Harford County's commitment.

Ensure the wildlife corridors contain pollen and nectar sources (weeds, blooming trees, clover etc.) so the bees and pollinators have sufficient nutrition. Honeybees cannot fly over large fields of corn & soybeans to get to the next pollen/nectar field. Their maximum range is about 2 miles and they will die of starvation/exhaustion if they have to fly too far.

Good overall format and focus.
Need to set interim goals/time table.
Need some additional public input prior to fall conclusion of plan.

Informative, well presented. Liked table interaction.
Jean Akers very good. Ted also.
Would have been grand to have coffee or suggest people bring their own.
Got me interested in looking at areas I was not aware of.
Christine was informative and good facilitator.

Time is of the essence. It's gratifying to know the County is doing a green infrastructure plan.

Look at historic areas as part of presentation. "Heritage Preservation" Harford Furnace Historic District vs 543?

Pervious sidewalks, see HCC have visible demo sites for sidewalks.
How to connect with bordering counties.
How to interface with APG North/South.
Use native species and remove evasive.
Trees to provide food for wildlife, plants too.
Involve schools, possible demo sites, North Harford, others.
What about State property?

Is the Chamber of Commerce involved?
The GI plan must promote business development.

MD DNR & can help with tree planting & forest assessment.
Forest buffers at least 100' wide & connect as many natural areas, towns, etc. by trails or trail connectors.
Plant tree canopy in towns and cities.
Large tree lawn greater than 6 feet in width to provide tree canopy of healthy trees in developments.
Crop field along MA & PA trail between Annie's Playground. Ground for weeds would be a great place for most of GI demo areas.

Include soil quality as a major component in most of the other infrastructure utilities both clean soil (lower pollution) & soil integrity (e.g. erosion control). Test soils before designing plantings to determine best vegetation for each soil type.

Sounds like there needs to be more education regarding Green Schools/MAEOE and then introduction of those programs into more Harford County Schools. School grounds would greatly benefit from more enviro/science activities. More wildlife corridors and invasive species removal around bodies of water/parks/etc.

On Route 40 and 24 there is water, on one side of the ramp towards Route 24 ducks & lily pads thrive. On the other side of the ramp everything in the water looks dead. I would like the dead side to be studied to find out why plants do not thrive. I do not see ducks on that side but they are on the other.

Fix flooding issues under one-lane bridge on Edgewood Road not far from Lakeside Boulevard. Water runs under bridge to the point that you cannot drive through it.

After the community open house, the County website was updated to share the summary of the feedback and level of participation.

COMMENT CARDS

Green Infrastructure Plan - September 27, 2018

Both Harford Land Trust and Maryland Environmental Trust lands are missing from mapped preserved lands. It is very understandable why you do not include soils as a natural resource on your natural resources map, but perhaps you could add a caveat regarding why soils were not a data layer you looked at. Great work!

Is it possible to get a copy of the slides presentation?

Is your analysis available online?

Thank you for the good work and for including Joppa and Joppatowne in the planning. Please encourage in your plan that the small area of Little Gunpowder that is not protected in parks should be protected.

Are hubs evaluated for the insect life supported?
Are size of home ranges evaluated?

Running power and other cable infrastructure underground frees up more overhead space. Tree canopy in urban areas can be dramatically increased.

Change planning, zoning and development policies to limit commercial (and residential) development, and calls for smarter development that does little impact to the environment and/or "offsets" another action.

Stormwater practices in private/public development.

Education, climate change implications. Clean air - asthma issues.

Multi-function green space is important! Co-location of natural areas near active spaces to get people outside!

Urban trail hubs as well.

Identify "gaps" that are important to making connections & target those for GI improvements.

Establish some way to connect & facilitate interaction by many & varied groups that have interests in this program.

1.) Tax incentives for pervious sidewalks and driveways

2.) Follow construction so that run-off is controlled on the property, see this old house 2018 for example

FINAL COMMENTS

Green Infrastructure Plan - December 28, 2018

Consider connecting the Baltimore County side of the Deer Creek watershed to the Harford side for Rural Legacy. Rural Legacy funds would be helpful as an option for lands with more environmental features.

Thank you for the opportunity of working with your department on the development of the GI Plan. It is great to see efforts for the Gunpowder River watershed, including selecting Mariner Point Park as a demonstration site.

There is a corridor along the railroad tracks in Magnolia that needs protection. Please consider purchasing a corridor/trail connection to Magnolia Middle School and fields on Trimble Road.

