National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Petersburg National Battlefield Natural Resource Condition Assessment

Virginia

Natural Resource Report NPS/PETE/NRR—2013/704

ON THE COVER

Earthworks in the Eastern Front Unit
Photo: Petersburg National Battlefield NPS

Petersburg National Battlefield Natural Resource Condition Assessment

Virginia

Natural Resource Report NPS/PETE/NRR—2013/704

Lookingbill, T.R., B.M. Miller, J.M. Madron, J.C. Finn, and A.T. Valenski. 2013. Petersburg National Battlefield natural resource condition assessment: Virginia. Natural Resource Report NPS/PETE/NRR—2013/704. National Park Service, Fort Collins, Colorado.

Department of Geography and the Environment
University of Richmond
Richmond, VA 23173

August, 2013

U.S Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government. To receive this report in a format optimized for screen readers, please email irma@nps.gov.

This report has undergone three rounds of peer-review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Please cite this publication as:

Lookingbill, T.R., B.M. Miller, J.M. Madron, J.C. Finn, and A.T. Valenski. 2013. Petersburg National Battlefield natural resource condition assessment: Virginia. Natural Resource Report NPS/PETE/NRR—2013/704. National Park Service, Fort Collins, Colorado.

NPS 325/122163, August 2013

Contents

Contents

Contents

Figures

Contents

Contents

Tables

Contents

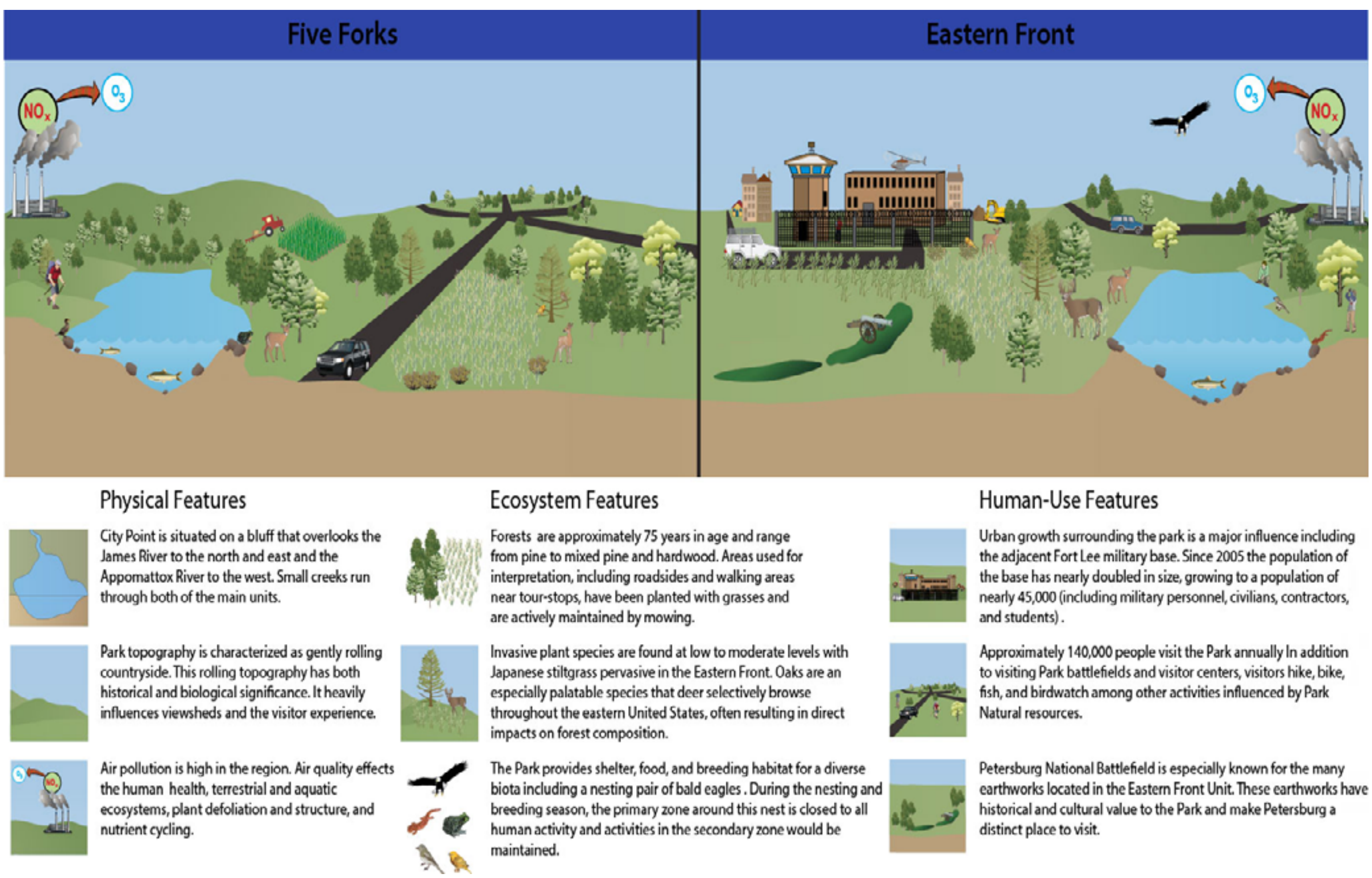
Appendices

Executive Summary

Natural Resource Condition Assessments (NRCAs) represent a relatively new approach to assessing and reporting on park resource conditions that is meant to complement traditional issue and threat-based resource assessments. The assessment reports on current conditions, trends, critical data gaps, and general level of confidence for a subset of park natural resource indicators. This report is designed to help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. It strives to deliver science-based information that is credible and has practical uses for a variety of park decision making, planning, and partnership activities.

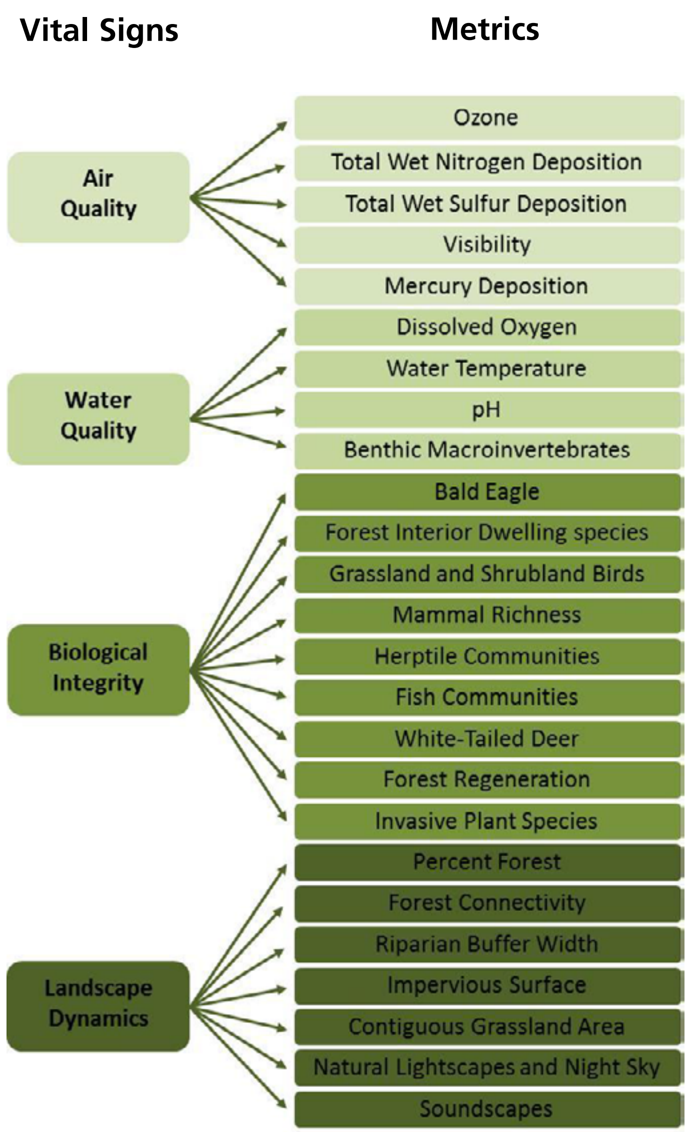
Petersburg National Battlefield (Petersburg NB) commemorates the site of the longest siege in the history of American warfare. This site of the last major confrontation of the Civil War was established as a park through congressional action on July 3, 1926. Today Petersburg NB is a 1,076 ha (2,659-acre) park located near the City of Petersburg. It consists of several distinct areas, including the Eastern Front, Five Forks Battlefield, Grant's Headquarters at City Point, and the Western Front including Poplar Grove National Cemetery. The park straddles the Fall Line that divides the Coastal Plain and Piedmont physiographic provinces of Virginia. Much of Petersburg NB is located within the Chesapeake Bay drainage basin. Threats to the natural resources of the park come from within the park (e.g., 140,000 visitors a year), outside and adjacent to park boundaries (e.g., contamination of streams flowing into the park), and the region at large (e.g., air pollution).

