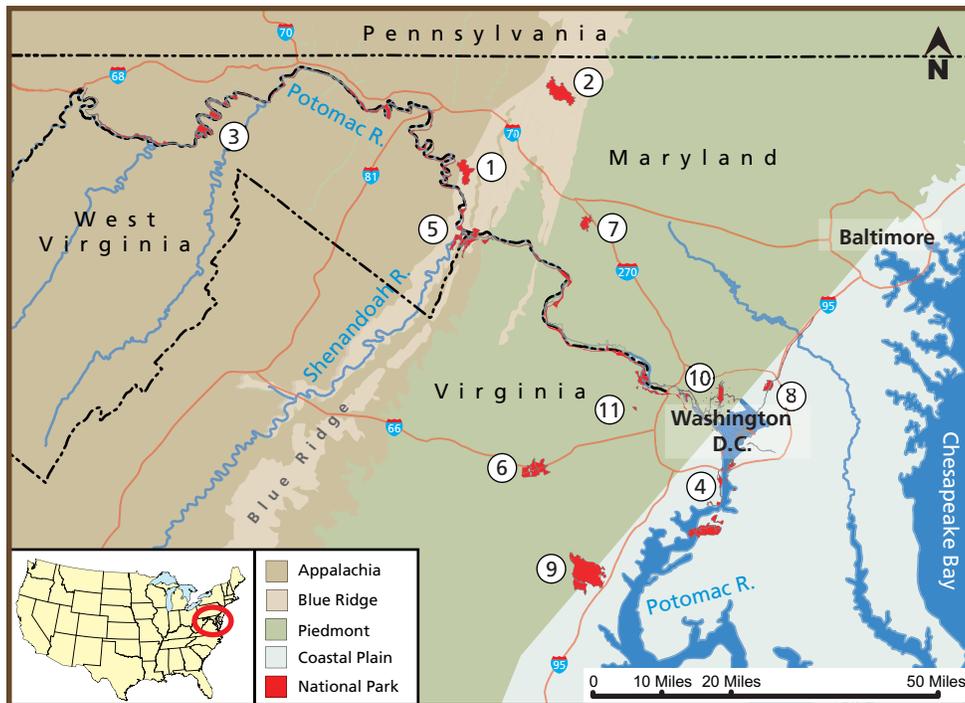




# A Conceptual Basis for Natural Resource Monitoring





Locations of the National Parks (red) in the National Capital Region used in the integrated environmental assessment process: 1. Antietam National Battlefield; 2. Catoctin Mountain Park; 3. Chesapeake and Ohio Canal National Historic Park; 4. George Washington Memorial Parkway; 5. Harpers Ferry National Historic Park; 6. Manassas National Battlefield; 7. Monocacy National Battlefield; 8. National Capital Parks–East; 9. Prince William Forest Park; 10. Rock Creek Park; and 11. Wolf Trap National Park for the Performing Arts.

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## Front Cover Photos

Chesapeake and Ohio Canal National Historic Park. Source: Brian Rosenbloom  
 Manassas National Battlefield. Source: Bryan Gosira, National Park Service  
 Cardinal, National Park Service.  
 Anacostia River and Kingman Lake, National Capital Parks-East. Source: National Park Service

## Back Cover Photos

Lotus blossoms in National Capital Parks–East. Source: Susan Rudy, National Park Service  
 Gray fox in tree. Source: Illinois Department of Natural Resources  
 Quantico Creek in Prince William Forest Park. Source: Kirsten Talken-Spaulding, National Park Service

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## Putting the puzzle pieces together: Monitoring the status and trends of the nation's parks

Knowing the condition of natural resources in national parks is fundamental to the National Park Service's (NPS) mission to maintain park resources "unimpaired for the enjoyment of future generations." Most parks are open systems vulnerable to threats such as air and water pollution and invasive species, which originate outside of the park's boundaries. Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making aimed to maintain, enhance, or restore the ecological integrity of park ecosystems.

A nationwide Inventory and Monitoring (I&M) program was launched to determine status and trends of indicators (or 'vital signs') that represent the condition of park ecosystems. Vital signs monitoring is meant to provide early warning of abnormal conditions and impairment of selected resources and data to better understand the dynamic nature and condition of park ecosystems. The I&M program will ultimately help managers make better-informed decisions and work more effectively

with stakeholders who benefit from proper park stewardship. Under the program, approximately 270 park units have been organized into 32 networks to conduct long-term resource monitoring (Figure 1). Each network links parks that share similar geographic and natural resource characteristics to improve efficiency and reduce costs.

The National Capital Region Network contains 11 parks having a range of natural and cultural resources (refer to table showing urban-rural gradient). The region's urbanized landscape plays a significant role in each park's ecology. Many of the parks were established for their cultural and recreational value yet provide numerous ecological benefits including riparian buffers that reduce watershed pollution, contribute to air quality, and protect scenic vistas. The parks also provide some of the last remaining habitats for many rare plant and animal species or communities. Invasion of exotic plant species, deer overabundance, suburban sprawl, and water pollution are some of the region's most urgent environmental concerns.



Photo: Russell Verbofsky

Figure 1. More than 270 parks, linked by geography and shared natural resource characteristics, have been grouped into 32 Vital Sign Monitoring Networks. Parks within each of the 32 networks work together and share funding and professional staff to plan, design, and implement an integrated long-term monitoring program. Source: Geoff Sanders, NPS/CUE.

The NCRN parks provide habitat for a wide range of plant and animal life, such as this muskrat.

# NATIONAL CAPITAL REGION NETWORK



## Natural and cultural resources in an urban landscape

The National Capital Region Network (NCRN) contains 11 parks within the District of Columbia, Maryland, Virginia, and West Virginia (see inside cover): Antietam National Battlefield (ANTI), Catocin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks–East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap National Park for the Performing Arts (WOTR).

Although they comprise only a small fraction of its total area, NCRN parks are among the most visited in the NPS system. The high numbers of visitors are due in part to the urban context in which many of the parks are found (Figure 2), and the parks act as important refugia in conserving remnants of the rich natural heritage disappearing from the urbanizing landscape surrounding the nation’s Capital. The network of parks act to promote healthy landscape dynamics within this landscape by providing valuable biotic source habitat and connectivity corridors.

Nearly all of the parks lie within the Potomac River basin, which is a major contributing source of water to the Chesapeake Bay (Figure 3). Rivers, streams,

wetlands, ponds, and seeps located in the parks contribute substantially to the overall water quality of the Bay. Park forests help to filter nutrients and sediment, stabilize soils, and moderate flooding of these streams and rivers. Forests also contribute to regional air quality by removing pollutants, fixing carbon, and buffering traffic and other noise pollution. Forest regeneration can be observed in many of the parks, while others maintain large expanses of grassland habitat, which serve as valuable habitat for the region’s imperiled grassland bird populations.

In total, NCRN parks cover more than 75,000 acres and span four physiographic regions: Atlantic Coastal Plain, Piedmont Plateau, Blue Ridge Mountains, and Appalachia. They contain a variety of forest, grassland, and wetland ecological communities, which support a diverse mixture of fish, bird, and amphibian species. Among the hundreds of species of concern identified by the parks, four are federally listed as threatened or endangered, including the bald eagle (*Haliaeetus leucocephalus*), Harperella (*Ptilimnium nodosum*), small-whorled pogonia (*Isotria medeoloides*), and Hay’s Spring amphipod (*Stygobromus hayi*).

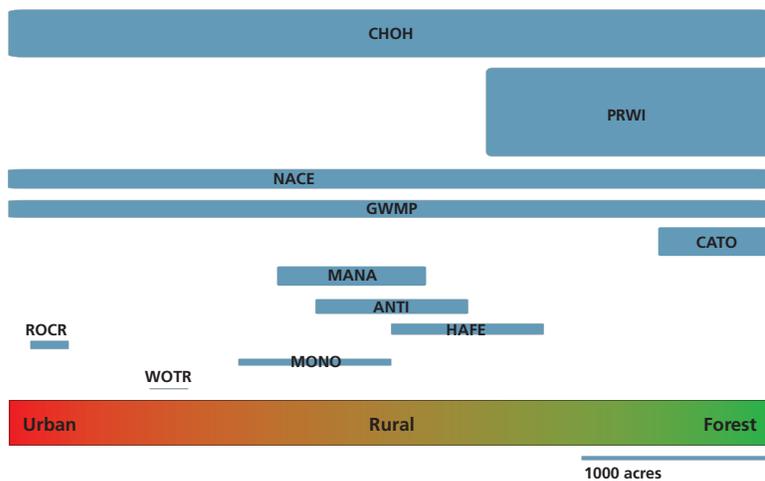


Figure 2. The relative size of the 11 national parks within the National Capital Region Network, from largest (top) to smallest (bottom). The horizontal position of the park acreage bar is indicative of the surrounding watershed land use (urban, rural, and forest).

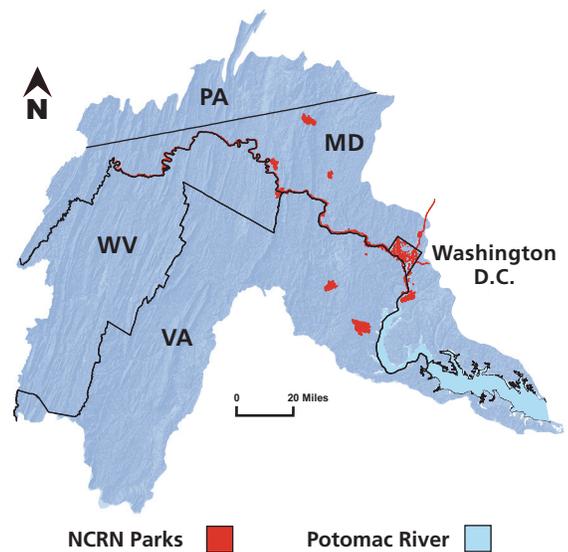


Figure 3. The National Capital Region Network parks are largely within the Potomac River watershed, the second largest watershed of the Chesapeake Bay. Source: J. Runde, NPS.

# VITAL SIGNS MONITORING

## A suite of indicators to inform park management

Park vital signs monitoring is designed to inform managers of the condition of water, air, geologic resources, plants, and animals, and the various ecological, biological, and physical processes that act on those resources. Network Vital Signs are selected physical, chemical, and biological elements and processes of park ecosystems that represent the overall health or condition of the park (Figure 4); they may also be park attributes that are highly valued but not necessarily indicative of general park health. The Vital Signs selected for the National Capital Region Network (page 7) are a subset of the total suite of natural resources that park managers are directed to preserve. In situations where natural areas have been highly altered so that physical and biological processes no longer function naturally (e.g., fires and floods in developed areas), information obtained through monitoring can help managers understand how to develop the most effective approach to restoration or, in cases where restoration is impossible, ecologically sound management. The broad-based, scientific information obtained through monitoring will have multiple applications for decision making, research and education.

Vital Signs monitoring is an integral part of the adaptive management cycle because it provides critical information about trends in natural resource

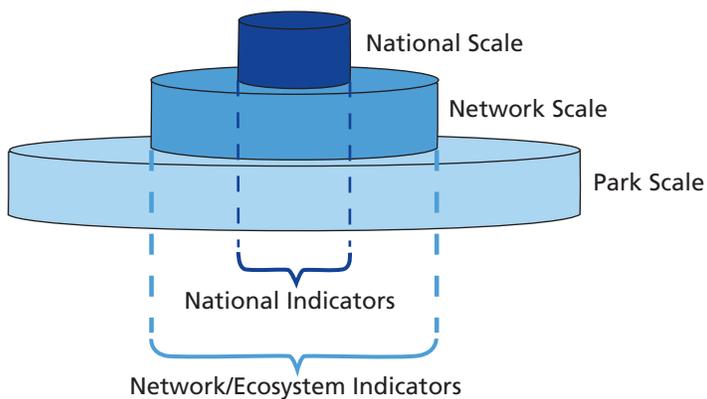


Figure 4. The list of ecological indicators monitored throughout the National Park System is expected to follow the 'wedding cake design' adopted from the USDA Forest Service and shown above, in which the majority of indicators are selected to provide site-specific data needed by park managers for making decisions and working with other agencies and individuals for the benefit of park resources. Nationwide, or at the level of the park network or ecosystem, there is also a set of indicators that are monitored in a standardized way to allow comparisons and synthesis of data across larger areas.



Photo: NPS

Park staff take river samples as part of water quality assessment.

conditions. Monitoring data help to define the normal limits of natural variation in park resources and provide a basis for tracking the effect of management actions. Furthermore, understanding the dynamic nature of park ecosystems and the consequences of human activities is essential to maintain, enhance, or restore the ecological integrity of park ecosystems. The quality and amount of information now being collected at park, network, regional, and national levels is unprecedented in the National Park Service and will yield untold insights to scientists, educators, and managers alike.



Photo: Brad Waldeon, NPS

A bald eagle soars over park farmlands.

# CONCEPTUAL DIAGRAMS



## Creating a framework for reporting ecological conditions

The knowledge gained through Vital Signs monitoring needs to be communicated to a broad community of scientists, managers, and stakeholders. Effective scientific communication to such a diverse audience requires appropriate synthesis, visualization, and context. Conceptual diagrams, or ‘thought drawings’, are an excellent tool for achieving these goals.

Conceptual diagrams use symbols to generate self-explanatory, self-contained figures that present synthesized concepts and knowledge (Figure 5). The diagramming process can be used to clarify thinking, to communicate complex messages in a simple and informative manner, and to identify gaps in knowledge and data that should become priorities of monitoring activities.

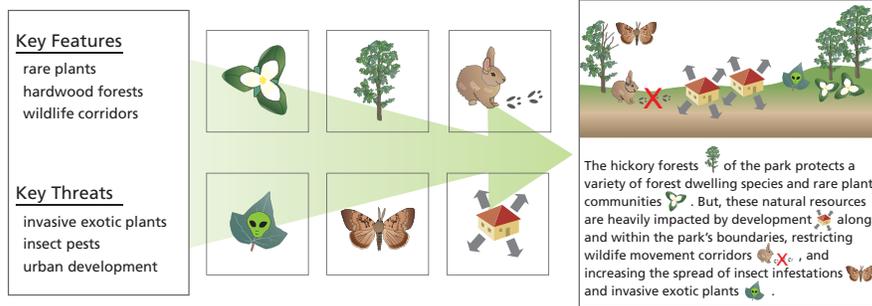


Figure 5. The conceptual diagramming process captures key natural resource elements as information-rich symbols, which are combined to tell visual stories of park resources.

One of the key aspects of conceptual diagrams is the use of symbols. Symbols are one of the most ancient forms of human communication and remain a common feature of everyday life. They are very useful at depicting unequivocal messages that can transcend cultures, languages, and times, and when arranged into a diagram, they can augment or replace content-driven text. Recent ‘click & drag’ technological advances have made it possible to use existing symbol libraries to quickly generate conceptual diagrams without graphic art training or specialized equipment ([www.ian.umces.edu/symbols/](http://www.ian.umces.edu/symbols/)).

A NCRN Vital Signs Workshop was convened in May 2005 to outline the essential stories (or ‘vignettes’) concerning NCRN parks in the form of conceptual diagrams. Workshop participants included staff and scientists from the NCRN I&M

Program, Center for Urban Ecology, Integration and Application Network (IAN) of the University of Maryland Center for Environmental Science (UMCES), and NCRN Park Managers.