Consider the idea of protecting core areas from future development by mandating Environmental Site Design and the preservation of corridors for wildlife and citizens.

Consider exploring grants or other partnerships to extend a continuous trail from Jerusalem Mill to the original port of Joppa.

Invasive species are a growing problem in the County. We would like educational information on management practices and would like to organize efforts to control invasive species.

The fee-in-lieu provision for open space should be removed as a way to ensure open space is preserved on-site. Development should be altered to make sure open space requirements are met.

There does not appear to be any green infrastructure in the Bel Air South area. Residents need access to open space and green infrastructure. Green infrastructure promotes active lifestyles and healthy communities. Green infrastructure should not be only in agricultural areas. Recreational opportunities, increased property values, and quality of life are all benefits of GI. Please consider these items in the implementation of the GI Plan.

Rain gardens, tree plantings, low mow area projects at road intersections should not be permitted to encroach into the sight line triangle. Any plantings should not exceed three feet in mature height in these areas.

Low mow/no mow areas should not be used in areas of limited sight distance (ie, blind curves) along County roadways.

Concern over erosion and sediment runoff into Deer Creek from Nobles Mill Rd and Harmony Church road. Improved mitigation and maintenance techniques should be incorporated in the GI Plan for these areas.

The GI plan is a great start which appears to encompass a lot of detail regarding the Harford County landscape. Please keep up the good work.

The data showing preserved lands should be updated to reflect recent efforts by Harford Land Trust.

Page 2- "(See Figure 5)" should be Figure 4. Page 28, the end of the first sentence contains two verbs "can are". Page 30, the two figures (30 &31) overlapped.

The plan document looks very good, looking forward to seeing the interactive GI web viewer.

I am blown away by the GI Plan. What an impressive document! While reading it, I may have repeatedly cheered "Yes, Yes, Yes!" This is my dream! This plan fills my soul with joy and hope for the future of our county.

Page 2- Is it possible to provide incentives to plant native species in important watersheds?

Could there be incentives by the County to repurpose existing structures instead of destroying habitat for new construction?

We should plant native perennials in community landscapes and public areas vs. planting annuals.

Page 4- Consider using the terminology that plants "naturalize" an area vs. "propagate".

Invasives are a major issue, areas need to be under control before native species are planted.

Love ideas that educate the community such as no mow or low mow zones. This makes my heart sing.

Deer are a problem. Continue to investigate the use of goats for invasive species management.

Has the topic of native plant communities come up? Please keep native plant communities in mind when selecting plants.

Page 15- Could someone offer an incentive to farmers to dedicate one acre of farmland to the creation of a native meadow?

When trees and plants are planted for mitigation or buffers, does someone follow up to make sure the trees and plants are alive? I have seen many trees planted for mitigation and then left to die.

Page 21- Explore the possibility of creating a corridor of green roofs to help manage stormwater management.

Page 23- Could new developments have incentives for using pervious material for roads and sidewalks? Cool idea using curbs to divert water. Watering trees with stormwater runoff is brilliant! Continue ideas for creating environmentally friendly communities.

Page 29- How about painting parking lots white to reduce temperatures of pavement and stormwater runoff?

Consider incentives for businesses to reduce light pollution, nocturnal species need darkness.

Page 35- Typo "Impervious"

No mention of using solar panels on roofs of public buildings or parking lots. People could park under the solar panels.

Love the idea of outreach, education and partnerships with organizations. People need to know.

Update regulations! Developers must use native plants in their landscapes with only a certain percentage of grass. Lawns are food deserts for our wildlife.

Page 36- Landowners who participate could receive a sign on their property stating they are part of the GI, similar to Chesapeake Bay Wise signs.

Hometown Habitat…churches plant native plants. They usually have a lot of barren property that does not support wildlife.

Page 37 –Penn State has a great webinar about vegetation management. HCC and public libraries would also be great additions to the GI network. Consider the idea of having veterans with PTSD assist with vegetation management as part of their therapy. Recovering addicts, minimum security inmates, and other organizations such as Master Gardeners, scouts, high school clubs need volunteer hours to help.

Page 39- Love the Lawn to Woodland and Star program for communities. Consider using black-eyed susans or the checkerspot butterfly or something related to Maryland.

Could developers build homes on wooded lots leaving as many existing trees as possible?

Would the County use Roundup to manage invasives? I've heard horrible things about, is it safe?