Framework and key characteristics of Petersburg National Battlefield in a conceptual diagram depicting the natural resource values and stressors at the Five Forks and Eastern Front units.



Data were compiled from all units of Petersburg NB to calculate overall park-level scores. Data sets were obtained from multiple divisions within the National Park Service (NPS) including the park, Air Resources Division, Exotic Plant Management Team, NPScape and the Inventory and Monitoring (I&M) Program; U.S. Environmental Protection Agency (EPA); and regional scientific experts who have worked in the park. When possible, condition scores also were calculated for the two main units: the Eastern Front and Five Forks units. These two units are significantly larger than other units of the park, and at this time, have significantly more information available on their natural resources.

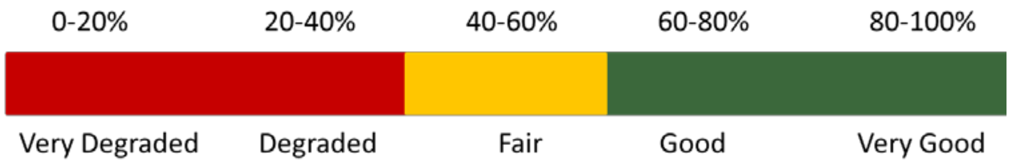
Strong collaboration with park natural resource staff was essential to the success of this assessment. Project collaboration and exchange of data occurred throughout the project by way of scoping meetings, site visits, and follow-up meetings with park staff from Petersburg NB, the Mid-Atlantic Network I&M Program, and the University of Richmond. Outcomes of these meetings helped identify natural resources to be included in the assessment, identify key metrics to assess the condition of these resources, and assign desired or target values for the metrics. These meetings also provided the context of current conditions and background information not necessarily available in published form.



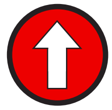
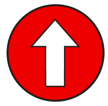
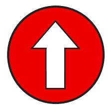
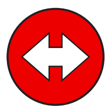
Vital signs categories and metrics used for assessment of Petersburg National Battlefield.

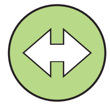
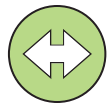
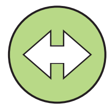
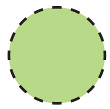
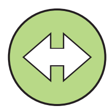
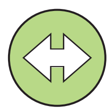
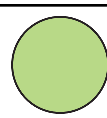
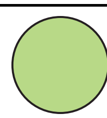
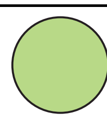
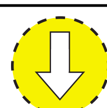
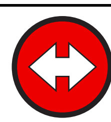
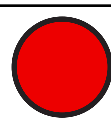
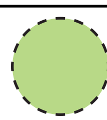
Efforts were made to integrate NPS I&M ecological monitoring metrics associated with the following 'vital signs' into the assessment: Air Quality, Water Quality, Biotic Integrity, and Landscape Dynamics. A total of 25 Vital Sign metrics were reviewed in this assessment. The approach for assessing resource condition within Petersburg NB (as separate units and the park as a whole) required establishment of a reference condition (i.e., threshold) for each metric. Thresholds ideally were ecologically based and derived from the scientific literature. However, when data were not available to support peer-reviewed ecological thresholds, regulatory and management-based thresholds were used.

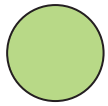
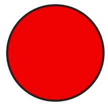
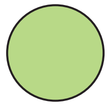
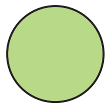
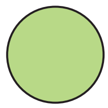
The attainment of threshold metrics were calculated based on the percentage of sites or samples that met or exceeded threshold values for each metric. A metric attainment score of 100% reflected that the metric at all sites and at all times met the threshold identified to maintain natural resources. Once attainment was calculated for each metric, an unweighted mean was calculated to determine the condition of each vital sign category for each major park unit and for the park as a whole. Attainment scores were categorized on a scale from very good to very degraded. Metrics were assigned a qualitative rating corresponding to the quantitative score: very degraded (0-20%), degraded (>20-40%), fair (>40-60%), good (>60-80%), and very good (>80-100%). Scores were color coded according to standard NPS NRCA symbology: red (Very Degraded and Degraded), yellow (Fair), and green (Good and Very Good).



The natural resources of Petersburg NB were assessed to be in "fair" condition, attaining 56% of desired threshold scores. Air quality degradation was identified as a resource of significant concern. Unfortunately, air quality degradation is a regional issue over which park management has limited control. However, the park can play a leading role in regional education of the causes and effects of air pollution. It is also important to note the improving trends in regional air quality (ozone, wet nitrogen deposition, wet sulfur deposition, and visibility). Future priorities include the implementation of a noise and light pollution monitoring protocol. Biological integrity was the next most degraded resource. White-tail deer overabundance in the Eastern Front unit is of special concern. Fish communities and invasive plants were also a concern for the Eastern Front unit. The lack of forest regeneration is a concern throughout the park. Additional data would be useful to further identify the potential scope of these problems and to help resolve biotic challenges in this urban environment. Petersburg NB has a dense network of sampling across multiple indicators; unfortunately, there is little co-location of sampling between indicators. Overlapping sample locations would be useful in future assessments to study the interactions between indicators. Water temperature, water chemistry, and riparian buffers are in relatively good condition, especially given the urban context of the park. A concern is the low summertime dissolved oxygen levels for small streams in the Five Forks unit of the park that dry out or become stagnant in summer months. The low scores for fish in the Eastern Front unit also raise some concern as it is considered a more integrative measures of overall water quality.

Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status/ Trend	Resource Condition	Threshold and Source	Attainment
Air Quality	Air Chemistry	Ozone		75.1 ppb	<60 ppb good condition, 60-75 ppb moderate, >75 ppb significant concern (NPS Air Resources Divisions standards).	0% Attainment
Air Quality	Air Chemistry	Wet Nitrogen Deposition		3.90 kg/ha/yr	<1 kg/ha/yr good condition, 1-3 kg/ha/yr moderate, >3 kg/ha/yr significant concern (NPS Air Resources Divisions standards).	0% Attainment
Air Quality	Air Chemistry	Wet Sulfur Deposition		4.20 kg/ha/yr	<1 kg/ha/yr good condition, 1-3 kg/ha/yr moderate, >3 kg/ha/yr significant concern (NPS Air Resources Divisions standards).	0% Attainment
Air Quality	Air Chemistry	Visibility		11.2 dv	<2 dv good condition, 2-8 dv moderate, >8 dv significant concern (NPS Air Resources Divisions standards).	0% Attainment
Air Quality	Air Chemistry	Mercury Deposition		11.3 ng/L	<2 ng/L in rainwater (U.S. EPA).	0% Attainment

Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status/ Trend	Resource Condition	Threshold and Source	Attainment
Water Quality	Water Chemistry	Dissolved Oxygen		119 out of 147 samples above threshold	>5mg/L (Virginia Department of Environmental Quality).	81% Attainment
Water Quality	Water Chemistry	Water Temperature		The highest recorded temperature 29.9 °C	<32˚ C (89.6˚ F) for non-tidal waters (Virginia Department of Environmental Quality).	100% Attainment
Water Quality	Water Chemistry	Water pH		122 out of 147 samples above threshold	pH range of 6.0-9.0 (Virginia Department of Environmental Quality).	83% Attainment
Water Quality	Benthic Macroinvertebrates	Benthic Index		2 out of 3 years above threshold	>16 on the Mid-Atlantic Network's CPMI scale (Voshell and Hiner 2012).	67% Attainment
Biological Integrity	Species of Special Concern	Bald Eagles		Nesting pair every year since December of 2003	Presence of breeding Bald Eagles.	100% Attainment
Biological Integrity	Avian Communities	Forest Interior Dwelling Species		18 sensitive FID species observed (96 of 99 expected total species observed)	Presence of ≥1 highly-area sensitive FIDS, or six ≥4 sensitive FIDS (Jones et al. 2000).	100% Attainment
Biological Integrity	Avian Communities	Grassland Bird Species		Five out of the seven functional groups observed	Percentages of the seven functional groups present (Peterjohn 2006).	71.5% Attainment
Biological Integrity	Mammal Communities	Species Richness		23 out of 38 expected species were observed	Percentage of expected species observed	61% Attainment
Biological Integrity	Herptile Communities	Species Richness		48 of 56 expected species were observed	Percentage of expected species observed	86% Attainment
Biological Integrity	Fish Communities	Fish Abundance		2 out of the 4 surveys had > 1.25 fish/m²	1.25 fish/m² good condition, 12.5-0.25 fish/m² moderate, <0.25 fish/m² significant concern (Southerland et al., 2007).	50% Attainment
Biological Integrity	Species of Special Concern	White-Tailed Deer Density		48.6 deer/km²	8.0 deer/km² (Knox 1997, Horsley et al., 2003).	0% Attainment
Biological Integrity	Forest Regeneration	Seedling Density		19 out of 52 plots had adequate regeneration	>3.5 seedlings/ m² (Comisky and Wakamiya 2011).	37% Attainment
Biological Integrity	Invasive Plant Species	Presence/Absence		46 out of 52 plots had invasive plant levels below threshold	Detected on less than 25% of the quadrats for a plot (Comisky and Wakamiya 2011).	88% Attainment

Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status/ Trend	Resource Condition	Threshold and Source	Attainment
Landscape Dynamics	Landcover	Percent Forest		77.3% forested	>59% good condition, 59-30% moderate, <30% significant concern (Turner et al. 2001).	100% Attainment
Landscape Dynamics	Forest Connectivity	Landscape Coincidence Probability (LCP)		Eastern Front unit LCP value of 0.73; Five Forks unit LCP value of 0.77; highly disconnected among park units	≥ 0.75 based on LCP value range from 0 to 1 (Saura and Pascual- Hortal 2007, Townsend et al. 2009).	0% Attainment
Landscape Dynamics	Riparian Area	Percent Buffer Forested		Riparian area 94% forested	70% Forest cover in 100-m riparian buffers (Sprague et al. 2006).	100% Attainment
Landscape Dynamics	Landcover	Percent Impervious Surface		Assessed at multiple scales. 4.5% impervious surface at small watershed local scale.	< 10% impervious cover (Arnold and Gibbons 1996).	100% Attainment
Landscape Dynamics	Grassland Area	Contiguous Grassland Patch Size		Three patches ≥ 10 ha in size; no patches ≥ 40 ha	At least one patch ≥ 40 ha optimal condition, ≥ 10 ha good condition, ≥ 5 ha fair condition (Watts 2000, Peterjohn 2006).	70% Attainment
Landscape Dynamics	Natural Lightscapes and Night Sky	V magnitudes	No Data	Currently there are no data concerning the night skies at Petersburg NB.	≥ 21.5 magnitudes arcsecond^2 (Skiff 2001).	No Attainment Score
Landscape Dynamics	Soundscapes	Sound Pressure	No Data	Currently there are no data concerning the soundscapes at Petersburg NB.	≤ 60 dB for more than 40% of the day (NPS 2011).	No Attainment Score

Acknowledgements

Claire Goeltz and Samantha Easby (University of Richmond) provided invaluable assistance with the formatting, layout, and copyediting of the report. Sarah Dawson, Matt Outland (James River High School), and Sarah Knight (Petersburg NB) assisted with photo acquisition and selection. TRL's Landscape Ecology class at the University of Richmond assisted with background research and initial scoping. Adam Baghetti (Petersburg NB) provided GIS data and support. Dana Bradshaw, Nathan Dammeyer, Chris Ludwig, Bill McShea, Joseph Mitchell, and Sara Wakamiya graciously shared data and expertise on park resources and stressors. Sheila Colwell, Jim Comiskey, Marian Norris, and Holly Salazar provided formal reviews of earlier drafts of the report. This report would not have been possible without the guidance, feedback, and support from Tim Blumenschine (Petersburg National Battlefield) and Peter Sharpe (National Park Service) throughout the entire process.

Photo Courtesy of Todd Lookingbill

Chapter 1: NRCA Background Information

1.1 NRCA BACKGROUND INFORMATION

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, i.e. "parks". The assessments also report on trends (as possible), critical data gaps, and general level of confidence for study findings. The resources and indicators emphasized in the project work depend on a park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators for that park, and availability of data and expertise to assess current conditions for the things identified on a list of potential study resources and indicators.

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement, not replace, traditional issue and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- are multi-disciplinary in scope; [1]
- employ hierarchical indicator frameworks;[2]
- identify or develop logical reference conditions/values to compare current condition data against; [3,4]
- emphasize spatial evaluation of conditions and GIS (map) products;[5]
- summarize key findings by park areas; [6] and
- follow national NRCA guidelines and standards for study design and reporting products.

Although current condition reporting relative to logical forms of reference conditions and values is the primary objective, NRCAs also report on trends for any study indicators where the underlying data and methods support it. Resource condition influences are also addressed. This can include past activities or conditions that provide a helpful context for understanding current park resource conditions. It also includes present-day condition influences (threats and stressors) that are best interpreted at park, watershed, or landscape scales, though NRCAs do not judge or report on condition status per se for land areas and natural resources beyond the park's boundaries. Intensive cause and effect analyses of threats and stressors or development of detailed treatment options is outside the project scope.