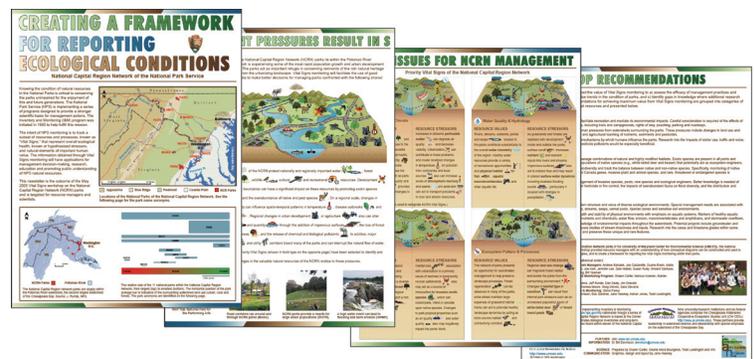


Photo: NPS

NCRN Vital Signs Workshop participants, May 2005.

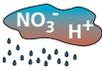
After learning the basic principles and concepts of science communication using conceptual diagrams, the participants were tasked with defining the natural resource challenges to the region as a whole and to the 11 individual parks in the NCRN. Based on the idea that a picture is worth a thousand words, draft conceptual diagrams were constructed to represent these vignettes. The process of developing first drafts of conceptual diagrams provided a central focus in working towards consensus on the key structural and functional properties of the different ecosystems.

Following an intensive editing process involving several rounds of feedback, conceptual diagrams were finalized that relate Vital Signs monitoring to regionally dominant natural resource vignettes (pages 9-10), and a newsletter was published. The park-based diagrams contained in this booklet (pages 11-32) additionally provide a geographic/spatial context to these stories and will be used to help guide I&M Vital Signs monitoring.



The NCRN Vital Signs Workshop newsletter “Creating a Framework for Reporting Ecological Conditions”, [www.ian.umces.edu/nps/](http://www.ian.umces.edu/nps/).

# NATIONAL CAPITAL REGION NETWORK VITAL SIGNS

CATEGORY	VITAL SIGN NAME		VITAL SIGN MEASURES
<b>AIR QUALITY AND CLIMATE</b> 	Ozone		Atmospheric ozone concentration
	Wet deposition		Wet deposition chemistry (pH, NO <sub>3</sub> <sup>-</sup> , SO <sub>4</sub> <sup>-2</sup> )
	Visibility and particulate matter		Visibility (particulate matter 2.5 mass fraction)
	Mercury deposition	 	Mercury Deposition Network
	Weather		Ambient temperature, precipitation
<b>WATER QUALITY AND HYDROLOGY</b> 	Surface water dynamics		Flow, discharge (cubic feet/second), gauge/stage height
	Water chemistry		Core parameters (pH, dissolved oxygen, specific conductance, temperature), acid neutralizing capacity
	Nutrient dynamics		Nitrate, ammonia, total phosphate
	Aquatic macroinvertebrates		Species composition and abundance
	Shoreline features		Rate of shoreline change
	Physical Habitat Index (PHI)		Stream habitat structure, river depth, vegetation composition on adjacent lands
<b>BIODIVERSITY</b> 	Invasive/exotic plants		Detection of new species in sensitive areas
	Forest insect pests		Presence of new pest species
	Forest vegetation		Species diversity, age and size classes
	Fishes		Species composition
	Amphibians		Species composition and proportion of area occupied, malformations
	Landbirds		Species composition and abundance
	White-tailed deer		Deer density
	R/T/E species and communities		Presence and absence of, status of, threats to Rare, Threatened or Endangered (R/T/E) species/communities
<b>ECOSYSTEM PATTERN AND PROCESSES</b> 	Land cover/land use		Area of dominant land cover types, connectivity, core/edge ratio of dominant forest communities, weighted average patch size, adjacency matrix
	Landscape condition		Land use intensity, disturbance status

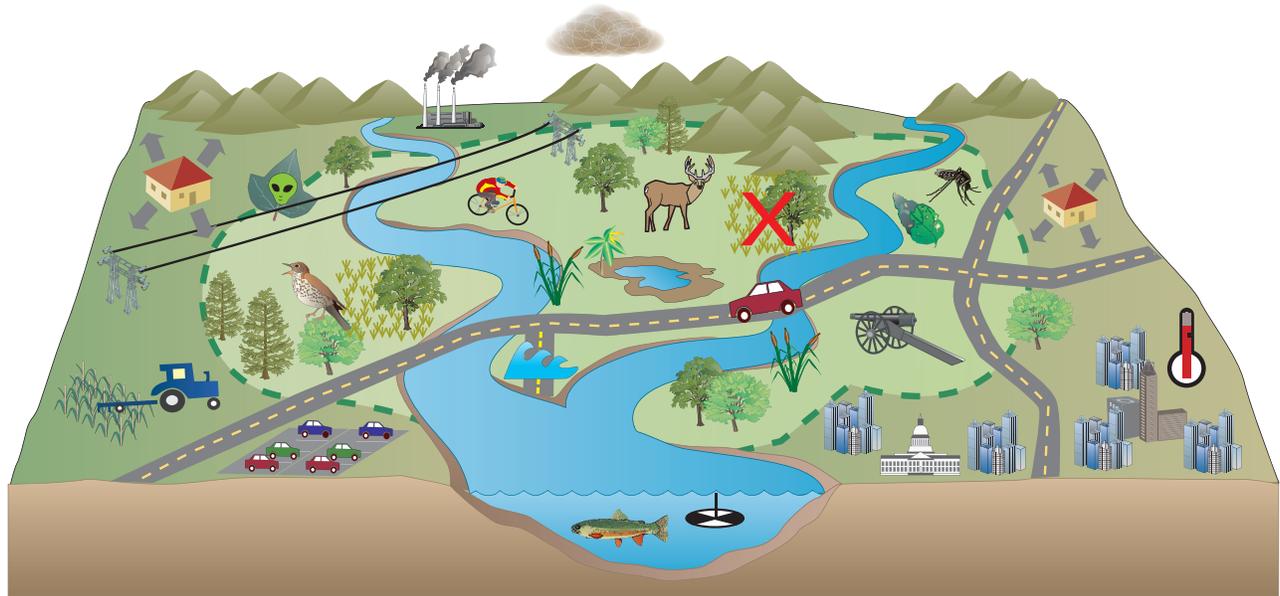
# NATIONAL CAPITAL REGION NETWORK REGIONAL ISSUES



## Development pressures result in shared issues for NCRN management

All 11 parks of the National Capital Region Network (NCRN) have shared resources. Nearly all parks lie within the Potomac River watershed, which is experiencing some of the most rapid population growth and urban development in the country. The parks act as important refugia in conserving

remnants of the rich natural heritage disappearing from the urbanized landscape. Vital Signs monitoring will facilitate the use of good science and data to make better decisions for managing parks confronted with the following shared issues.



The parks of the NCRN protect nationally and regionally important water, forest and grassland, wildlife, historic, and recreational resources. Development adjacent to park boundaries can have a significant impact on these resources by promoting exotic species invasions and the overabundance of native and pest species. On a regional scale, changes in land use intensity can influence spatio-temporal patterns in temperature, disease outbreaks, and air pollution. Regional changes in urban development or agriculture also can alter water quality and quantity through the addition of impervious surfaces, the loss of forest and grassland areas, and the release of chemical and biological pollutants. In addition, major transportation and utility corridors bisect many of the parks and can interrupt the natural flow of water, air, and biota. Priority Vital Signs have been selected to identify and understand changes in the valuable natural resources of the NCRN relative to these pressures.



Photo: NPS  
Road corridors run around and through NCRN parks (MANA).



Photo: NPS  
NCRN parks provide a respite for large urban populations (WOTR).

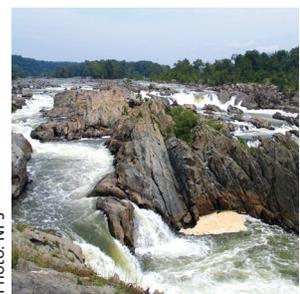


Photo: NPS  
A high water event can lead to flooding and bank erosion (GWMP).

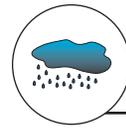
# NATIONAL CAPITAL REGION NETWORK RESOURCE VALUES AND STRESSORS

**RESOURCE VALUES**

The NCRN offers many opportunities for natural and cultural experiences to the public. Clean air benefits human and environmental health, and provides high visibility for park visitors to appreciate the scenic vistas. Because the atmosphere interacts with all parts of the environment, air quality and weather monitoring provides a context for evaluating changes to other natural resources.

**RESOURCE STRESSORS**

Increases in airborne particulate matter can degrade air quality and decrease visibility. Urbanization can contribute to these problems and create localized changes in temperature. Air pollution from continental and local sources also can increase levels and atmospheric mercury and ozone, and acid rain can act to transport pollutants to river and stream resources.



## Priority vital signs for Air Quality and Climate

- Air quality impacts scenic vistas (HAFE)

Photo: Greg Goodman, <http://photography.universalexports.net>



Inspiring park vistas can be obscured by degraded air quality, Harpers Ferry.

**RESOURCE VALUES**

Rivers, streams, wetlands, ponds, and seeps located in the parks contribute substantially to the overall water chemistry of the region. Healthy water resources provide a variety of recreational opportunities and physical habitat for fish, aquatic macroinvertebrates and other aquatic life.

**RESOURCE STRESSORS**

As grasslands and forests are replaced with development, inside and outside the parks, surface runoff increases nutrient and toxicant inputs into rivers and streams. Impervious surfaces also act to redirect flow and may result in altered surface water dynamics including localized flooding events, particularly if coupled with changes in precipitation.



## Priority vital signs for Water Quality and Hydrology

- Upstream and surrounding land uses impact water quality (ANTI)
- Protected headwaters promote pristine water resources (CATO)
- Dynamic river conditions influence canal environments (CHOH)
- Water quality is impacted by agriculture adjacent and within park (MONO)
- Restoring wetland habitat along a troubled river (NACE)
- Continuous forest habitat protects watershed (PRVI)
- Impervious surfaces surround park (ROCR)

Photo: NPS



Post-Hurricane Isabel flood stage of the Potomac River, September 2003.

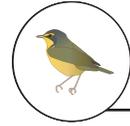


### RESOURCE VALUES

The parks act as green island refugia for at-risk fauna/flora in the urbanizing landscape. They contain a diverse variety of wetland, forest, and grassland ecological communities, which support a rich mixture of bird, amphibian, and fish species.

### RESOURCE STRESSORS

Habitat loss associated with urbanization is a primary cause of declines in biodiversity. Human settlements also may act as a source of introduction for invasive/exotic species, which can outcompete, infect, or prey upon native species. Changes to park physical properties, that lead to poor water and air quality may also negatively impact the parks' biota.



## Priority vital signs for Biodiversity

- Deer overgrazing degrades forest condition (CATO)
- Potomac Gorge is a unique natural heritage site (GWMP)
- Natural and anthropogenic disturbances threaten historic resources (HAFE)
- Landscape habitat diversity supports an important bird refuge (MANA)
- Parks serve as species refugia and migratory corridors (NACE)
- Urban pressures impact natural resources (ROCR)



Photo: NPS

Amphibians are threatened in some parks.

### RESOURCE VALUES

The network of parks presents an opportunity for coordinated management to help preserve landscape processes. Forest regeneration can be observed in many of the parks, while others maintain large expanses of grassland habitat. Parks can act to promote healthy landscape dynamics by acting as biotic source habitat and connectivity corridors.

### RESOURCE STRESSORS

Regional land use change can fragment forest habitat and isolate the parks from the surrounding environment. Changes in habitat type or condition can result from internal park stressors such as an unchecked population boom of white-tailed deer or forest insect pests.



## Priority vital signs for Ecosystem Pattern and Processes

- Park management maintains diverse land uses (ANTI)
- Forest edges are both highly valuable and vulnerable (CHOH)
- Park units connect in a fragmented landscape (GWMP)
- Roads divide park and fragment habitat (MANA)
- Urban development is encroaching on park boundaries (MONO)
- Large intact forest provides valuable indicators of ecosystem processes (PRVI)
- Natural settings provide suburban green space (WOTR)



Photo: NPS

Roadways often bisect an urban park.

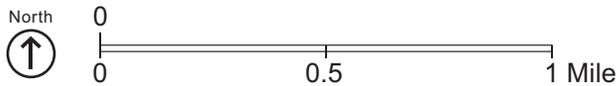
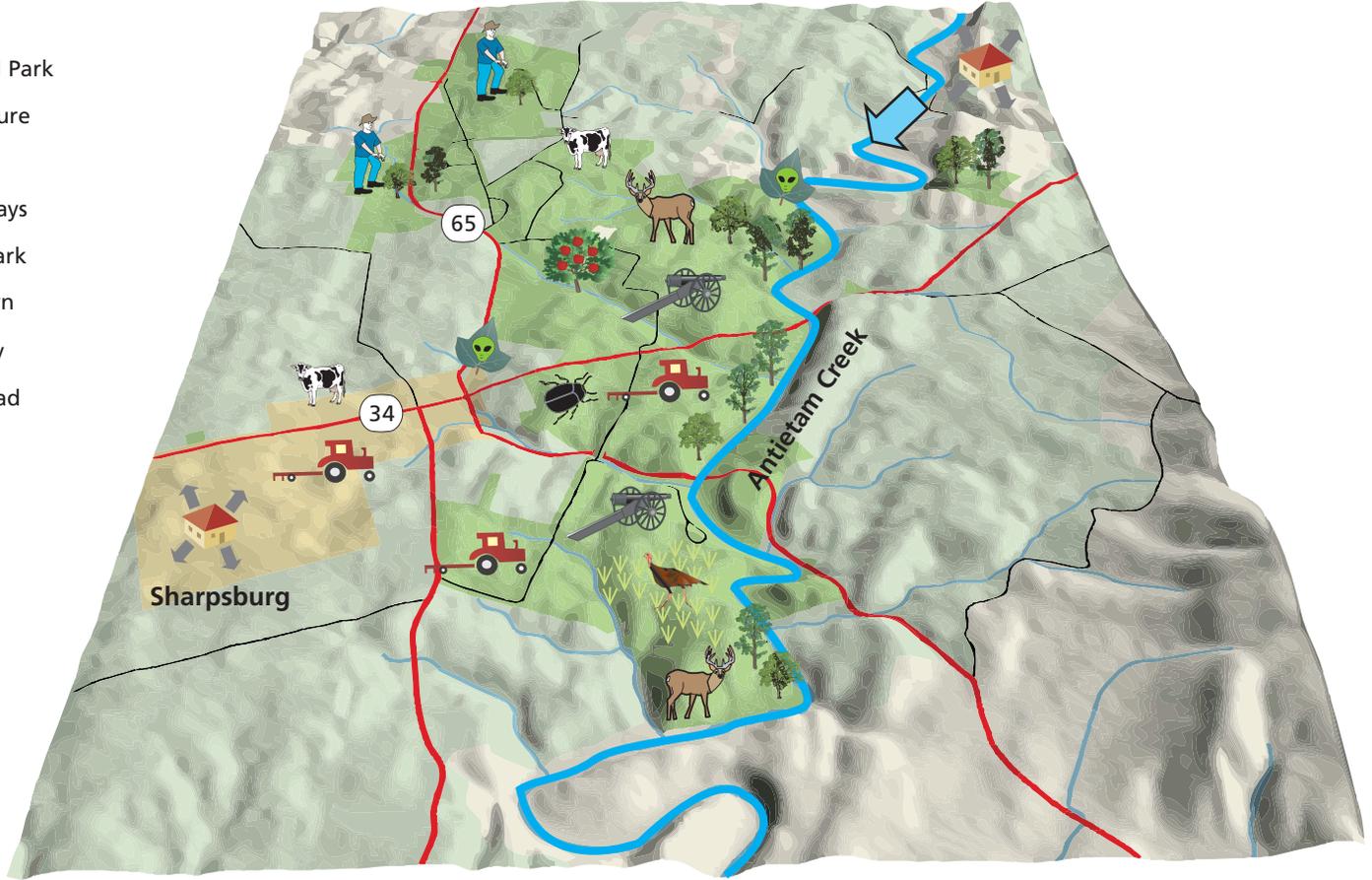


# ANTIETAM NATIONAL BATTLEFIELD

Antietam National Battlefield is managed within the historical context of General Robert E. Lee's first invasion of the North during the Civil War. The 1,926 acre park is located in the heart of Maryland and is surrounded by rolling hills dotted with farm fields and pastures reminiscent of the day of battle. Patches of forest, open meadow, streams, and cropland are found within the park. It is the park managers' challenge to understand how all these natural elements work together to achieve the desired landscape along with managing for the highest quality of environmental protection.