A-49 The percentage of invasives in County parks is astounding and heartbreaking.

APPENDIX I: Park Project Site Assessments

Tudor Hall

Ownership: Harford County
Location: 17 Tudor Lane
Size: 8.38 acres

GENERAL LAND USE / CLASSIFICATION

Historic home with accessory structures (spring house, garage, etc.) hosting historic tours operated by the Junius B. Booth Society. Gate is locked expect when historic home is open for visitors. Site contains a creek and pond. Informal access via walking occurs from neighborhood or turnaround at end of Tudor Lane where locked gate limits vehicular access.

GREEN INFRASTRUCTURE DESIGN ASSESSMENT

Feasibility Due to limited open times, this site has less visibility than other public park sites. However, the existing stream that runs through the site could be a good candidate for improvement through various GI techniques. A headwater tributary to Thomas Run, the steam is impounded to create the fishing pond. The pond has a mown grass (and eroded) edge for approximately half its edge. Lots of sun exposure can increase water temperature while impounded. Interpretive signage could convey better pond edge treatments for healthy aquatic environments – a good message to fishermen.

Strategies The property contains numerous old trees in different stages of decline. These old trees add historic value and enhanced landscape settings for the historic home. A full tree planting plan (#1 photo) or at least a tree succession plan is warranted to help continue the historic setting. Shade trees will be needed around the house, along the entry drive and boundary fence. Canopy trees along the exposed pond edge can help shade the water surface and provide cooler picnic spots for visitors. A wider riparian buffer (#2 photo) of native plantings (and related no-mow zone) could be beneficial beyond the pond outlet. Shade trees (#3 photo) could be added to the parking lot as well.

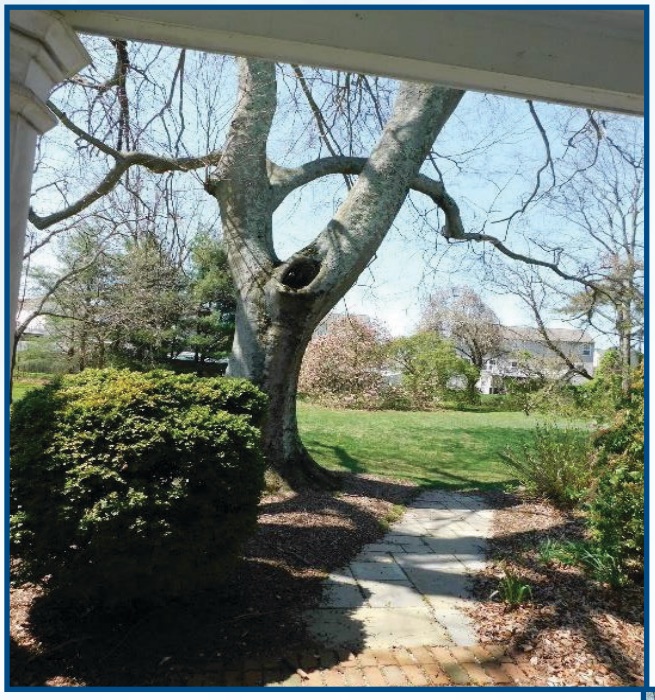
MANAGEMENT CONSIDERATIONS

Adding 2 stream crossings (foot bridges) at pond inlets with a connected perimeter path to follow the circumference of the pond can provide more intentional access where current users have been creating informal crossings and wandering paths around the pond. Access to the pond edge should be planned to facilitate fishing without the need to mow the entire pond edge.

This historic house site could be enhanced with a historic landscape setting. If documentation is available that recorded its earliest landscape design, some re-creation could be integrated with environmentally sensitive design treatments to offer dual messages to site visitors.

SITE PHOTOS

locations for potential green infrastructure stormwater management techniques



#1 Photo

A significant amount of the older trees throughout the landscape are in stages of decline or dying. A successional plan, ideally tied to the site's master plan, could be prepared to ensure a continuing level of tree canopy and sense of place for the historic landscape.

The landscape setting for this historic house could be tied to a restoration of the historic garden, representing the period for early occupation. A tree planting plan for the site could tie-in to the master plan for historic recreation combined with an environmental restoration focusing on the creek and pond landscape improvements.

#2 Photo

The stream edge should be protected with a riparian buffer landscape and wider "no-mow" zone. Pond edge plantings could provide more tree cover/shade for the pond surface without significantly impacting recreational fishing.