Credibility for study findings derives from the data, methods, and reference values used in the project work—are they appropriate for the stated purpose and adequately documented? For each study indicator where current condition or trend is reported it is important to identify critical data gaps and describe level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject matter experts at critical points during the project timeline is also important: 1) to assist selection of study indicators; 2) to recommend study data sets, methods, and reference conditions and values to use; and 3) to help provide a multi-disciplinary review of draft study findings and products.

NRCAs provide a useful complement to more rigorous NPS science support programs such as the NPS Inventory and

NRCAs strive to provide credible condition reporting for a subset of important park natural resources and indicators

Important NRCA success factors

Obtaining good input from park and other NPS subjective matter experts at critical points in the project timeline.

Using study frameworks that accommodate meaningful condition reporting at multiple levels (measure—> indicators —> broader resource topics and park areas).

Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings.

1. However, the breadth of natural resources and number/type of indicators evaluated will vary by park.
2. Frameworks help guide a multi-disciplinary selection of indicators and subsequent 'roll up' and reporting of data for measures ->conditions for indicators ->condition summaries by broader topics and park areas.
3. NRCAs must consider ecologically based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions.
4. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-on response (e.g., ecological thresholds or management 'triggers').
5. As possible and appropriate, NRCAs describe condition gradients or differences across the park for important natural resources and study indicators through a set of GIS coverage's and map products.
6. In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds and 2) for other park areas as requested.

Monitoring Program. For example, NRCAs can provide current condition estimates and help establish reference conditions or baseline values for some of a park's "vital signs" monitoring indicators. They can also bring in relevant non-NPS data to help evaluate current conditions for those same vital signs. In some cases, NPS inventory data sets are also incorporated into NRCA analyses and reporting products.

In-depth analysis of climate change effects on park natural resources is outside the project scope. However, existing condition analyses and data sets developed by a NRCA will be useful for subsequent park-level climate change studies and planning efforts. NRCAs do not establish management targets for study indicators. Decisions about management targets must be made through sanctioned park planning and management processes. NRCAs do provide science-based information that will help park managers with an ongoing, longer term effort to describe and quantify their park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning [7] and help parks report to government accountability measures. [8]

Due to their modest funding, relatively quick timeframe for completion and reliance on existing data and information, NRCAs are not intended to be exhaustive. Study methods typically involve an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in our present data and knowledge bases across these varied study components.

NRCAs can yield new insights about current park resource conditions but in many cases their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Additional NRCA Program information is posted at: *http://www.nature.nps.gov/water/nrca*

NRCA reporting products provide a credible snapshot in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations (near-term operational planning and management)
- Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values (long-term strategic planning)
- Communicate succint messages regarding current resource conditions to government program managers, to congress, and to the general public ("resource condition status" reporting)

7. NRCAs are an especially useful lead-in to working on a park Resource Stewardship Strategy (RSS) but study scope can be tailored to also work well as a post-RSS project.
8. While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of 'resource condition status' reporting as may be required by the NPS, the Department of the Interior, or the Office of Management.

2.1 INTRODUCTION

2.1.1 History and Enabling Legislation

Petersburg National Battlefield (Petersburg NB) commemorates the last major confrontation of the Civil War, leading to General Lee's surrender and the fall of the Confederacy. It is known as the site of the longest siege in the history of American warfare.

Petersburg NB is situated just south of the Appomattox River, near the Fall Line (Figure 2.1). Early European settlers referred to this area as "Apamatica Country." It was originally home to numerous Native American tribes, including the Eastern Siouan, Southern Iroquois, and the Appomattox, dating back over 10,000 years (Auwaerter 2009). Europeans arrived in the area in 1608, just one year after the establishment of Jamestown, though European settlement did not begin until the mid-18th century. The city of Petersburg was originally laid out in 1748 at the head of navigable waters on the Appomattox River. By 1791, the city had a population of over 3,000 and had established itself as the commercial center for the surrounding agricultural areas. The production of tobacco and secondary crops, such as wheat and corn, dominated the surrounding agricultural areas.

Though the area's agriculture grew in the late 18th and early 19th centuries, soil depletion and market competition from farms in the Midwestern United States ultimately resulted in declining productivity and massive farm value losses. In 1848 journalist Benson J. Lossing wrote of the area:

...the country is broken, and patches of sandy soil with pine forests, alternated with red clay, bearing oaks, chestnuts, and gum-trees. Worse roads I never expect to travel, for they would be impassable...The country is sparsely populated, and the plantations generally bore evidences of unskilled culture. Although most of the soil is fertile, and might be made

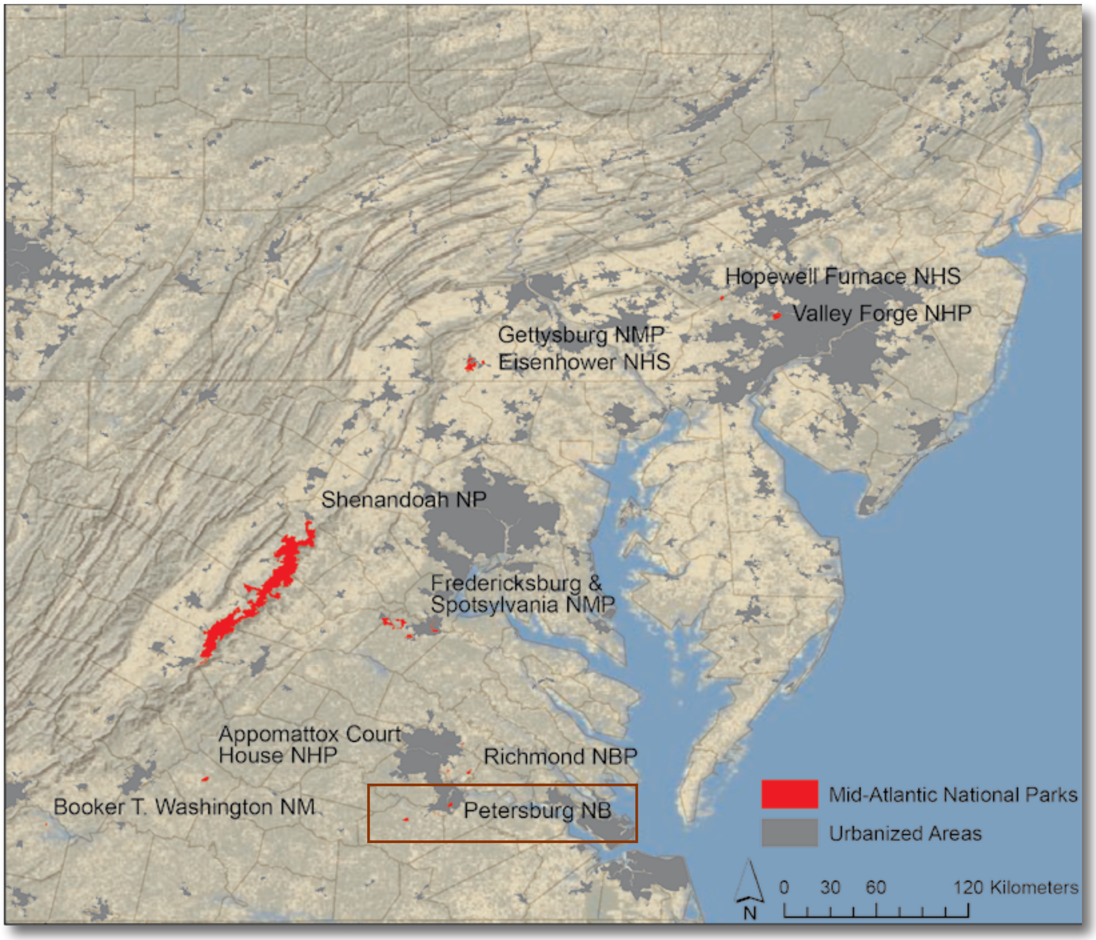


Figure 2.1 *Location of the parks included in the Mid-Atlantic Network (NPS 2010).*

Historical Railroad in City Point in Petersburg, Va.