## Land Use

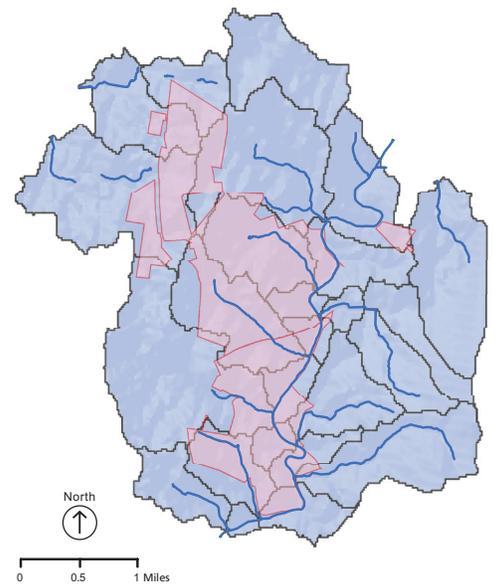
- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad



- Antietam National Battlefield
- Sub-watershed of Potomac River watershed

Figure Legend (see also page 34)

- river flow direction
- historic sites (Civil War battlefield)
- hickory/chestnut oak forests
- grasslands
- agriculture (crops, cows, orchards)
- replanting
- native species (wild turkey)
- development
- white-tailed deer
- invasive/exotic species
- insect pests (hemlock woolly adelgid)



# ANTIETAM NATIONAL BATTLEFIELD



## Park management maintains diverse land uses

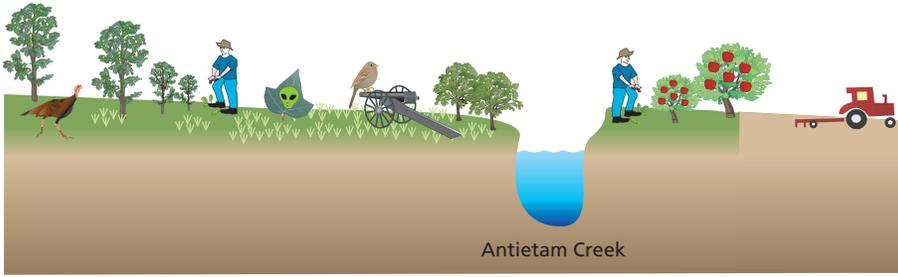


Photo: NPS

Agriculture often shares space with park forests.

Antietam National Battlefield offers a mixture of farmland , pasture , woodlots, and rich oak/hickory forest . The diverse land use conditions influence exotic species  introductions to and native species  movements within the park. Land use changes in and surrounding the park will greatly affect these processes. Restoration activities associated with recreating historic land use patterns also influence natural and cultural resources. For example, managed grasslands  contribute to regional grassland bird conservation , and historic orchards  and woodlots continue to be replanted  throughout the park.

## Upstream and surrounding land uses impact water quality

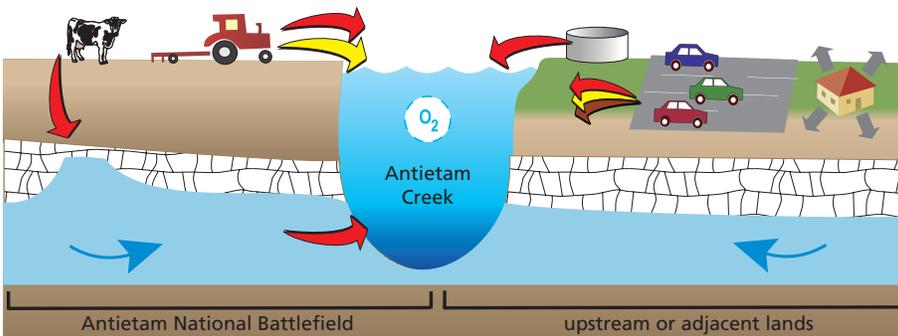


Photo: Michele Carter, NPS

Cows wade into watershed streams.

Antietam Creek is a major component of the park's landscape and surface waters within the park are currently of moderately high quality ( $O_2$ ). However, the future quality of the creek and its tributaries are potentially impacted by agricultural inputs (manure and fertilizers , pesticides ) from park and adjacent farmlands, upstream industrial and sewage discharge , and the increase of impervious surfaces  and stormwater runoff  in surrounding residential areas. Groundwater  is also easily impacted because the park lies on a porous, limestone bed .



# CATOCTIN MOUNTAIN PARK

Catoctin Mountain Park originated as a Recreation Demonstration Area and is managed today for its recreational use (including the Presidential Retreat, Camp David) and the conservation of its cultural and natural resources. The park encompasses 5,810 acres of mostly mixed hardwood forest located in the mountains of the Catoctin Ridge in north-central Maryland. Two high-quality streams bisect the park and the unique geology forms a number of cliffs and scenic overlooks. Management issues include the effects of white-tailed deer overpopulation, exotic invasive plants, gypsy moth, hemlock woolly adelgid, and dogwood anthracnose. Water quality degradation is also a concern as residential and agricultural activity increase along the park's boundary.

## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad

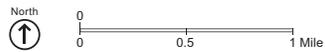
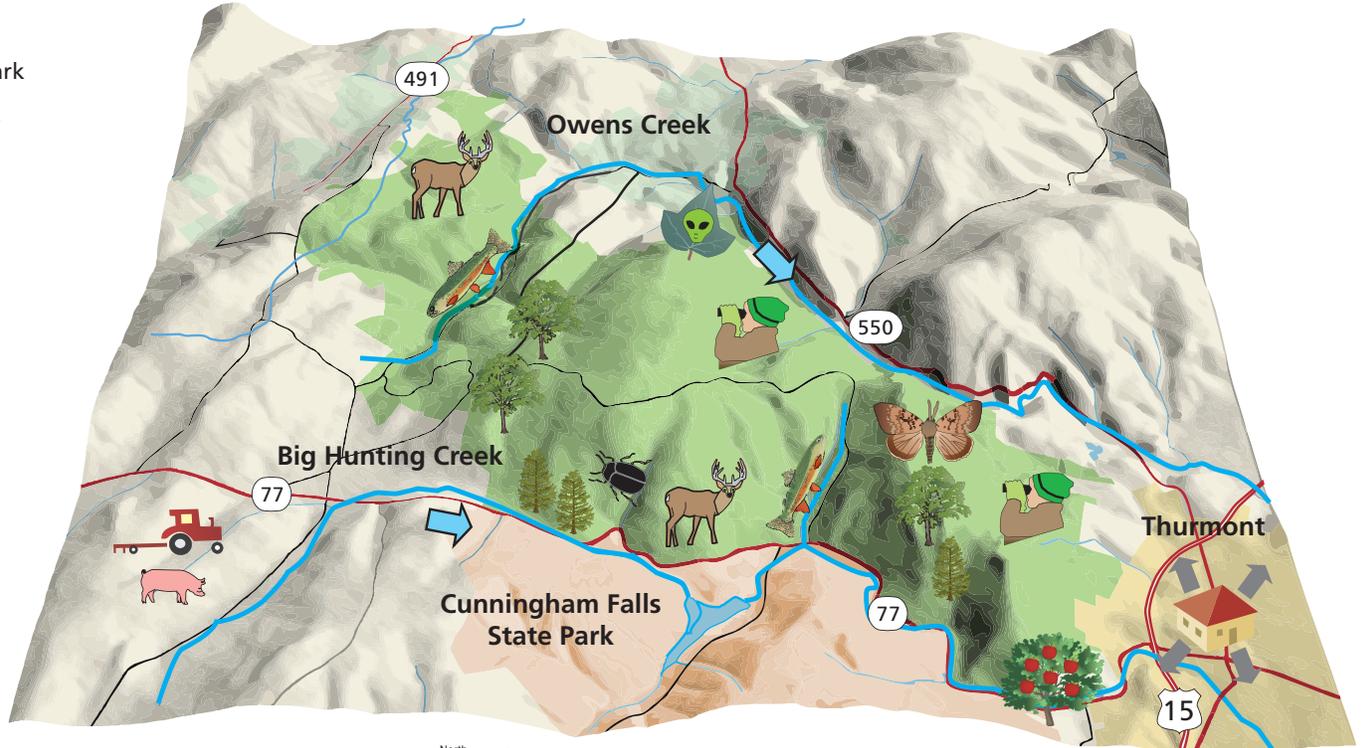


Figure Legend (see also page 34)

- river flow direction
- native species (brook trout)
- hemlock/chestnut oak forests
- agriculture (crops, pigs, orchards)
- scenic vistas
- development
- white-tailed deer
- invasive/exotic species
- insect pests (gypsy moth, hemlock woolly adelgid)
- Catoctin Mountain Park
- Sub-watershed of Potomac River watershed

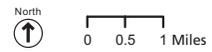
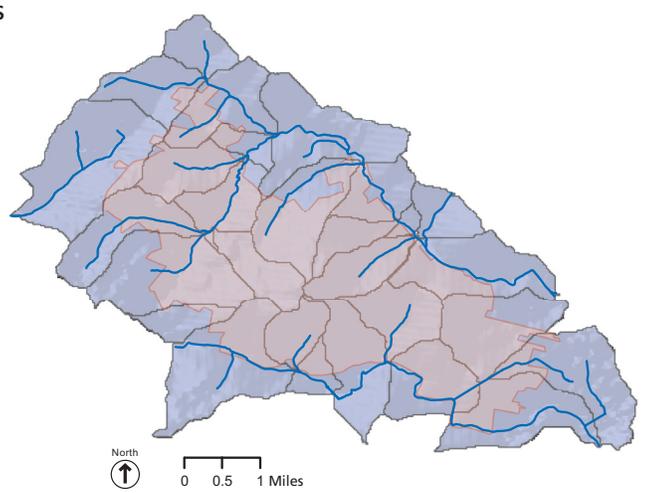


Photo: NPS

Mountain lake recreation.

# CATOCTIN MOUNTAIN PARK



## Protected headwaters promote pristine water resources

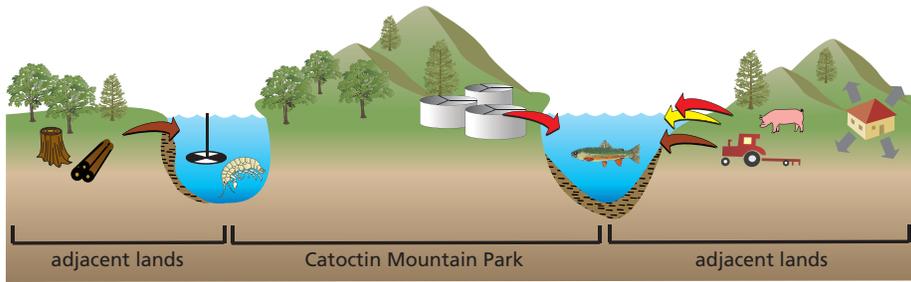


Photo: NPS

Big Hunting Creek provides recreational opportunities.

Streams of excellent quality are an important natural component of Catoctin Mountain Park. The headwaters of Big Hunting Creek and Owens Creek are highly valued for their native populations of brook trout , natural beauty, and superior water quality . Streams also provide habitat for diverse macroinvertebrate communities . The future integrity of water resources is threatened by inputs of sediment , pesticides , and nutrients  from residential  and agricultural  development and logging  adjacent to the park.

## Deer overgrazing degrades forest condition

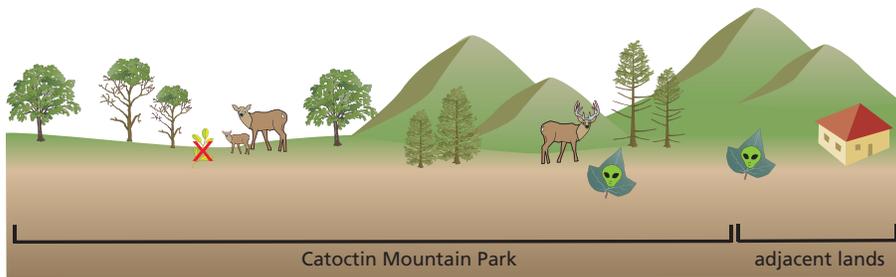


Photo: Scott Bates, NPS

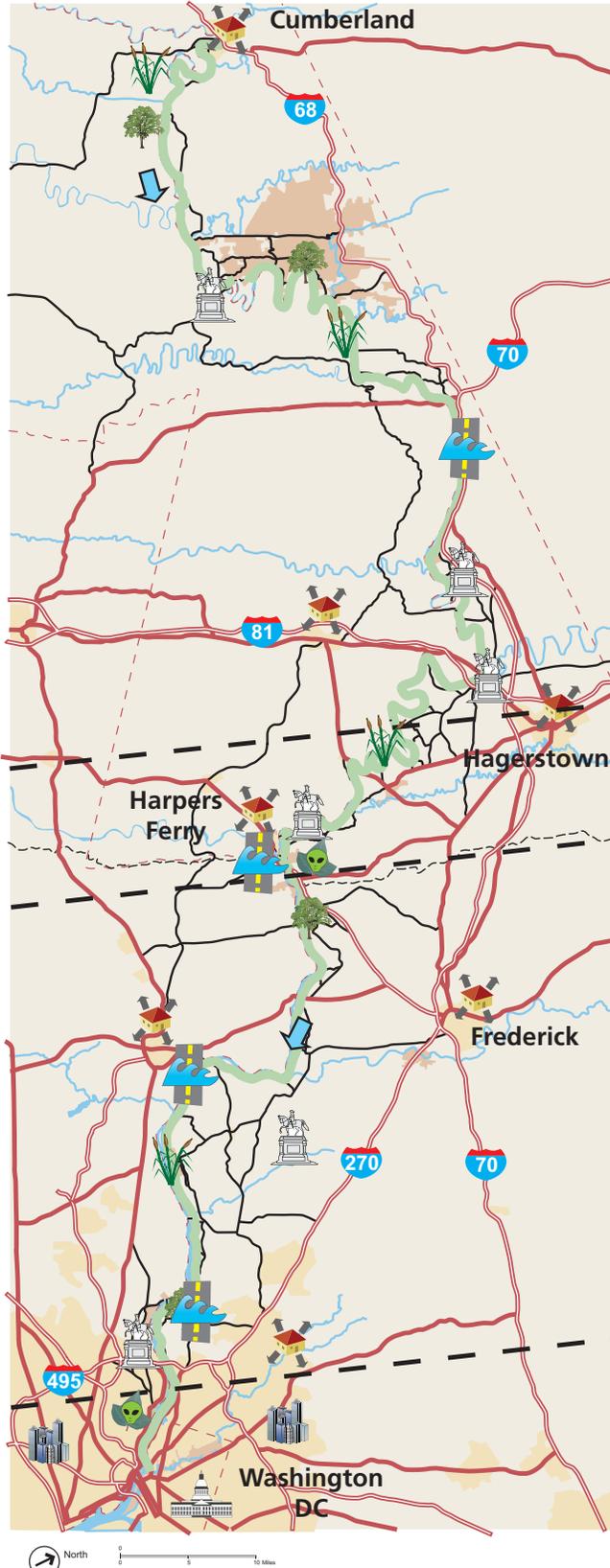
The deer browse-line is clearly shown by the lack of understory in this park forest.