#3 Photo

Shade trees planted around the perimeter of the parking lot could mitigate for heat island effects and reduce runoff temperatures.

Shamrock Park

Ownership: Town of Bel Air
Location: Located between Lee Way and E. Pennsylvania Ave, adjacent to the Police Dept.
Size: 9.9 acres

GENERAL LAND USE / CLASSIFICATION

Neighborhood park with amphitheater, picnic area, open grass lawn, playground, parking and restrooms. Park hosts a summer concert series.

GREEN INFRASTRUCTURE DESIGN ASSESSMENT

Feasibility High visibility and actively programmed park with its concert series provides potential exposure for a GI demonstration project. Park landscape is primarily mown grass and trees. Park is located in headwaters for a tributary to Bynum Run and collects runoff/drainage from adjacent neighbors.

Strategies Enhancing the existing tree canopy (1) could help lower runoff temperatures as well as provide shade for picnic area, parking lots and on street parking. A more densely vegetated swale (2) leading into the inlet drain located behind the playground could add some better water quality treatment however, aesthetic change in landscape treatment might raise concerns from neighbors and park users accustomed to "neat" mown areas. Vegetated swale would be a "no-mow" zone.
Potential rain garden behind amphitheater where water collects and picnic areas provides close visibility.

MANAGEMENT CONSIDERATIONS

A number of the park trees are aging. A proactive tree succession plan could help maintain the desired level of shade and aesthetics in the park's landscape.

SITE PHOTOS - locations for potential green infrastructure stormwater management techniques

#1 Photo

Enhance the tree canopy throughout the park, particularly where picnic, playground and parking areas could benefit from cooler, shaded conditions.

#2 Photo

Consider vegetating existing drainage swale with native plantings, woody & herbaceous to slow & filter surface water movement and enhance habitat value. Drainage area runs along Park's southern property edge.

#3 Photo

A rain garden or biorentention area proximate to the picnic area could help capture surface water runoff and provide habitat enhancement. Interpretive signage could convey green stormwater messages.

Plumtree Park

Ownership: Town of Bel Air
Location: Between Thomas and George Streets, east of S. Atwood Rd.
Size: 2.75 acres

GENERAL LAND USE / CLASSIFICATION

Neighborhood park with parking, two playground areas, basketball court, open lawn area, Plumtree Run stream corridor with adjacent natural area.

GREEN INFRASTRUCTURE DESIGN ASSESSMENT

Feasibility Popular neighborhood park with local users and good visibility. Paved pathway follows stream alignment and offers good visibility for demonstrating enhanced riparian buffer conservation.

Strategies Expand existing edge to no-mow zone for stream corridor (#1 photo) with additional native plantings and add interpretive signs and "no-mow" delineation signs to convey concept and implementation for softer stream edge. Maintain mow area along both sides of paved pathway to keep good visibility and clearance for path users. Add shade trees (#2 photo) to planting area between parking lot and basketball court to help shade and cool paved surfaces.

MANAGEMENT CONSIDERATIONS

Consider establishing "no-mow" zones along streams and drainage alignments to allow natural vegetative cover to slow, filter and shade stormwater runoff and surface water flows. Signage along the designated edge of mown grass management areas can convey the intention to allow taller plant growth both to the public and to the land managers and maintenance crews.

SITE PHOTOS - locations for potential green infrastructure stormwater management techniques

#1 Photo - Expand natural riparian plantings along edge of stream to within five (5) feet of paved pathway. Follow alignment of pathway edge to designate the edge of natural (no-mow) zone for riparian corridor.

#2 Photo - Add native canopy trees to provide shade to parking area and basketball court.

Mariner Point Park

Ownership: Harford County
Location: 100 Kearney Drive, Joppa. Land between Foster Branch & Taylors Creek.
Size: 3.77 acres

GENERAL LAND USE / CLASSIFICATION

Regional county park with boat launch facility, parking, picnicking, trails, pavilions, fishing piers and playgrounds. Active public uses for water access for boaters and fishermen as well as park setting in natural areas for outdoor recreation such as walking, running, wildlife viewing, picnicking and play.

GREEN INFRASTRUCTURE DESIGN ASSESSMENT

Feasibility Highly visible due to active public uses. Parking lot at entry near Visitor's Center is potential GI target for a green stormwater treatment. Drainage patterns direct flows towards drain located in mown lawn area from parking lot as well as steep slope above parking area. Stormwater runoff from developed park areas currently flows into Taylors Creek without treatment.