Photo Courtesy of Petersburg National Battlefield, NPS

very productive, yet so wretchedly is it frequently managed that twenty bushels of wheat is considered a good yield for an acre…Tobacco is the staple product, yielding from five hundred to one thousand pounds per acre; but in the absence of manure, it destroys the vitality of the soil (cited in Auwaerter 2009).

Even with agricultural decline in the early and mid-19th century, Petersburg's antebellum years were prosperous (Auwaerter 2009). Following the completion of a railroad line linking Petersburg and North Carolina in 1833, links were quickly established to Richmond, Norfolk, and City Point. By the beginning of the Civil War, a network of five railroads and six major roads converged on Petersburg (Auwaerter 2009). The city was second in the state only to Richmond as a hub of industry and culture (Trowbridge 1866).

When the Civil War began, Petersburg was Virginia's second largest city and the seventh largest in the Confederacy. Petersburg would play a pivotal role in the final year of the War as the site of a ten-month siege that would be decisive in ending the War in 1865. In the spring of 1864, after several failed attempts to take the city of Richmond directly, General Ulysses S. Grant, commander of the Union Army, shifted his strategy to cutting off Richmond's supply routes. Standing just 40 km (25 mi) south of Richmond, Petersburg would be key with its many roads and rail lines. On June 9, 1864, the Union Army began building what would eventually become nearly 30 miles of trenches stretching from just east of Richmond to eastern and southern Petersburg. This would essentially surround the city and cut it off from the outside. After ten months of siege operations, the Confederate Army fled Petersburg to the West on April 2, 1865. President Lincoln arrived in Petersburg the next day via the military railroad as the Union Army occupied the city. One week later, on April 9, 1865, Confederate Army General Robert E. Lee surrendered to Grant at Appomattox Court House, about 150 km (95 mi) west of Petersburg, effectively ending the Civil War.

The siege of Petersburg is also noted to have had the largest concentration of African American troops on the side of the Confederacy during the Civil War. During the Petersburg campaign, General Lee was in need of labor and pushed for legislation in the Confederate Congress to grant the freedom of any slave who, with the permission of his master, enlisted in the Confederate Army. At the time, nearly 200,000 African

Americans served in the Union Army. Out of 16 total Medals of Honor awarded to African American troops throughout the entirety of the Civil War, 15 were awarded for service during the Petersburg Campaign.

Petersburg National Military Park was established through congressional action on July 3, 1926. A report from the US House of Representatives noted that:

Manassas was, in the largest sense, the beginning of the war; Gettysburg was the high tide of hostilities on both sides, but Petersburg was the final field where the fratricidal struggle was fought to a finish. There, if anywhere, should be a permanent memorial to a restored peace between the states. Such a memorial, in the form of a park, would commemorate the highest ideals and exploits of American valor and strategy, without the taint of bitterness or shame to either side… The committee believes that the marking and preservation of the battlefields of the siege of Petersburg, according to the plan recommended by the commission and as embodied in this bill, will serve very practical, educational, historical, military and patriotic purposes, and recommends the passage of the bill (NPS 2004).

In 1933, control of all national military parks (including Petersburg) was transferred from the War Department to the National Park Service, within the Department of the Interior. In the same year, control of the Poplar Grove National Cemetery was transferred to the National Park Service, and in 1935 its upkeep was assigned to the Petersburg National Military Park.

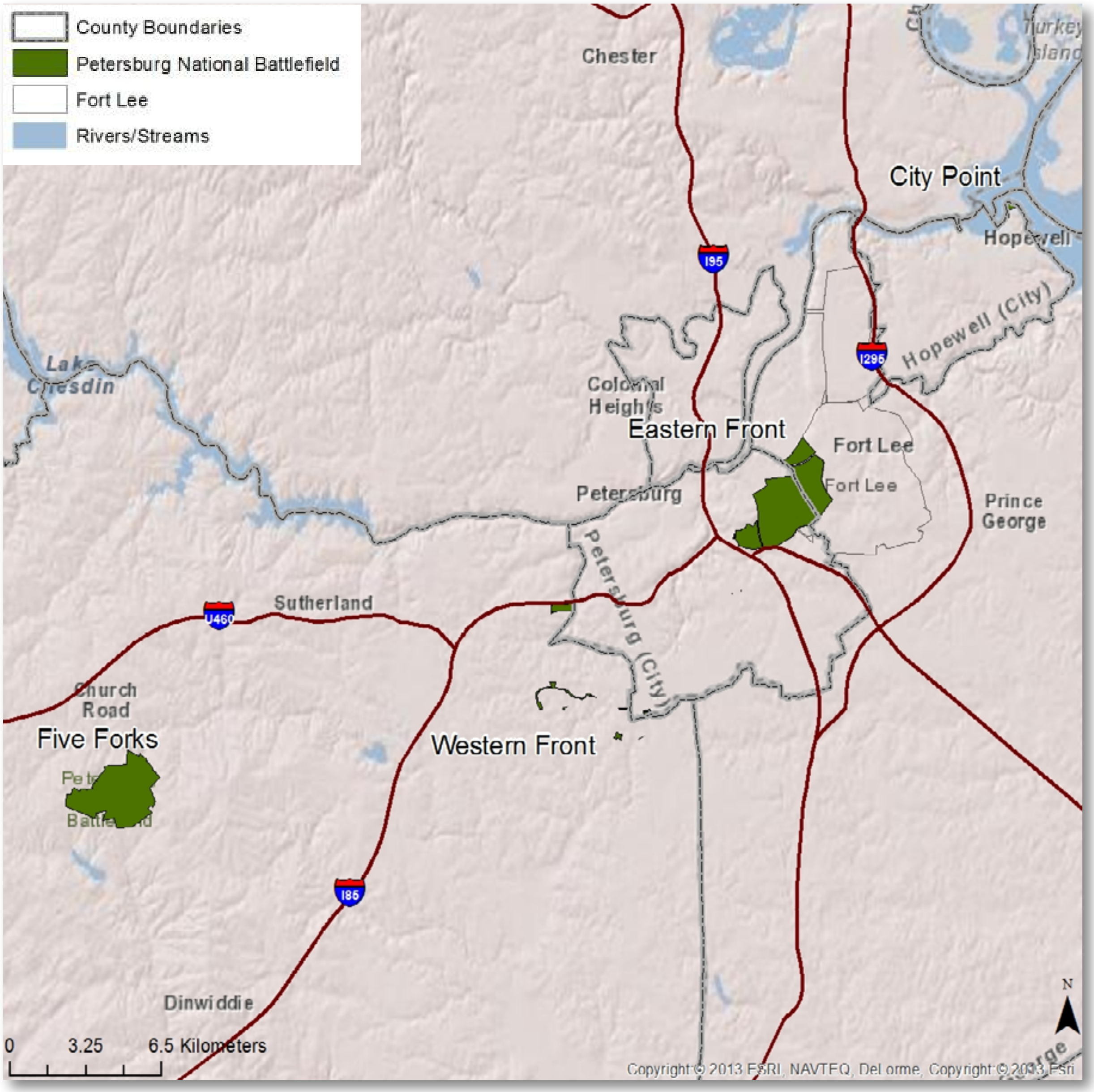
In 1962 the US Congress declared the Petersburg National Military Park a "National Battlefield," stating:

In order to commemorate the campaign and siege and defense of Petersburg, Virginia, in 1864 and 1865 and to preserve for historical purposes the breastworks, earthworks, walls, or other defenses or shelters used by the armies therein, the battlefields at Petersburg, in the State of Virginia, are declared a national battlefield whenever the title to the same shall have been acquired by the United States by donation and the usual jurisdiction over the lands and roads of the same shall have been granted to the United States by the State of Virginia—that is to say, one hundred and eighty-five acres or so much thereof as the Secretary of the Interior may deem necessary in and about the city of Petersburg, State of Virginia. (US HR 2006)

Photo Courtesy of Petersburg National Battlefield, NPS

Exit sign for Petersburg National Battlefield.