White-tailed deer  are a natural component of this forest ecosystem, but overstocked populations can have negative effects on forest regeneration. Deer grazing  can greatly reduce the number of seedlings and saplings  in the forest, thus altering the natural patterns of forest succession and providing new opportunities for non-native invasive plant species  to move into the forest.



# CHESAPEAKE AND OHIO CANAL NATIONAL HISTORICAL PARK

Chesapeake and Ohio Canal National Historical Park is the largest and longest park in the National Capital Region, stretching along the Potomac River for 184.5 miles from Washington, DC to Cumberland, MD. The park's 19,236 acres cut through four major physiographic provinces and include diverse wetlands, floodplain, and upland forests. Hundreds of historic structures are preserved as reminders of the canal's role as a major transportation system during the Canal Era. Today, the Canal and towpath support a large variety of recreational opportunities, but also permit the rapid spread of exotic and weedy species.



## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad

## Figure Legend (see also page 34)

- river flow direction
- physiogeographic region
- historic/cultural sites (monument)
- chestnut oak forests
- wetlands (cattails)
- development
- invasive/exotic species
- flooding

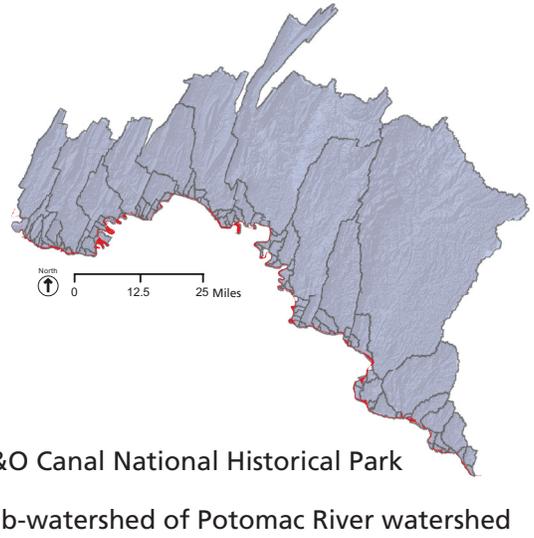


Photo: NPS

Great Falls Tavern, C&O Canal.

# CHESAPEAKE AND OHIO CANAL NATIONAL HISTORICAL PARK



## Dynamic river conditions influence canal environments

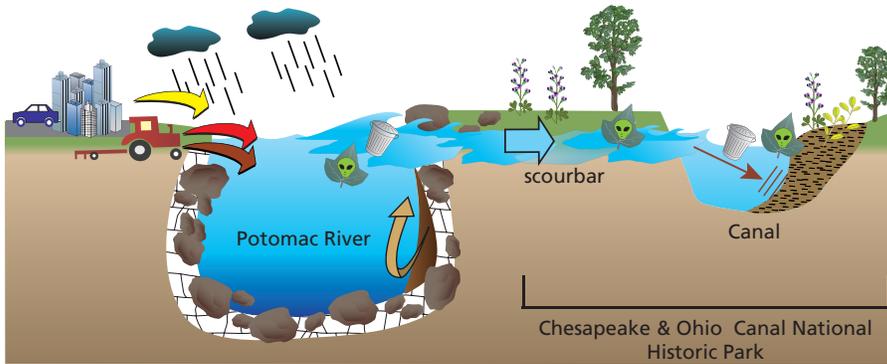


Photo: Kevin Ambrose



Photo: Kathy Sholl, NPS

Potomac flooding and debris overflow.

The C&O Canal is greatly influenced by the adjacent Potomac River. The Potomac River floodplains, scoured bars, and exposed rocky surfaces along the park house many rare, threatened or endangered species . Both the Potomac and the Canal are highly impacted by increased amounts of dumping , nutrient  and sediment  inputs (from houses, agricultural fields, industry, roads), and the rapid spread of invasive species . The Canal experiences accelerated filling by sediments  carried by surface run-off.

## Forest edges are both highly valuable and vulnerable

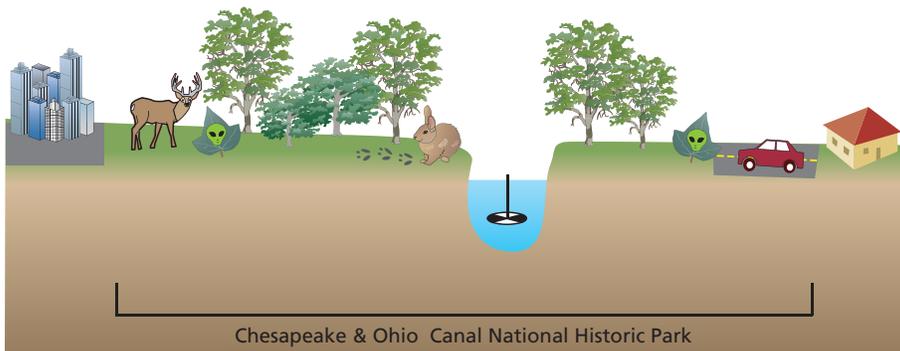


Photo: NPS

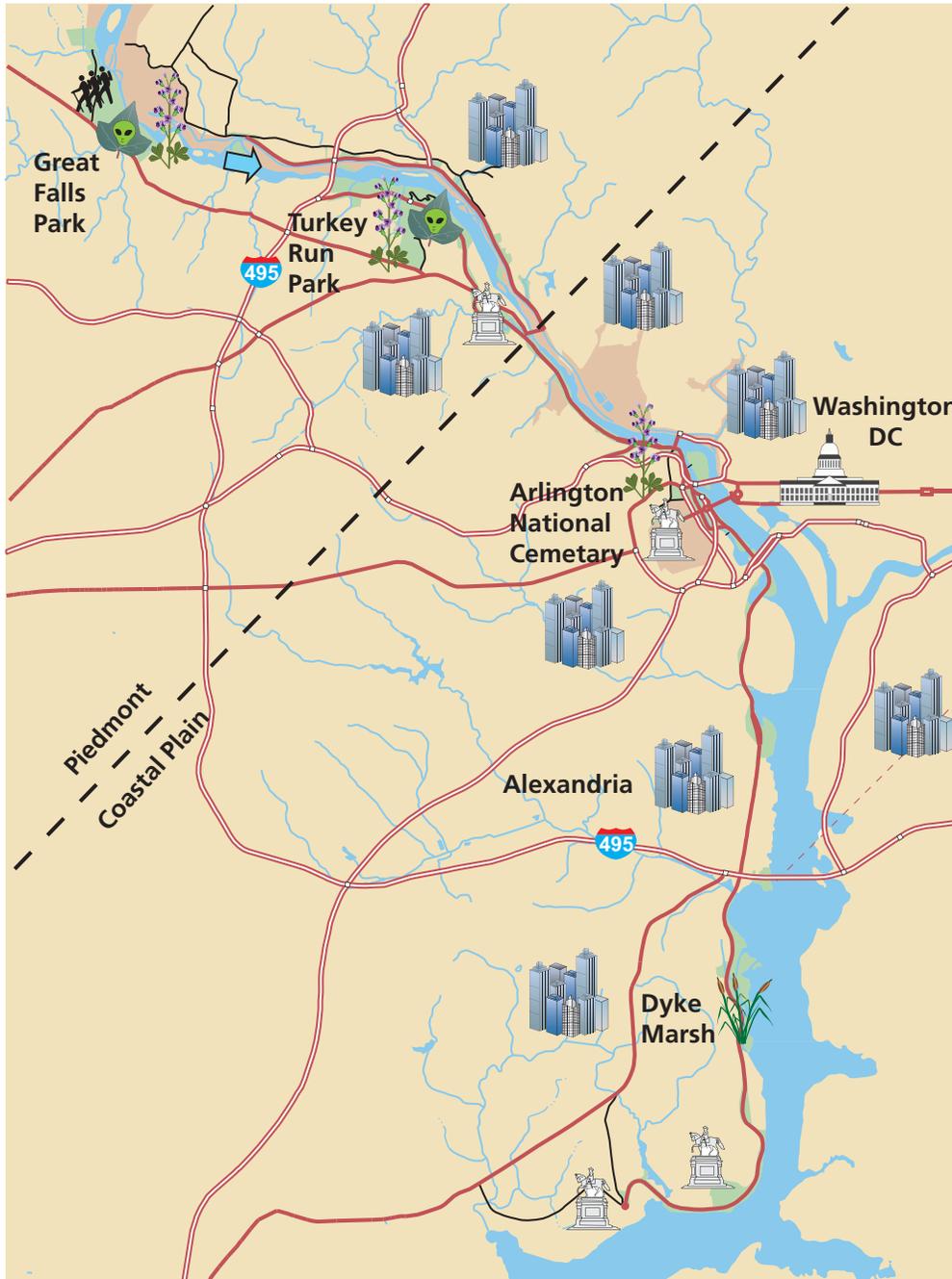
Bridge over C&O Canal and towpath.

The diversity of park neighbors  , multiple rights-of-ways  and narrow shape add to the complexity of managing C&O Canal National Historic Park. The health of the riparian buffer forests is critical to preserving high quality water resources . Stretching from western Maryland to the nation's Capital, the park provides important movement corridors  for a variety of forest-dwelling species. The long stretch of forest edge habitat also promotes the proliferation of human-tolerant and shade-intolerant species such as white-tailed deer  and many invasive plants .



# GEORGE WASHINGTON MEMORIAL PARKWAY

George Washington Memorial Parkway was established to protect the scenic view along the Potomac River and its tributaries in the Washington, DC area. The park's 7,210 acres provide habitat for dozens of state-listed species of rare, threatened, or endangered plants and animals, many of which are associated with rare plant communities of the Potomac River Gorge. The Parkway is the most visited of the National Capital Region parks and the sixth most-visited unit in the National Park System, with over seven million recreational visits in 2004. This high human visitation results in management concerns. Development along and within the park's boundaries and the related introduction of invasive species threaten park resources.



## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad

## Figure Legend (see also page 34)

- river flow direction
- physiogeographic region
- historic/cultural sites (monument)
- threatened species (wild false indigo)
- wetlands (cattails)
- development
- increased visitor use
- invasive/exotic species

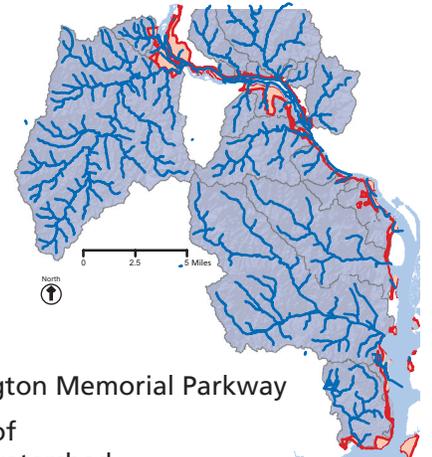


Photo: NPS

George Washington Memorial Parkway.

- George Washington Memorial Parkway
- Sub-watershed of Potomac River watershed

# GEORGE WASHINGTON MEMORIAL PARKWAY



## Park units connect in a fragmented landscape

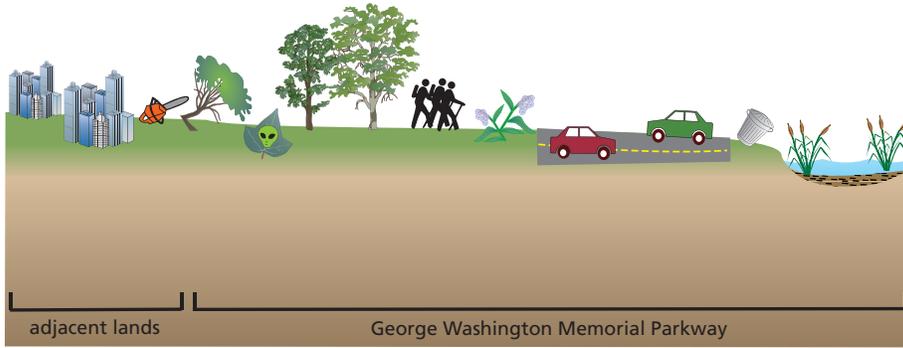


Photo: Greg Goodman, <http://photography.universalexports.net>



Debris and invasive plants float the Potomac and end up on Roosevelt Island.

Much more than a road, George Washington Memorial Parkway protects a system of valuable natural resource patches in the urban environment of Washington, DC. Preserving the ecosystem health, function, and connectivity of these wetlands 🌿, wildflower fields 🌸 and mature forests 🌳 is important for the general health of the Potomac River watershed. However, due to adjacent urban development 🏙️ and visitor use pressures 👣, this linear park's fragmented resources are heavily impacted by the rapid spread of invasive exotics 🦹, tree cutting 🪚, dumping 🗑️, and the demand for new trails and parking lots.

## Potomac Gorge is a unique natural heritage site



Photo: Dan Sealy, NPS

Great Falls, Potomac River.

Shared between George Washington Memorial Parkway and C&O Canal National Historical Park, the management of the Potomac Gorge protects a variety of rare, threatened, and endangered species 🐢 or rare plant communities 🌿 that are adapted to the unique, complex, rock topography 🪨 and the constant flooding and scouring forces of the Potomac River. The Gorge has a complex system of wetlands including vernal pools and seeps where globally rare amphipods 🐛 occur. The volume and quality of the groundwater 💧 that feeds these systems are affected by increased impervious surface 🚗 run-off of nutrient 📉 and pollutant 🗑️ inputs.