Strategies Steep slope plantings (#1 photo) on the steep hillside above the northernmost parking lot could help attenuate rapid runoff. Slope is steeper than recommended for mower operation. Mowers tend exasperate erosion where their tires slip on the incline. Best long-term (green) approach is to eliminate need for any mowing on the slope. (#2 photo) Rain garden, vegetated swale, or bio-retention technique could be implemented in the grass area with drain that captures the surface runoff from the north parking surface. Add canopy trees (and wet-tolerant shrub layer with no-mow zone) (#3 photo) in existing drainage basin area that captures runoff from second parking lot as well as diversionary structures to encourage longer retention of runoff before it's discharged into Taylors Creek. Southernmost parking lot could benefit from shade generated by adding canopy trees along its perimeter and planting internal island (#4 photo).

MANAGEMENT CONSIDERATIONS

Several kiosks located on site could include green stormwater treatment descriptions and project details. Reducing some mowing areas could improve habitat and green stormwater/ infrastructure value without impacting public use and enjoyment.

SITE PHOTOS - locations for potential green infrastructure stormwater management techniques

#1 Photo

Steep slope behind north parking area is eroded and difficult to mow and should be considered for slope stabilization plantings to establish complete woody cover and eliminate the need for mowing.

#2 Photo

Drainage swale that captures surface runoff from north parking area could be re-designed as rain garden or bioretention treatment area to pretreat runoff prior to direct discharge into Taylors Creek.

#3 Photo

Low drainage area between second parking lot and paved trail that captures runoff could be retrofitted with stormwater detention structures, planted with wetland vegetation and mowing eliminated. In redesign, consider accommodating one or two connections to path from parking.

#4 Photo

Enhance parking areas with additional native canopy shade trees to mitigate for heat islands and help.

County Courthouse Parking Corner, Bel Air

Ownership: Harford County
Location: Downtown Bel Air at the corner of Hays and Thomas Streets
Size: unknown acreage

GENERAL LAND USE / CLASSIFICATION

Parking lot for courthouse has corner area where trees in planter have failed or are in decline. Potential additional space could be generated by re-aligning parking lot surface and raised planter area.

GREEN INFRASTRUCTURE DESIGN ASSESSMENT

Feasibility Parking lot corner area, where surface drain is located, has curbed planting area and asphalt pavement where parking stalls do not fit. Site has high visibility as a downtown corner. Existing Zelcova tree is in decline due to limited soil area and stress from urban conditions.

Strategies A bioretention area (#1 photo) could be retrofitted by removing the curbing and existing asphalt and realigning drainage to move through the retention area prior to entering the storm drain. Creating an increased planting soil area in corner triangle (#2 photo) could better sustain any canopy trees needed for mitigating pavement heat.

MANAGEMENT CONSIDERATIONS

None.

SITE PHOTOS - locations for potential green infrastructure stormwater management techniques

#1 Photo - Existing planting area is low spot for courthouse parking lot and could be redesigned to capture runoff before entering stormwater drain.

#2 Photo - Corner of parking pavement (with drain) could be retrofitted into contiguous bioretention area with existing planter bed. Trees would be increased longevity with resulting larger soil volume for root growth.

Eleanor & Millard Tydings Park (Oakington property)

Ownership: Harford County
Location: 401 Oakington Road. On the Neck between Swan Creek and Chesapeake Bay
Size: unknown acreage

GENERAL LAND USE / CLASSIFICATION

Located along Oakington Road, with acreage both north and south of the Ashley Treatment Center campus, this conservation property consists of active agricultural fields and forested shoreline habitat. The target site within the property is accessed by traveling south on a one lane gravel road before the Treatment Center guardhouse. The focus area contains an old barn and accessory structures and two houses. Recent improvements included a paved parking area, paved access lane and stormwater treatment basin.

GREEN INFRASTRUCTURE DESIGN ASSESSMENT

Feasibility Access to the site is fairly remote with no casual public visibility to add value to a green infrastructure demonstration project. Plans for future development of an equestrian facility with indoor arena and outdoor riding area have been cancelled.

Potential Strategies The forested edge of the shoreline habitat (#1 photo) could be expanded along the Bay side, reducing some of the field production area to provide a more resilient shoreline.

The stormwater basin (#2 photo) currently under a regular grass mowing regime could be naturalized beginning with establishment of canopy trees to shade captured runoff.