Figure 2.2 *Location of Petersburg National Battlefield park units (NPS LRD 2011)*.



Since then, land has periodically been added to Petersburg NB. Today the park consists of several distinct areas: the Eastern Front, Five Forks Battlefield, Grant's Headquarters at City Point, and the Western Front including Poplar Grove National Cemetery (Figure 2.2).

2.1.2 Geographical Setting

Today, Petersburg NB is a 1,076 ha (2,659-acre) park located near the City of Petersburg with units spread throughout Prince George County, Dinwiddie County, the City of Hopewell, and the City of Petersburg (Figure 2.2). To put this area in geographical context, the City of Petersburg is located on Interstate 95 approximately 40 km (25 mi) south of Richmond, 210 km (130 miles) south of Washington D.C., and 120 km (75 mi) west of the Chesapeake Bay. The park is located along the Fall Line that divides the Coastal Plain of Virginia and the rockier lands of the Piedmont (Horning 2004) (Figure 2.3). This region lies within a humid subtropical climate zone characterized by hot, humid summers and mild winters. July is the hottest month with an average high temperature of 91°F, while January is the coolest month with an average high of 50°F. The record high was 106°F in 1932, and the record low was -11°F in 1985. Precipitation is relatively constant year round, ranging from an average of 2.80 inches in June to 4.73 inches in September.

The Eastern Front unit is predominantly situated within the boundaries of the City of Petersburg and Prince George County, VA. Fort Lee, a U.S. military installation, is immediately to the east of the Eastern Front unit (Figure 2.2). This largest unit of Petersburg NB lies in the Coastal Plain region just east of the fall line (Figure 2.3). With an average elevation of approximately 30 meters (98 ft), the Eastern Front Unit comprises some 585 ha (1,445 ac). The land cover of the Eastern Front unit includes fields of fescue grasses and a mosaic of forested habitat types ranging from pine to hardwood forests (Pagels et al. 2005). Remnants of Civil War activity, as well as more recent training for World War I, are evident in many areas of the unit. Approximately 90% of the area is forested, containing an even mix of deciduous and coniferous species, and several creeks that meander through the park.

The 452-hectare (1117- acre) Five Forks Unit is located 32 km (20 mi) west of the Eastern Front unit in Dinwiddie County. Five Forks unit is located just west of the Fall Line in the eastern portion of the Piedmont region, and has an average elevation of approximately 70 meters (230 ft) (Figure 2.3). Similar to the Eastern Front unit, this unit is mostly wooded and is comprised of fescue grasses and pine and hardwood forests. Young coniferous stands dominate the landscape. Within this unit, there is a small lake, its associated wetlands, and a beaver pond. Unlike the Eastern Front unit, the Five Forks unit is surrounded by a rural setting that includes agricultural activity, forests of various ages, and scattered residences that are characteristic of present-day south-central Virginia (Pagels et al. 2005).

Grant's Headquarters at City Point is located within the City of Hopewell, approximately 16 km (10 mi) northeast of Petersburg. City Point is situated east of the Fall Line upon dramatic bluffs that overlook the James River to the north and east and the Appomattox River to the west. Appomattox Manor sits on a terrace atop the bluff above the confluence

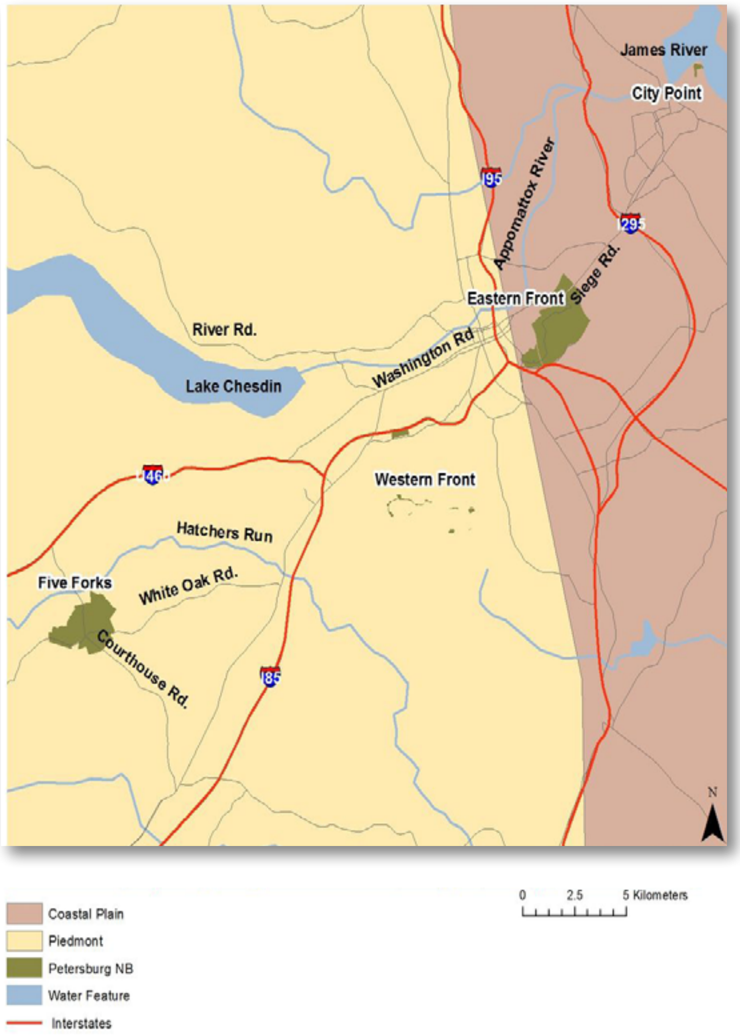


Figure 2.3 *Petersburg National Battlefield is located in both the Piedmont and Coastal Plain physiographic regions of Virginia (Keys et al. 1995; NPS LRD 2011).*

of the two rivers. Historic use of the waterfront, including significant Civil War activity, occurred principally on the low terrace running along the base of the bluffs along the James River (Horning 2004).

The Western Front unit includes the Poplar Grove National Cemetery and several other small sites located 10 km (6 mi) south of the Eastern Front unit in a transitional suburban/rural area surrounded by second growth woods, farm fields, and residential development within Dinwiddie County. Included as a part of Petersburg NB, Poplar Grove National Cemetery is the 11th stop on the park's Siege Line Tour, beginning at the park's main area on the east side of Petersburg and extending south and west along the line of Union fortifications that encircled the city (Auwaerter 2009).