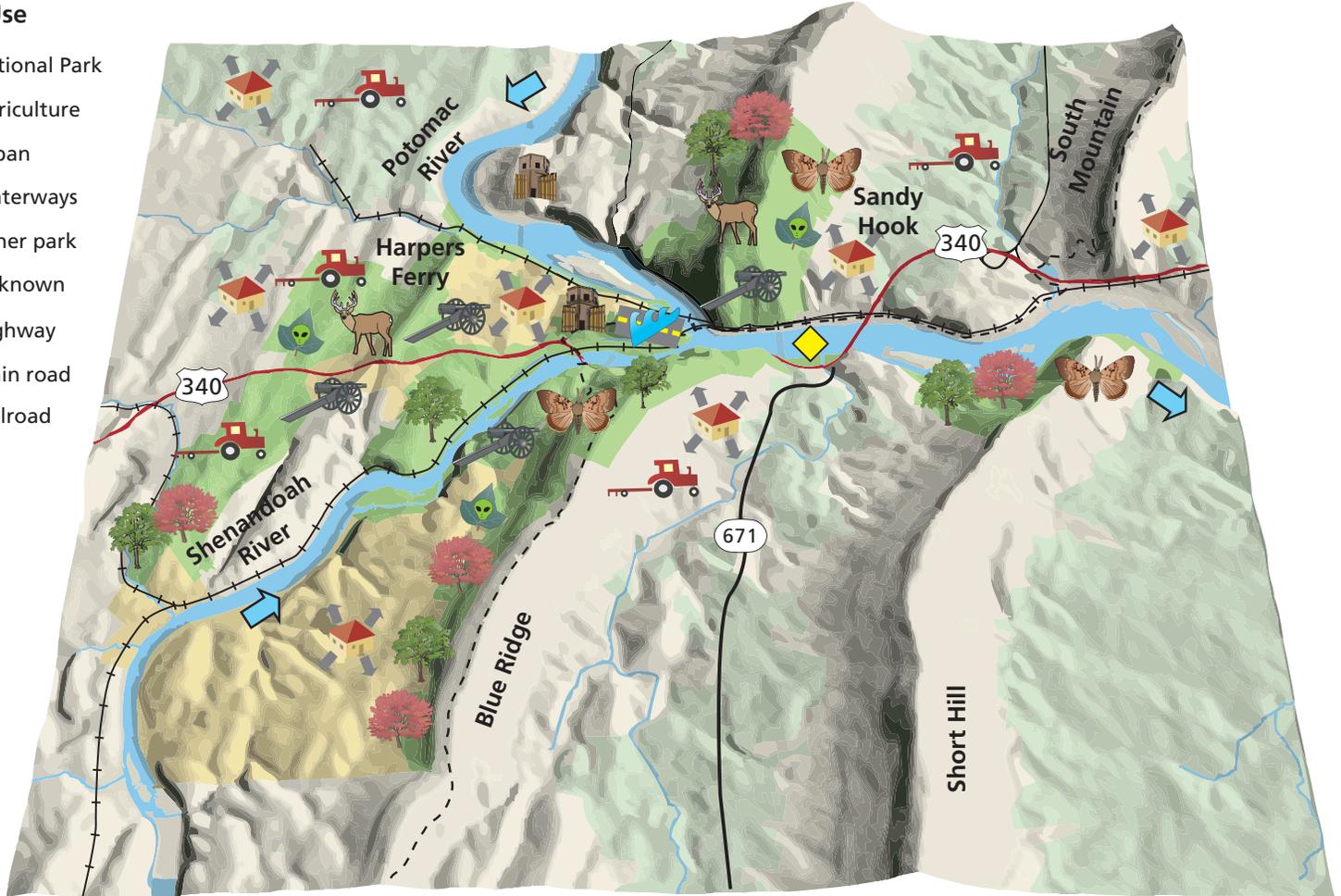


# HARPERS FERRY NATIONAL HISTORICAL PARK

Harpers Ferry National Historical Park protects the historic town area and surrounding natural resources lands at the confluence of the Shenandoah and Potomac rivers in WV, VA, and MD. Preserved structures and landscapes in the park tell of the historic role of the town and lands in the Civil War, African American history, manufacturing, and transportation and other historic events. The natural heritage of the park is equally rich, and over 70% of the park's 3,645 acres is covered with eastern deciduous forest. Changes in adjacent land use that may affect park resources (e.g., water quality, invasive species, deer population) are of primary concern to park management. Because of its unique location, flooding is also a major concern.

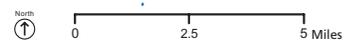
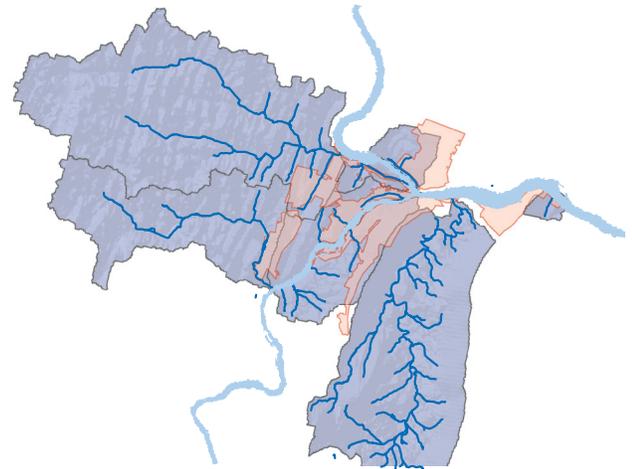
## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad



## Figure Legend (see also page 34)

- river flow direction
- chestnut oak/red maple forests
- historic sites (fort, Civil War battlefield)
- agriculture (crops)
- railways
- development
- white-tailed deer
- insect pest (gypsy moth)
- invasive/exotic species
- flooding
- toxicants



- Harpers Ferry National Historical Park
- Sub-watershed of Potomac River watershed

# HARPERS FERRY NATIONAL HISTORICAL PARK



## Air quality impacts scenic vistas

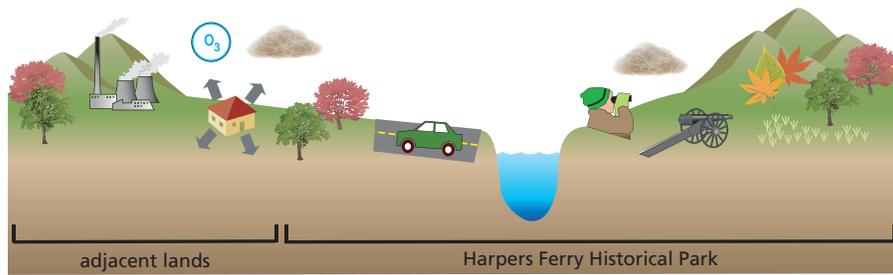


Photo: Greg Goodman, <http://photography.universalexports.net>

Mountain vista, Harpers Ferry.

The natural landscape of Harpers Ferry National Historical Park includes major rivers, forested mountains, riparian habitats, old fields, grasslands, and agricultural lands. Panoramic views  and spectacular landscape  serve as context for the interpretation of other historic  and Civil Rights events that the park commemorates. Degraded air quality and haze  from regional pollution sources  cause increased ozone levels  that threatens vegetation and degrades views from scenic viewing sites in the park. Expanding residential development  also adversely affects the historic and scenic vistas.

## Natural and anthropogenic disturbances threaten historic resources

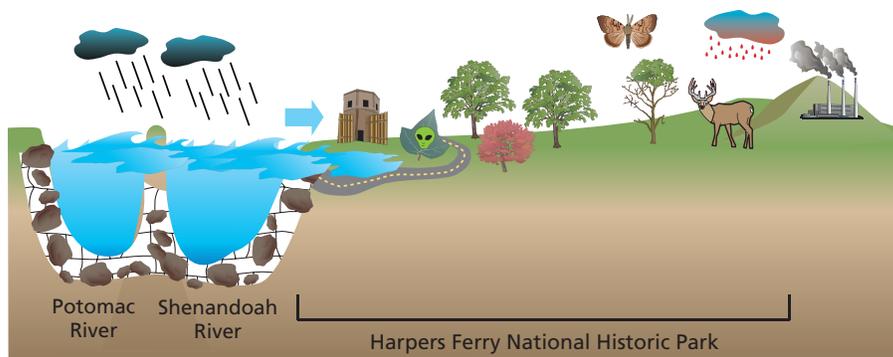


Photo: Dale Nisbet, NPS

Harpers Ferry Flood, 1996.

Flooding is a natural occurrence at Harpers Ferry National Historical Park. Located at the lowest point of the confluence of the Potomac and Shenandoah rivers, flooding  can have a devastating impact on historic buildings  and archeological features. Gypsy moth  infestations and unchecked populations of white-tailed deer  have severely defoliated sections  of the park's historic Maryland Heights forest. Invasive exotic plants  and acid rain  threaten Civil War sites and historic geologic structures such as the Stone Steps and Jefferson Rock.

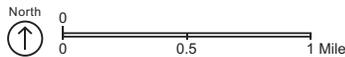
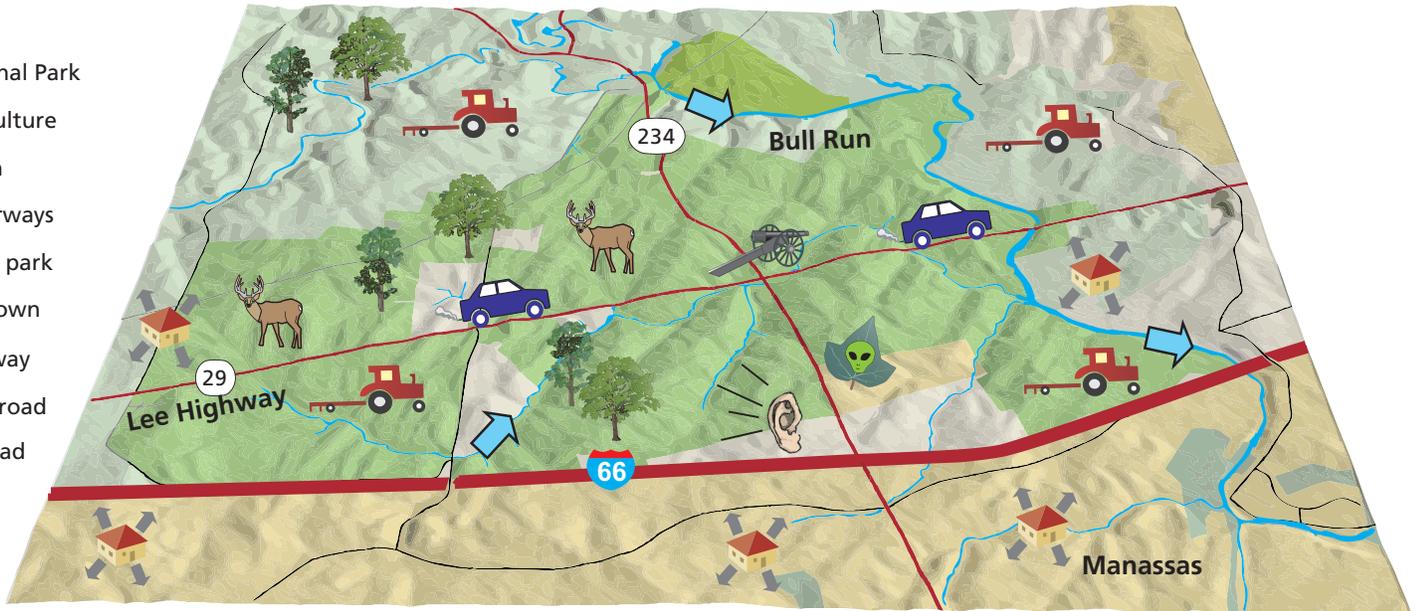


# MANASSAS NATIONAL BATTLEFIELD

Manassas National Battlefield was established to preserve the scene of two major Civil War battles. Much of the landscape retains its wartime character with a patchwork of open fields and woodlots scattered across gently rolling hills. The 5,073 acre park is located within the northern VA Piedmont, approximately 72 km southwest of Washington, DC. It is surrounded by farmland experiencing conversion into residential and light industrial park developments. A major transportation corridor passes through the park, with associated impacts. Additional natural resource issues for Manassas National Battlefield include suburban sprawl, overpopulation of white-tailed deer and beaver, and exotic species invasions.

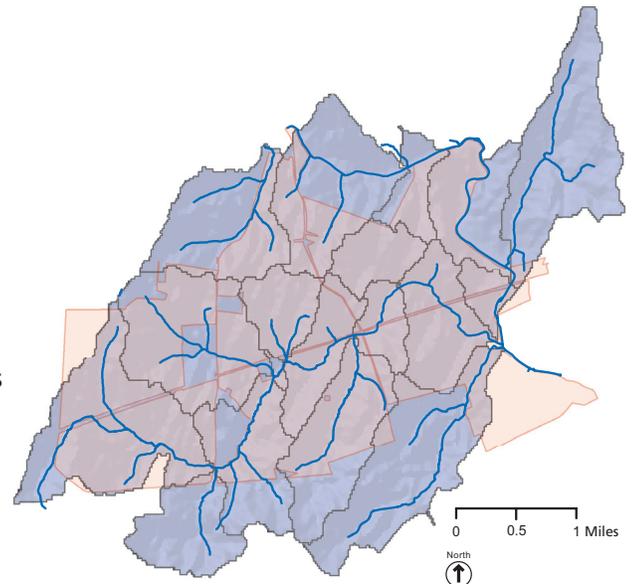
## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad



## Figure Legend (see also page 34)

- river flow direction
- historic sites (Civil War battlefield)
- hickory/chestnut oak forests
- agriculture (crops)
- development
- traffic
- noise
- white-tailed deer
- invasive/exotic species



- Manassas National Battlefield
- Sub-watershed of Potomac River watershed



Photo: Brad Waldron, NPS

A Manassas battlefield in the morning mist.

# MANASSAS NATIONAL BATTLEFIELD



## Roads divide park and fragment habitat

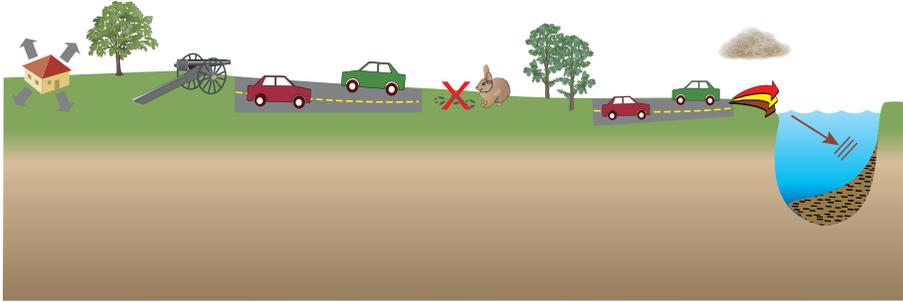


Photo: NPS

Traffic flows through the heart of the park.

Manassas National Battlefield provides the opportunity for visitors to explore the historic  terrain in a natural setting while immersed in the increasingly urbanized landscape  of northern Virginia. However, two busy commuter corridors, Routes 29 and 234  , transect the park and diminish visitor movement and relaxation opportunities. Degraded air quality  associated with the traffic also affects aquatic habitats and sensitive species, and continued road development increases stormwater run-off of sediments and pollutants  into the rivers.

## Landscape habitat diversity supports an important bird refuge

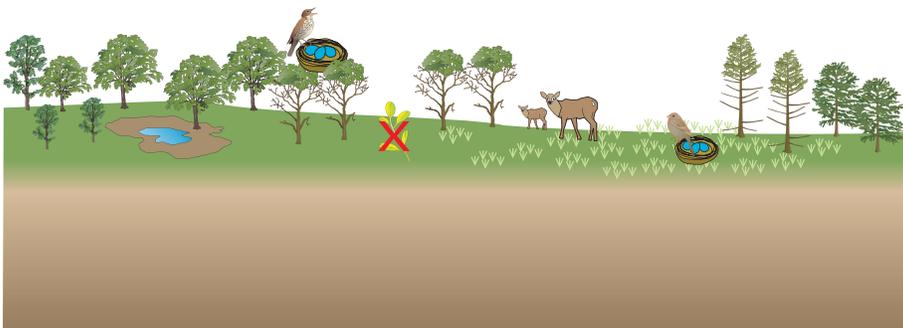


Photo: Bryan Gosira, NPS

Wildflower meadow in summer.

The landscape of grasslands, meadows, woodlands, and swamps contribute significantly to preservation of local and regional biodiversity. The park is a particularly important refuge for grassland birds  , which are of high conservation concern in the region. The overpopulation of deer  in the park has greatly reduced woodland understory vegetation  with potentially negative consequences on the park's woodland bird  populations.