MANAGEMENT CONSIDERATIONS

Prior to any green infrastructure project installation, management should consider the potential for any future development of planned or postponed recreation facility projects. Tree plantings should avoid potential development envelopes to protect tree longevity and value.

SITE PHOTOS - show locations for potential GI-SWM techniques

#1 Photo - Forest edges along farm fields could be expanded to enhance shoreline resiliency and improve capture of soil runoff from active agricultural fields.

#2 Photo - Stormwater basin could be naturalized to reduce grass mown areas and provide shade and filtering of runoff.

Alice & William Longley Park

Ownership: Harford County
Location: Long Bar Harbor & Longley Roads
Size: 3.1 acres

GENERAL LAND USE / CLASSIFICATION

Neighborhood park containing baseball/softball field, parking, two playgrounds, basketball sports court and swing set. Small bridge crossing intermittent steam connects one playground and parking lot to second playground and ball field.

GREEN INFRASTRUCTURE DESIGN ASSESSMENT

Feasibility Site is highly visible and accessible to the public. Parking lot pavement extends to the top of streambank slope where stormwater drainage flows directly to the stream without treatment. This condition provides a notable and highly interpretive opportunity to display the need to treat streams with greener landscape approaches.

Strategies Slope stabilization plantings (#1 photo) and stream restoration techniques (#2 photo) followed by some additional riparian plantings (#3 photo) could enhance the distressed intermittent stream. Some bioretention techniques (#4 photo) may be feasible if enough room is available for directing surface runoff. Canopy trees (#5 photo) to shade the parking lot can provide some mitigation for reducing hot runoff. No mow zones (#6 photo) with edge designation markers would be helpful to reinforce the riparian corridor protection.

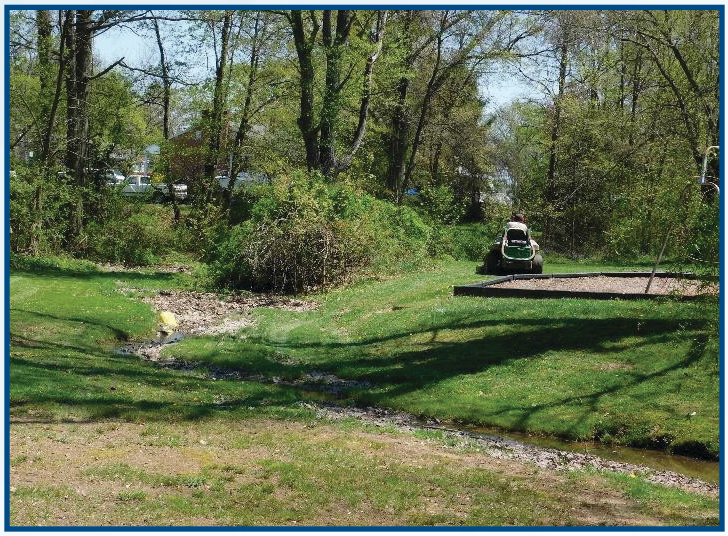
MANAGEMENT CONSIDERATIONS

Currently, lawn mowing equipment rides directly across the creek to get access to both sides of the park as well as mown grass growing to the edge and into the stream. Mowers can access the other side of the park via Longley Road and do not need to have a special bridge crossing. *(The existing footbridge is not ADA accessible and should be retrofitted to remove the steps up onto the bridge deck to allow stream crossing from the parking lot to the other side of the park. The existing bridge is too narrow for use by any mowing equipment but mowers can use the road instead.)*

SITE PHOTOS - show locations for potential GI-SWM techniques

#1 Photo - Slope stabilization plantings could reduce erosion and slow runoff from parking surface into small creek.

#2 Photo - Stream restoration techniques could reduce continual sedimentation of intermittent stream and provide defined stream corridor.



#3 Photo

Adding riparian plantings along stream corridor to provide shade, buffer, stabilization and habitat could help define the watercourse, direct park users to other areas, and keep mowers out of stream channel.

#4 Photo

If adequate space is available, bio retention area could be designed to help capture and filter parking lot surface runoff prior to discharge into intermittent stream.

#5 Photo

Native canopy trees could be added to the perimeter of the parking lot to provide shade for vehicles and reduce heat island affecting surface runoff temperature.

#6 Photo

Designating "no-mow" zones along the stream corridor could allow native plantings to stabilize streambanks, reduce erosion and improve stream water quality.