2.1.3 Visitation Statistics

More than 175,000 people visit Petersburg NB annually (Stynes 2011). While entrance to the Five Forks unit, City Point unit, and the Poplar Grove National Cemetery is free, there is a $5/car (or $3 per individual entering on foot) fee for the Eastern Front unit.

While there are little recent data on the breakdown of park visitors, in the summer of 1990 the Cooperative Park Studies Unit at the University of Idaho conducted a Visitor Study (Madison 1991) at the park, prior to the acquisition of Five Forks. The study's 379 questionnaires yielded information on the demographics and preferences of summertime park visitors. Visitors traveled primarily as families (68 %), with the largest clusters being visitors 31 to 50 years old (41 %) and children 15 years old or younger (22 %). While visitors traveled from all 50 states to visit the park, 26 % reported that they resided in Virginia. Smaller percentages came from North Carolina (8 %), Florida (7 %), Pennsylvania (6 %), and Ohio (5 %). Seventy-seven percent of visitors were visiting the National Battlefield for the first time, and nearly 80 % stayed for four hours or less. Because this survey was conducted in the summer, however, it does not account for student groups. The park website provides curriculum material for all grade levels.The survey was also conducted before the acquisition of the Five Forks unit.

There are a wide variety of activities that patrons engage in while visiting Petersburg NB. According to the 1990 survey, 84 % of visitor groups visited the Battlefield Visitor Center and 76 % visited Fort Stedman and the Union Camp. Eighty-nine percent of visitors used the battlefield audio tour, 44 % attended an interpretive program, and 43 % attended an artillery demonstration. Other activities included photography, jogging/hiking, historical research, picnicking, bicycling, and fishing. Of the visitors surveyed, 19 % went to the City Point Unit. Of those, 96 % visited Appomattox Manor, 91 % visited Grant's cabin, and 65 % viewed the outside exhibits.

2.2 NATURAL RESOURCES

2.2.1 Watershed Context

Much of Petersburg NB is located within the Chesapeake Bay drainage basin (Prince George County lands), with portions of the park (Dinwiddie County lands) also draining into the Nottoway River, Chowan River, and ultimately the Albemarle Sound (Figure 2.4). The Appomattox River flows into the James River at City Point approximately 16 km (10 mi) northeast of the Eastern Front unit. The James River flows into the lower main stem of the Chesapeake Bay, the largest estuary in the United States. The Chesapeake Bay watershed stretches over 166,000 km^2 (64,000 mi^2) across six states, and is home to approximately 16.6 million people (CBP 2008). Prince George County, and the Cities of Hopewell and Petersburg are included in the Virginia Coastal Zone.

The James River provides the drainage for a 26,511 km^2 (10,236 mi^2) watershed, originating in the Appalachian Mountains in central-western Virginia and flowing across the Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain physiographic provinces until reaching the Chesapeake Bay near Norfolk, Virginia. The watershed accounts for approximately 25% of Virginia's total

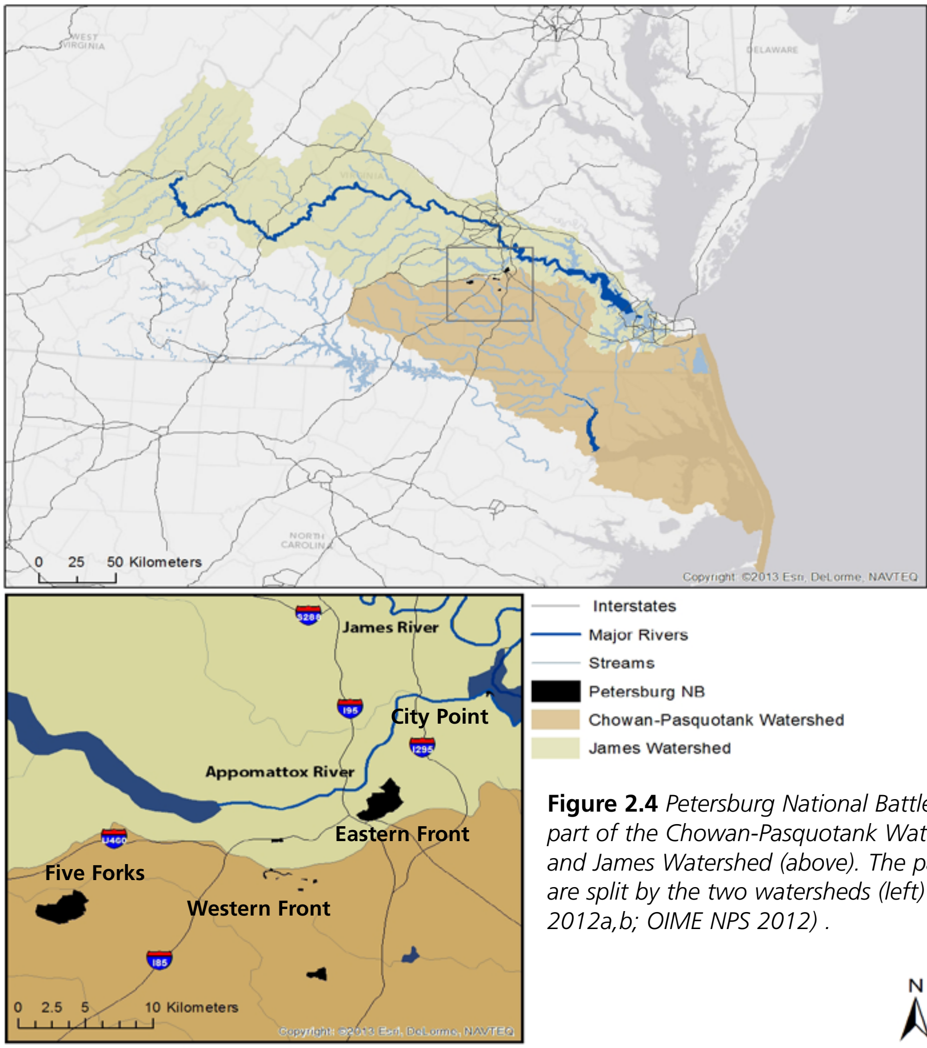


Figure 2.4 *Petersburg National Battlefield is part of the Chowan-Pasquotank Watershed and James Watershed (above). The park units are split by the two watersheds (left) (USGS 2012a,b; OIME NPS 2012) .*