# MONOCACY NATIONAL BATTLEFIELD

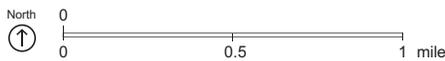
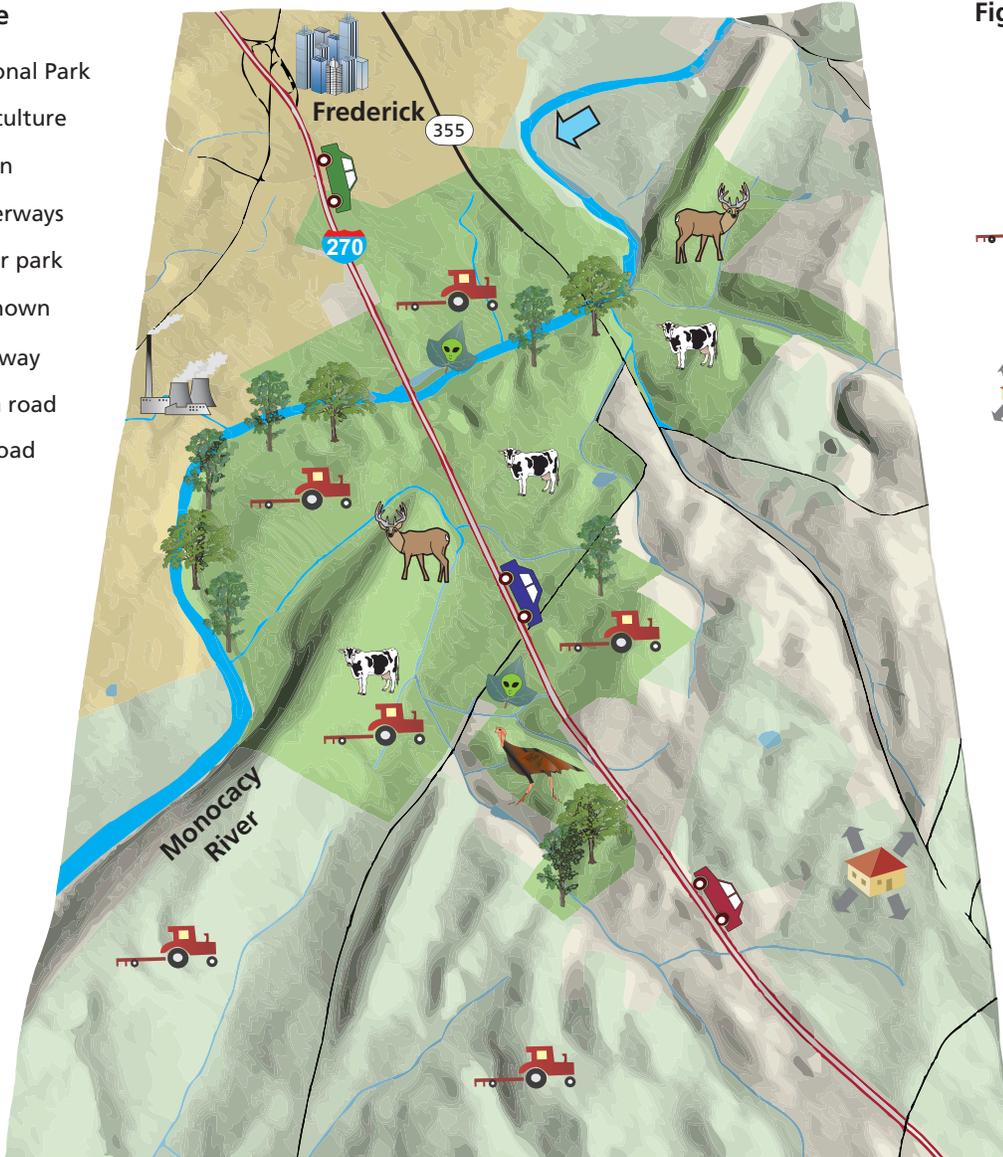
Monocacy National Battlefield is managed as a cultural resource commemorating the Civil War battle that took place along the Monocacy River south of Frederick, MD. The 1,647 acre park is dominated by active farms with some mixed hardwood forests and field/edge habitat. Like other battlefield parks, it has the challenge of combining the preservation of a historic landscape with natural resource management. Potential threats to the park's natural resources include the release of pollutants from agriculture, industrial plants located southwest of the park, and heavy traffic on Interstate 270, which bisects the park. Suburban sprawl makes the park an important preserve for wildlife, and the spread of exotic plants and an increase in deer population have already been documented.

## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad

## Figure Legend (see also page 34)

- river flow direction
- hickory/chestnut oak forests
- agriculture (crops, cows)
- native species (wild turkey)
- development
- industry
- traffic
- white-tailed deer
- invasive/exotic species



- Monocacy National Battlefield
- Sub-watershed of Potomac River watershed

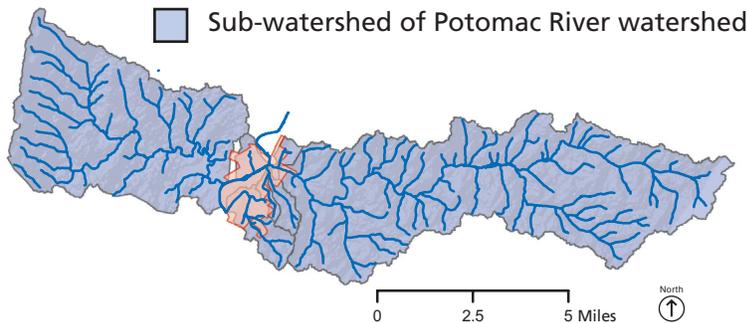


Photo: NPS

Civil War monument overlooks parklands.

# MONOCACY NATIONAL BATTLEFIELD



## Water quality is impacted by agriculture adjacent and within park

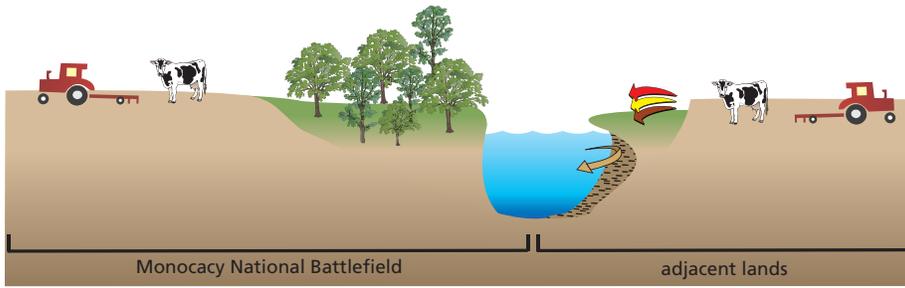


Photo: NPS

Riparian habitat and farming, side by side.

Much of the land in Monocacy National Battlefield is managed as a historic agricultural landscape through permits for crops 🚜 and pasture 🐄. Farm activities inside and outside the park threaten the health of the Monocacy River through high inputs of nutrients 📉, sediments 📉, and pesticides 📉. To combat these threats, the park encourages best management practices within its boundaries including the preservation of large forested buffers 🌳 between agricultural fields and waterways, reducing erosion 📉 along river banks and absorbing runoff from neighboring fields.

## Urban development is encroaching on park boundaries



Photo: NPS

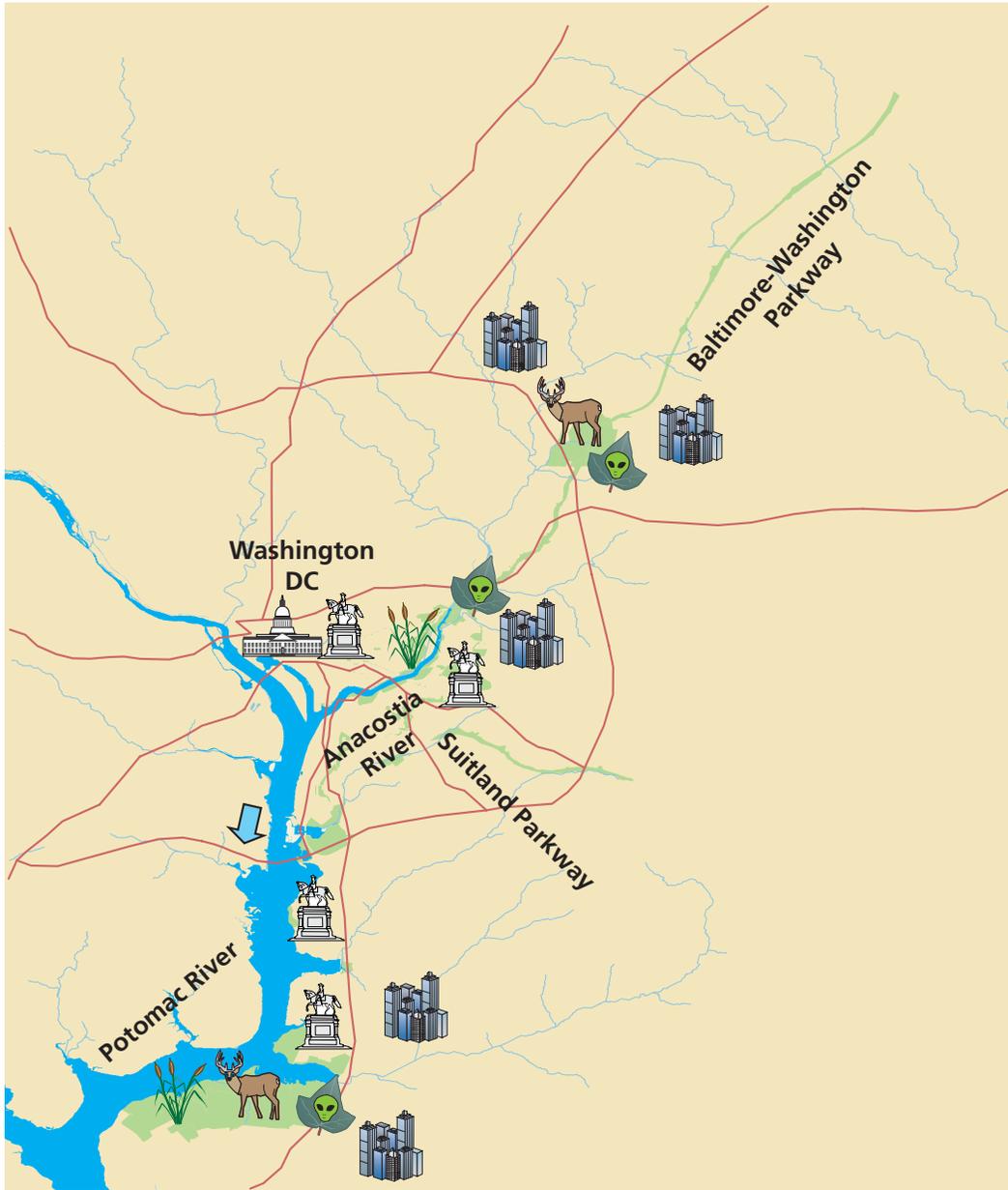
Urbanization can put pressure on park habitat.

Monocacy National Battlefield has seen considerable change along its borders since land acquisition began in the 1980s. Development with the city of Frederick 🏢 has spread to the park's northern boundary and housing developments 🏠 are rapidly approaching the southern boundary. The battlefield represents a sanctuary for many plant and animal species 🦃 within this rapidly urbanizing environment and significant habitat fragmentation has occurred because of this development and proliferation of utility corridors 🏗️ and roads 🚗. Demographic changes in the area also bring increased visitation 🚶 and greater opportunities for the establishment of invasive species 🌿.



# NATIONAL CAPITAL PARKS–EAST

National Capital Parks–East includes 14 major sites covering approximately 11,000 acres within Washington, DC and three nearby counties in MD. The parks lie entirely within the upper Coastal Plain physiographic region and are managed for a variety of natural, cultural, and recreational resources. Significant natural features of the parks include sand and gravel beaches, shoreline bluffs, flood plain and upland forest, shell marl ravine forest with its associated fossil outcrops, two large river systems, and numerous streams, seeps, and wetlands. Major threats include those associated with its urban setting: overabundant deer populations, exotic species invasion, shoreline erosion, and boundary management issues.

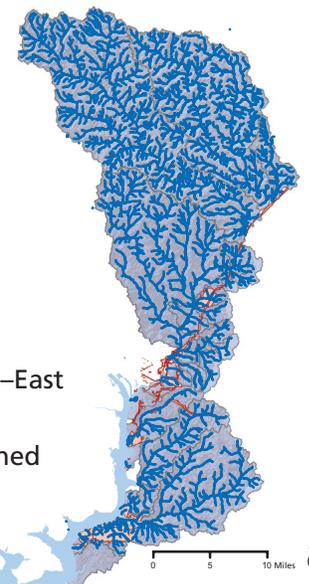
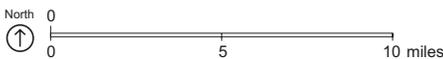


## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad

## Figure Legend (see also page 34)

- river flow direction
- historic/cultural sites (monument)
- wetlands (cattails)
- development
- white-tailed deer
- invasive/exotic species



- National Capital Parks–East
- Sub-watershed of Potomac River watershed



Lotus blossoms, Anacostia River.

# NATIONAL CAPITAL PARKS–EAST



## Restoring wetland habitat along a troubled river

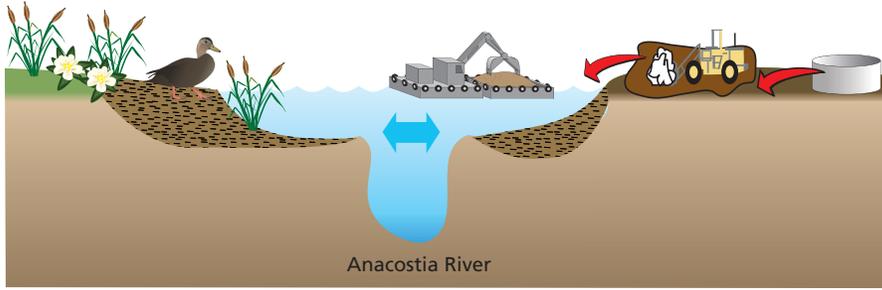


Photo: NPS

Kingman Lake and Anacostia River.

The Anacostia River is a tidal freshwater  tributary flowing through Maryland and the District of Columbia to the Potomac River. Tidal wetlands  within Washington DC are rare. Historic dredging operations  have impacted the wetlands, along with brownfields, sanitary landfills , dumping, and large inputs of nutrients  from stormwater discharges and combined sewers. Restorations at Kingman Lake and Kenilworth Marsh have recreated ~110 acres of emergent tidal wetland, providing habitat for many wetland species including migratory birds .

## Parks serve as species refugia and migratory corridors

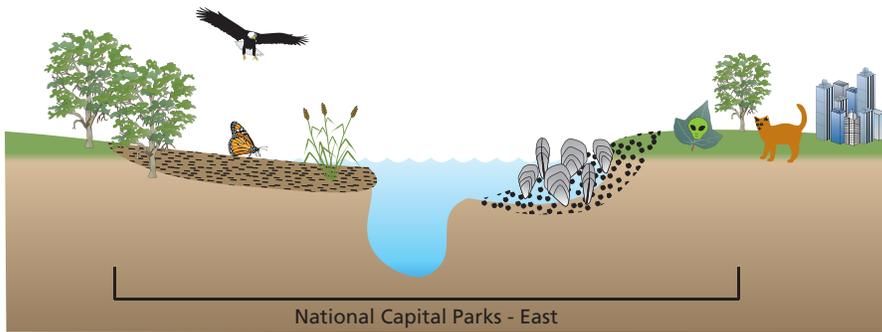


Photo: NPS

Park meadow and Washington Monument.

Sites within National Capital Parks–East provide protection for many species from increasing development . The parks have rare habitats such as sand and gravel beaches, floodplains, upland forests, and various wetland systems. The parks host 100 rare, threatened, and endangered plants and animals, including the lamp mussel  and bald eagle , and create migratory corridors for birds and butterflies. Urban pressures, such as invasive plant species  and increased feral cats , make park lands critical resources to preserving native species.

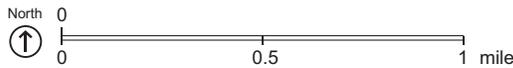
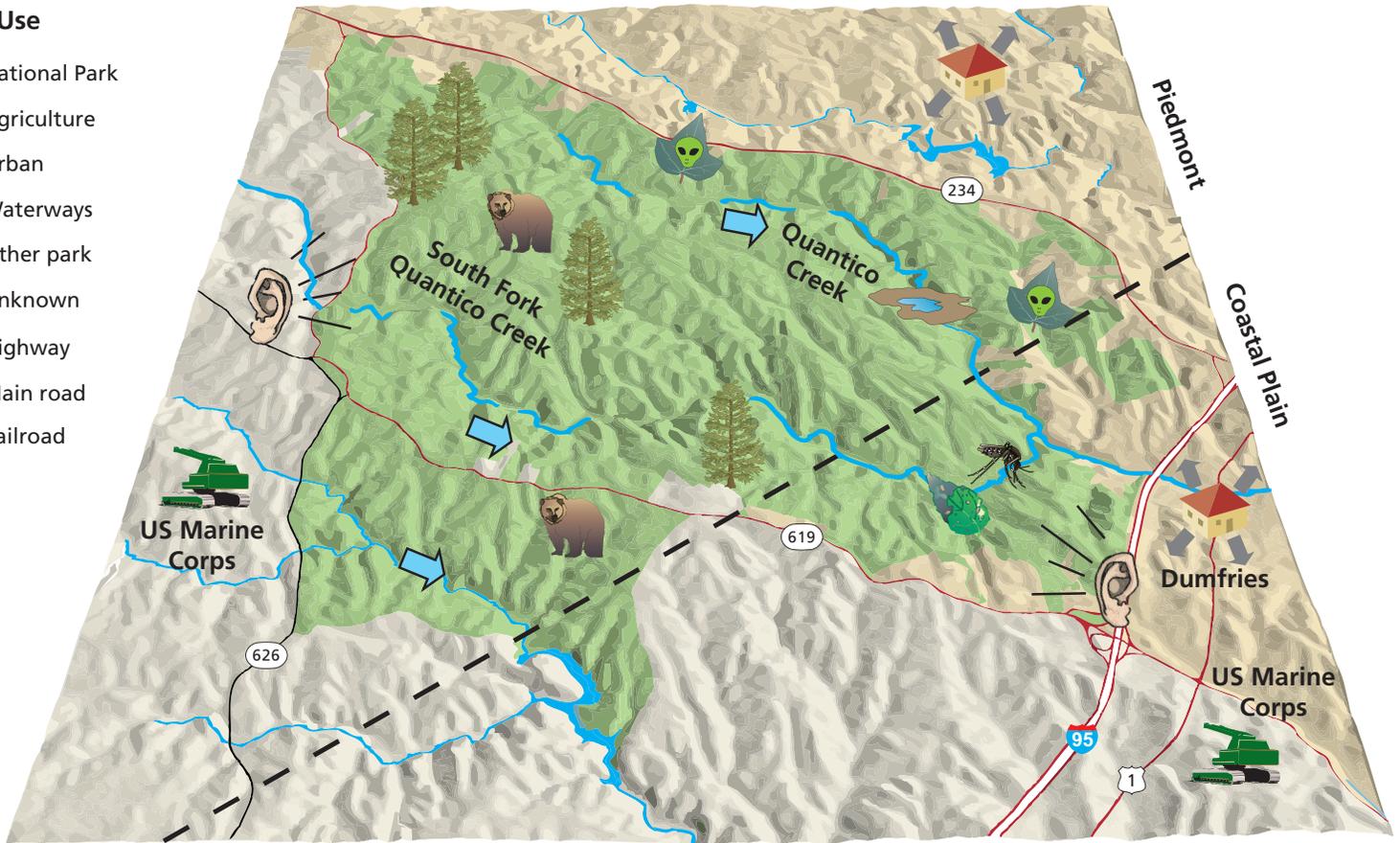


# PRINCE WILLIAM FOREST PARK

Prince William Forest Park is the largest protected example of Piedmont forest in the National Park System. The 19,377 acre park in northern VA also protects the Quantico Creek watershed, and is a sanctuary for numerous native plant and animal species. Because the park includes two physiographic provinces (Piedmont and Coastal Plain) and lies in the transition zone between northern and southern climates, it exhibits a wide range of vegetative communities, including rare seepage swamp habitat and remote stands of eastern hemlock with old-growth characteristics. Major threats to park resources include adjacent land development, noise pollution, and the introduction of invasive species and disease.

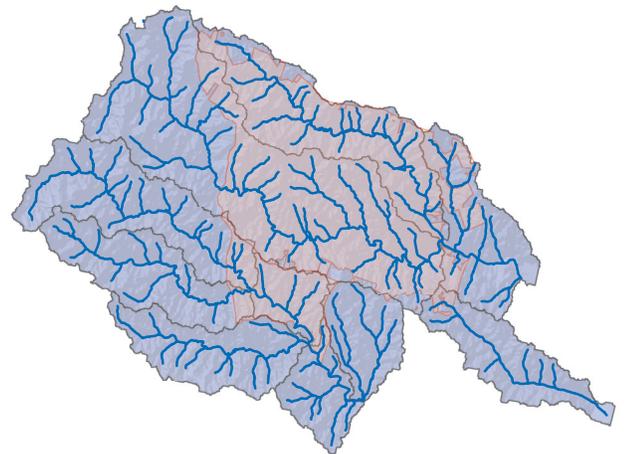
## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad



## Figure Legend (see also page 34)

- river flow direction
- physiogeographic region
- native species (black bear)
- hemlock forests
- seepage swamp
- development
- military base
- noise pollution
- invasive/exotic species
- disease



- Prince William Forest Park
- Sub-watershed of Potomac River watershed

# PRINCE WILLIAM FOREST PARK



## Large intact forest provides valuable indicators of ecosystem processes

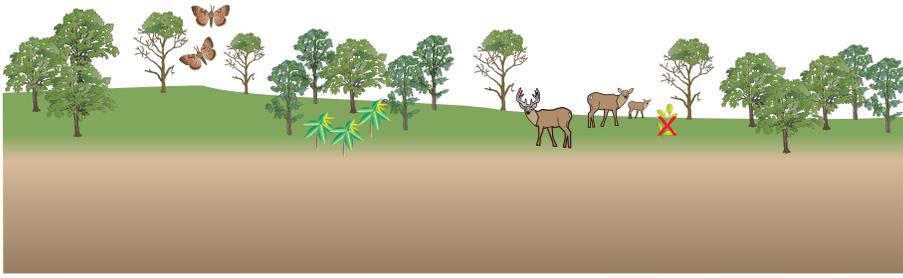


Photo: Kirsten Spaulding, NPS

Quantico Creek.

The large intact forests of Prince William Forest Park provide an opportunity to track changes in forest communities through time and space. Natural processes of succession  may be perturbed by overabundant deer populations  or outbreaks of forest pathogens and pests . The park supports a wide variety of forest-dwelling species including the small-whorled pogonia , a Federally-listed threatened species. The confluence of diverse habitat types makes these forests valuable early indicators of the effects of regional environmental change such as potential changes in climate.

## Continuous forest habitat protects watershed

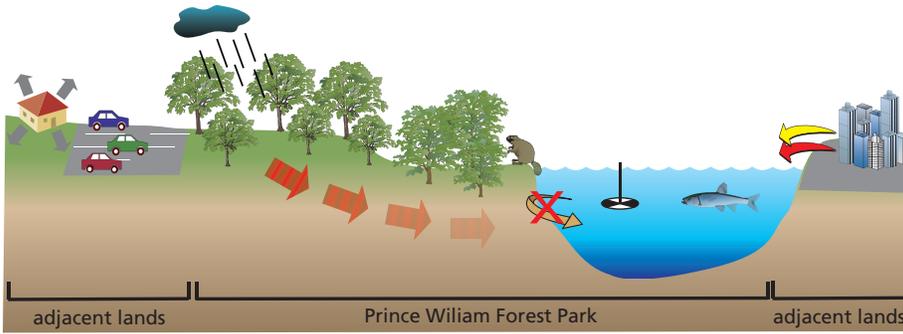


Photo: NPS

Parklands are surrounded by development.

Most of the Quantico Creek watershed lies within the park. The water quality of Quantico Creek is excellent and supports numerous fish species  and other aquatic life . Continuous forest habitat  protects this watershed and contributes to the high water quality  by helping to filter nutrients and sediment , stabilize soils , and moderate flooding. The health of this watershed is potentially impacted by increasing development , impervious surfaces , and urban input .

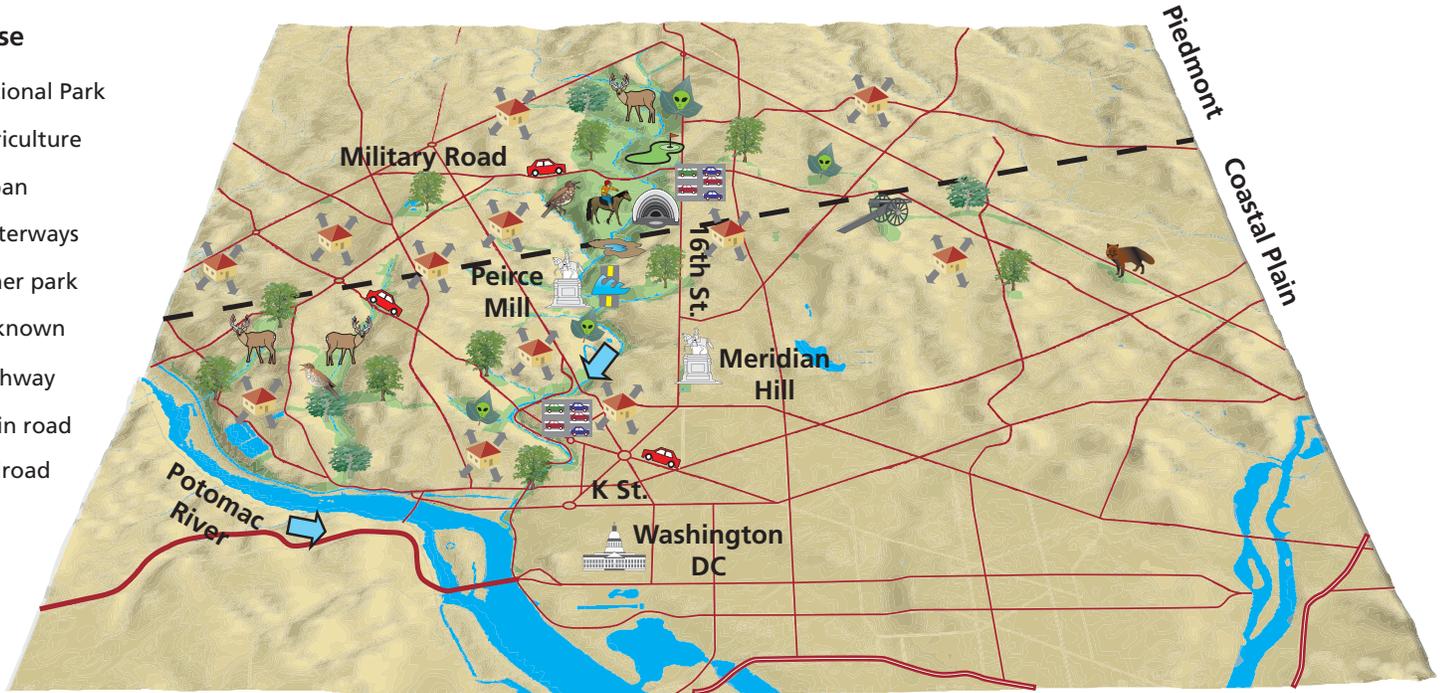


# ROCK CREEK PARK

Rock Creek Park is one of the largest forested urban parks in the United States, containing a wide variety of natural, historical, and recreational features in the midst of Washington, DC. The majority of the 3,000 acre park surrounds the lower watershed of Rock Creek and its tributaries as the drainage drops from the Piedmont Plateau to the Coastal Plain. The mixed deciduous forests, streams, and sensitive floodplain communities of the park represent a largely isolated natural system surrounded by urban areas, which impact park resources through traffic, flooding and pollution of park streams, introductions of invasive species, recreational demand, dumping, collecting, creation of unauthorized trails, and boundary encroachments.

## Land Use

- National Park
- Agriculture
- Urban
- Waterways
- Other park
- Unknown
- Highway
- Main road
- Railroad



## Figure Legend (see also page 34)

- river flow direction
- physiogeographic region
- historic/cultural sites (monument, amphitheater, Civil War battlefield)
- beech/oak/tulip poplar forests
- native species (red fox)
- native species (wood thrush)
- seep
- development
- golf course
- traffic
- impervious surface
- white-tailed deer
- invasive/exotic species
- flooding

- Rock Creek Park
- Sub-watershed of Potomac River watershed

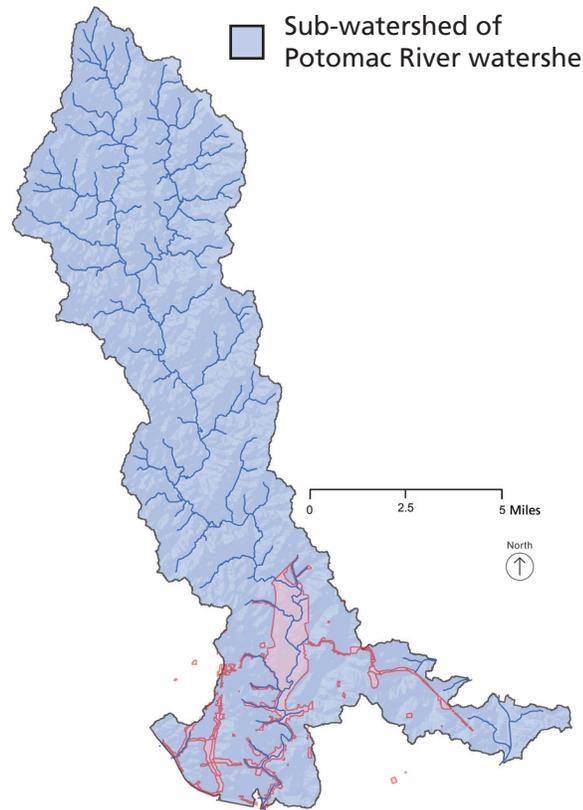


Photo: NPS

Rock Creek.

# ROCK CREEK PARK



## Urban pressures impact natural resources

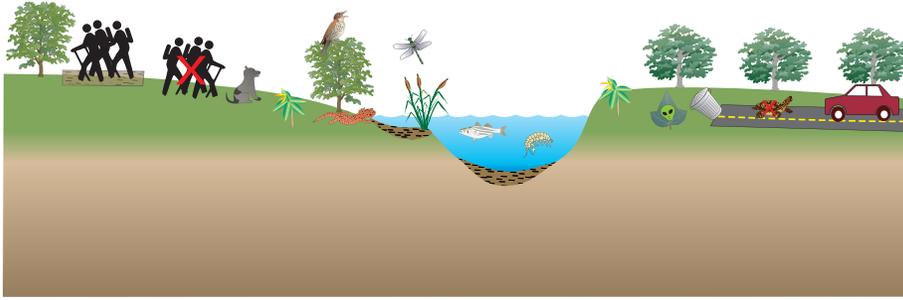


Photo: NPS

A classic car rally attracts many visitors.

Rock Creek Park offers a wide range of recreational and respite opportunities for the park visitor while preserving the original biodiversity of the area including rare dragonflies 🦗, amphipods 🐛, salamanders 🦎, fish 🐟, interior forest birds 🐦, and native plants 🌿. However, visitor use may significantly impact the natural resources of the park. Vehicular traffic 🚗 results in numerous road kills 🐢 and park roads fragment forests. The spreading of invasive exotic plants 🌿 by dumping 🗑️, the creation of unauthorized trails 🚶, and dogs off-leash 🐕 damage resources and threaten fragile forest habitat and biodiversity.

## Impervious surfaces surround park

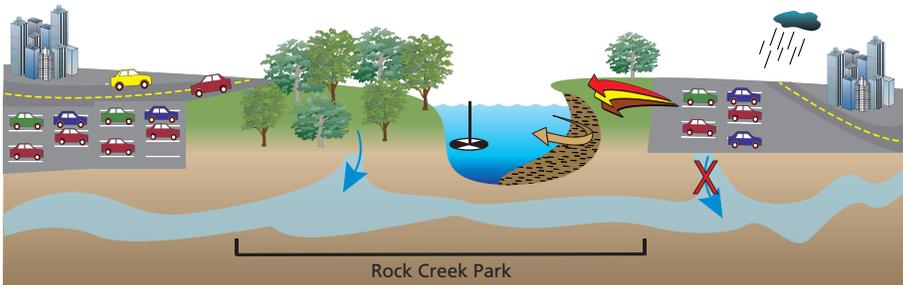


Photo: NPS

Roadways around and through park.

As the first urban park in the National Park Service, Rock Creek Park provides and protects an important ecological resource for the nation's Capital. Expanding development outside the park 🏙️ continues to increase impervious surfaces 🚗, resulting in increased stormwater runoff 🌧️ of sediments and nutrients, creek bed scouring 🌀, and reduced groundwater recharge ❌. The park's large tract of forest 🌳 (85% of the park is woodland) buffers stormwater impacts and improves water quality 🌿 within the park by filtering out nutrients and other pollutants.

# WOLF TRAP NATIONAL PARK FOR THE PERFORMING ARTS

Wolf Trap National Park for the Performing Arts is the only National Park dedicated to the performing arts. Performance structures on the 130 acre property include a 7,000-person main stage. The park includes protected stream, meadow, and forest patches in the urban Washington, DC landscape. Noise from the Dulles Toll Road threatens the primary function of the park as a performance venue and is a major management concern. Water quality degradation, exotic species introductions, deer overabundance, and the encroachment of development against park boundaries are also issues of concern.

## Land Use

-  National Park
-  Agriculture
-  Urban
-  Waterways
-  Other park
-  Unknown
-  Highway
-  Main road
-  Railroad

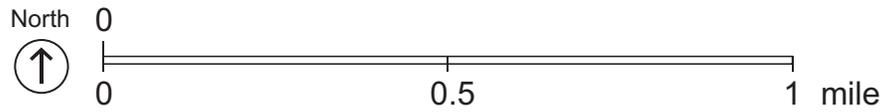
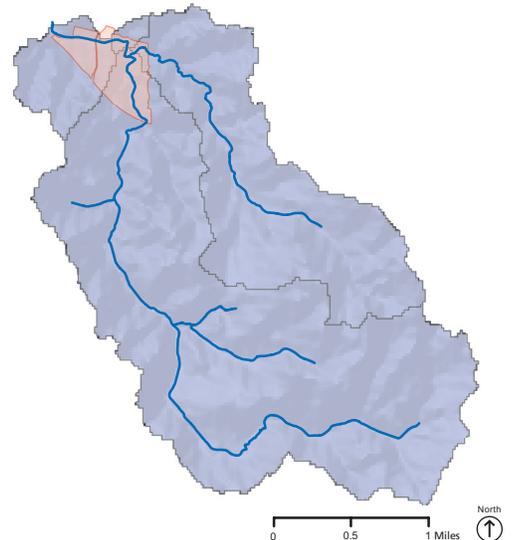


Figure Legend (see also page 34)

- |   |                               |   |                         |
|---|-------------------------------|---|-------------------------|
|   | hickory/chestnut oak forests  |  | development             |
|   | wetlands (cattails)           |  | traffic                 |
|   | cultural sites (amphitheater) |  | impervious surface      |
|  | white-tailed deer             |  | invasive/exotic species |
|  | flooding                      |   |                         |



-  Wolf Trap National Park for the Performing Arts
-  Sub-watershed of Potomac River watershed

# WOLF TRAP NATIONAL PARK FOR THE PERFORMING ARTS



## Natural settings provide suburban green space

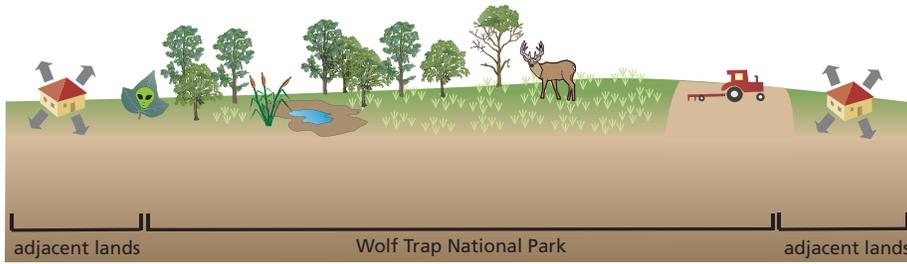


Photo: NPS

Summer afternoon in the park.

Wolf Trap National Park for the Performing Arts provides a great natural setting for the enjoyment of artistic performances. The park, surrounded by accelerated and dense commercial and residential development , has become a natural enclave in the middle of suburbia. The woodlands , streams, and various wetlands  dispersed throughout the park are threatened by increasing populations of deer  and invasive plant species  associated with the suburban setting. The park harbors a large variety of habitat for its small size including farmland , forest , and upland meadows , and contributes to the overall water quality of Fairfax County, VA.



Photo: Scott Suchman

Intense visitor use can take a toll on park resources.



Photo: NPS

A performance at the Theater in the Woods.

## SUMMARY: WHERE TO?

Participants in the May 2005 Workshop recognized the value of Vital Signs monitoring to: a) assess the efficacy of management practices and restoration efforts; b) characterize trends in the condition of parks; and c) identify gaps in knowledge where additional research should be promoted. Recommendations for achieving maximum value from Vital Signs monitoring are grouped into categories of human, biotic, and environmental resources and presented below.

### HUMAN

- **Target management** actions that facilitate recreation and mediate its environmental impacts. Careful consideration is required of the effects of increasing visitation upon the parks, including trails and campgrounds, rights of way, poaching, parking, and roadways.
- **Develop monitoring** to assess human pressures from watersheds surrounding the parks. These pressures include changes in land use and impervious surface, encroachment, and agricultural leaching of nutrients, sediments, and pesticides.
- **Promote research** to understand mechanisms by which humans influence the parks. Research into the impacts of visitor use, traffic and noise, as well as nutrient, sediment, and pesticide pollutants would be especially beneficial.

### BIOTA

- **Target management** strategies to manage combinations of natural and highly modified habitats. Exotic species are present in all parks and require management, along with populations of native species (e.g., white-tailed deer and beaver) that potentially act as ecosystem engineers.
- **Develop monitoring** to evaluate biodiversity and track the balance between native and non-native species. Specifically, monitoring of native populations of white-tailed deer and Canada geese, invasive plant and animal species, and rare, threatened, or endangered species is recommended.
- **Promote research** to inform management of invasive species, pests, rare species, and ecological engineers. Better knowledge is needed of exotic plant species reinvasion after herbicide or fire control, the impacts of overabundant fauna on floral diversity, and the distribution and behavior of understudied fauna.

### ENVIRONMENT

- **Target management** actions to retain structure and value of diverse ecological environments. Special management needs are associated with unique habitats in wetland marshes, streams, seeps, vernal pools, riparian zones, and sensitive soil environments.
- **Develop monitoring** to assess health and stability of physical environments with emphasis on aquatic systems. Markers of healthy aquatic ecosystems include water column nutrients and chemicals, water flow, erosion, macroinvertebrates and amphibians, and stormwater overflows.
- **Promote research** to improve knowledge of environmental impacts throughout the watersheds. Potential projects include groundwater and wetland mapping, and watershed-scale studies of stream intactness and inputs. Research into the caves and limestone glades within some parks also may help to understand and preserve these unique and rare features.

The conceptual diagrams we depict are not static products. These ‘thought drawings’ will be continually refined as our knowledge of ecological systems in the National Capital Region Parks becomes more sophisticated. Data collected through vital signs monitoring will be used to support the processes and interactions portrayed by the vignettes. Collectively, the scoping, visual elements, and ecological themes synthesized in this booklet form the basis for integrated assessments.

The next phase of this project will define ranges of condition for both individual vital signs and suites of indicators that can be used to report on ecological condition. The ultimate goal for our work will be to institute a framework for ecological assessments using monitoring data and to visually present the results of assessments in an effective manner such that informed research, management, or monitoring decisions can be made (Figure 6).

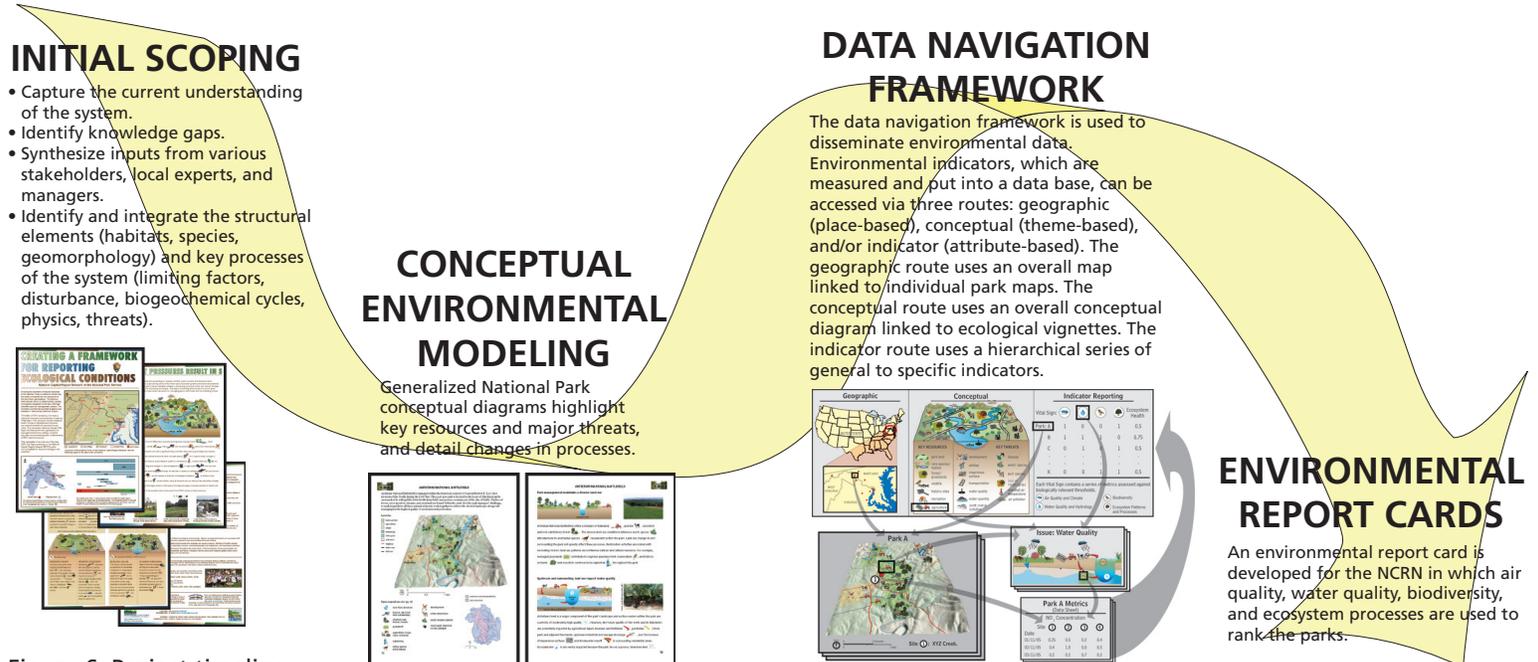
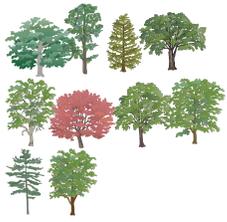


Figure 6. Project timeline.

# CONCEPTUAL DIAGRAM LEGEND



## Flora and Fauna (left to right)



**Trees** (white oak, shagbark hickory, virginia pine, american chestnut, sycamore, red maple, chestnut oak, american beech, eastern white pine, tulip poplar)



**Flowers and Plants** (false wild indigo, virginia bluebell, snow trillium, small whorled pogonia, bog magnolia, cattails, grasses)



**Mammals** (black bear, white-tailed deer, coyote, red fox, beaver, raccoon, rabbit)



**Invertebrates** (Hay's Spring amphipod, lamp mussel)



**Insects** (gypsy moth, dragonfly, monarch butterfly, hemlock wooly adelgid)



**Fish** (brook trout, rainbow trout, striped bass, shiner)



**Amphibians and Reptiles** (diamondback terrapin, northern salamander, eastern box turtle, wood turtle)



**Birds** (bald eagle, canada goose, wild turkey, wood thrush, american black duck, field sparrow)

## Land Use and Features (left to right)



Residential/urban development



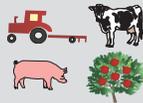
**Historic/Cultural Sites** (battlefield, monument, fort, amphitheater)



**Bedrock** (limestone, metamorphic)



Impervious surface



**Agriculture** (crops, farm animals, orchards)



Seeps/springs



Roads and traffic



**Recreation** (riding, hiking, cycling)



Logging



Railways



Archeological site



Land fill



Utility corridors



Scenic vistas and landscapes



Dredging



Military/industry



Unleashed or feral pets



Tree cutting



Water treatment plant



Dumping



Replanting

## Ecosystem Health Indices



Visitor impact



Overgrazing or defoliation



Water quality (high, low)



Good visibility



Noise pollution



Invasive/exotic species



Groundwater



Ozone (high)



Movement corridor



Disease



Freshwater flow



Oxygen (high, moderate, low)



Understory regeneration



Toxicants



Low air quality

## Processes



Input: nutrient



River bank erosion



Phosphate



Wet deposition



Input: sediment



Sediment deposition



Atmospheric nitrogen



Acid rain



Input: toxicant



Transport: sediment/nutrient



Mercury deposition



Weather/precipitation



Input: sediment/toxicant



Flooding



Input: sediment/nutrient



**Inventory & Monitoring Program**  
Center for Urban Ecology  
National Park Service

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