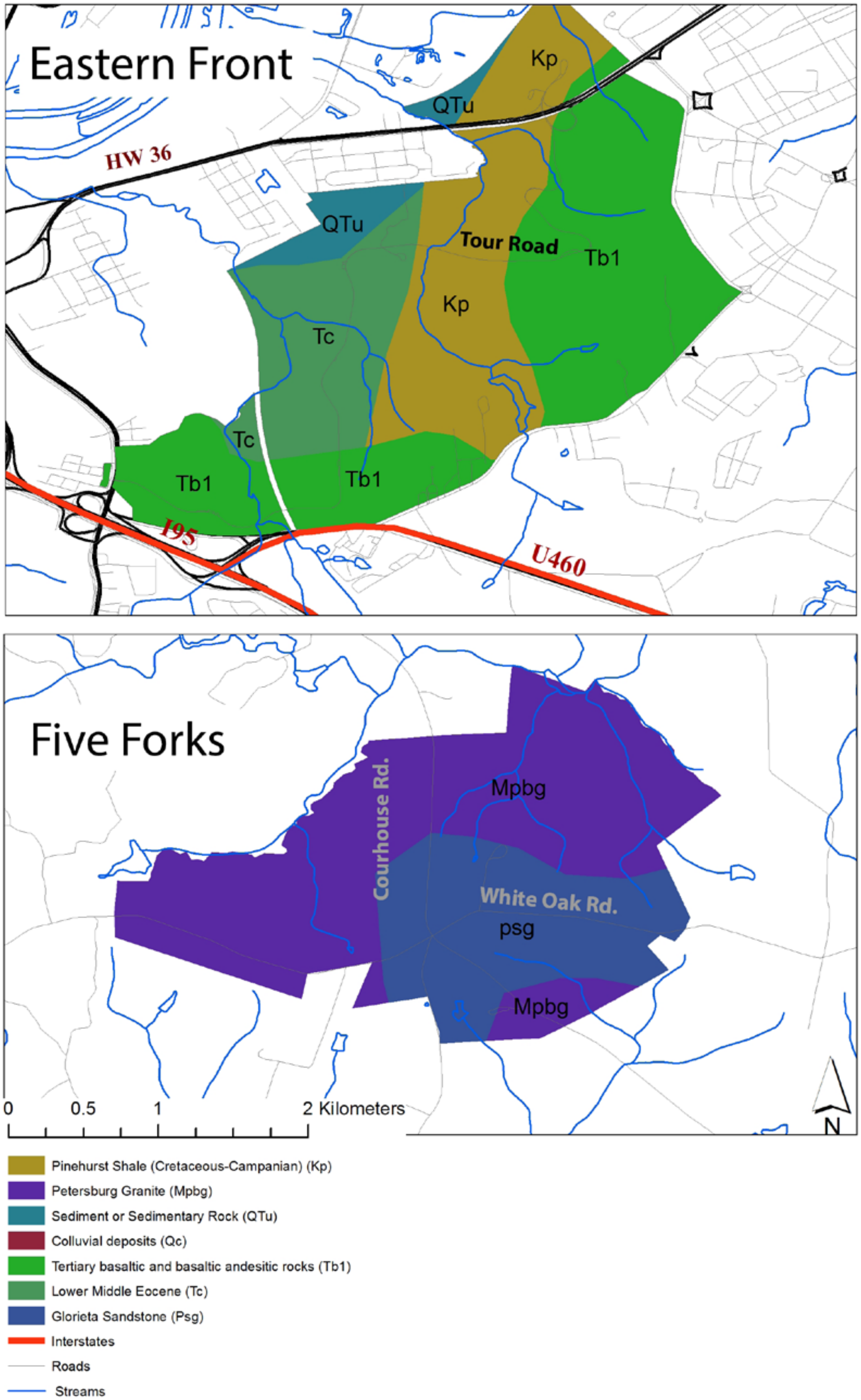
land area. The Appomattox River is a major tributary of the James River. Land use within the James River watershed is 71% forest, 7% agriculture, 5% urbanized, 4% open water, and 3% wetland (Commonwealth of Virginia 2005). Approximately 2.6 million people live in the watershed. This population is primarily concentrated in the eastern portion of the watershed, representing nearly one third of Virginia's total population. All waters found within the park are Class III nontidal waters of the Coastal Plain and Piedmont regions, and all thresholds used in this assessment are for Class III waters (State Water Control Board 2011).

2.2.2 General Resource Features

Geology

The geology of Petersburg NB is described in detail in the park's General Management Plan (NPS 2004). In the vicinity of Petersburg NB, Interstate 95 delineates the Fall Line, a geological transition between the Piedmont and Atlantic Coastal Plain physiographic regions (Figure 2.3). Portions of Petersburg NB in Dinwiddie County lie on the eastern edge of the Piedmont region; the remainder of the park lies in the Atlantic Coastal Plain region. Lands proposed for boundary expansion are included in either the Piedmont or Atlantic Coastal Plain physiographic regions. The Eastern Front unit is mainly comprised of tertiary basaltic and basaltic andesitic bedrock (Figure 2.5). In contrast, the Five Forks unit is largely comprised of Petersburg Granite (Figure 2.5).

Figure 2.5 *Surficial and bedrock geology for two largest units of Petersburg National Battlefield (NPS 2004).*



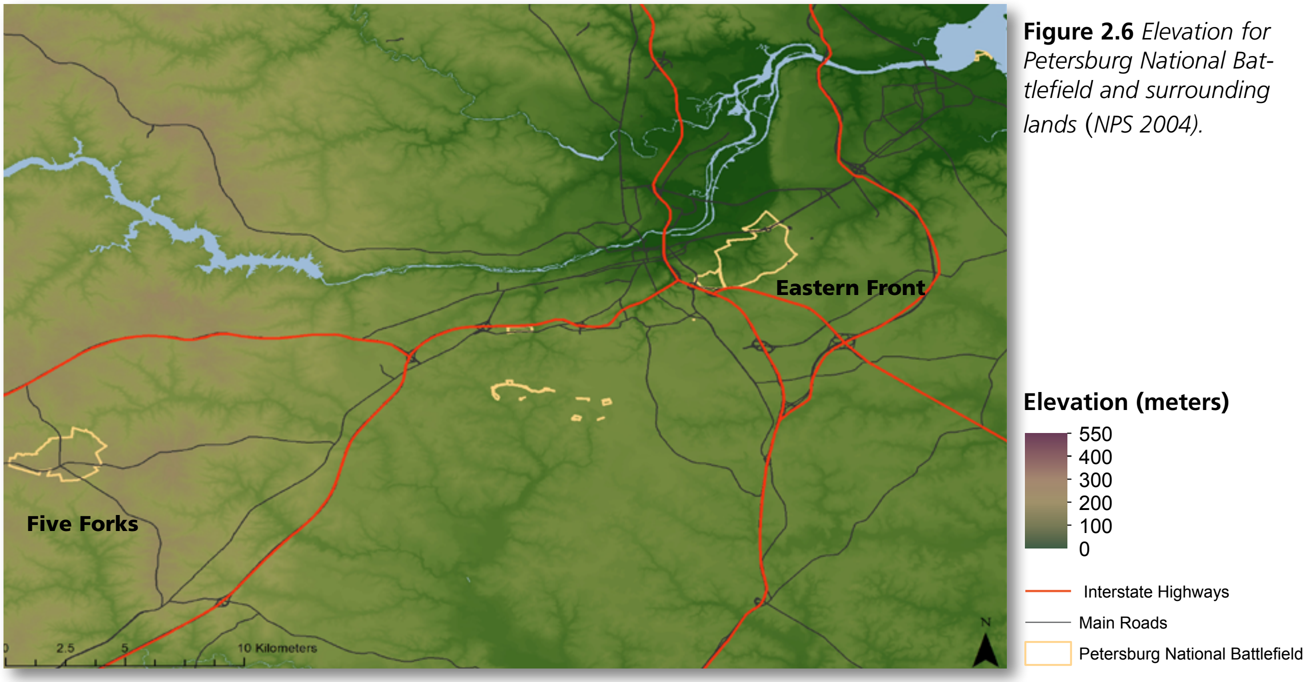


Figure 2.6 *Elevation for Petersburg National Battlefield and surrounding lands (NPS 2004).*

Topography

Generally, Petersburg NB topography is characterized as gently rolling countryside. The elevation ranges between 12.2 m (40 ft) along the flood plain of the Appomattox River to 51.2 m(168 ft) above sea level in the Eastern Front Unit and 92 m (302 ft) at the Five Forks unit (NPS 2004)(Figure 2.6).

Soils

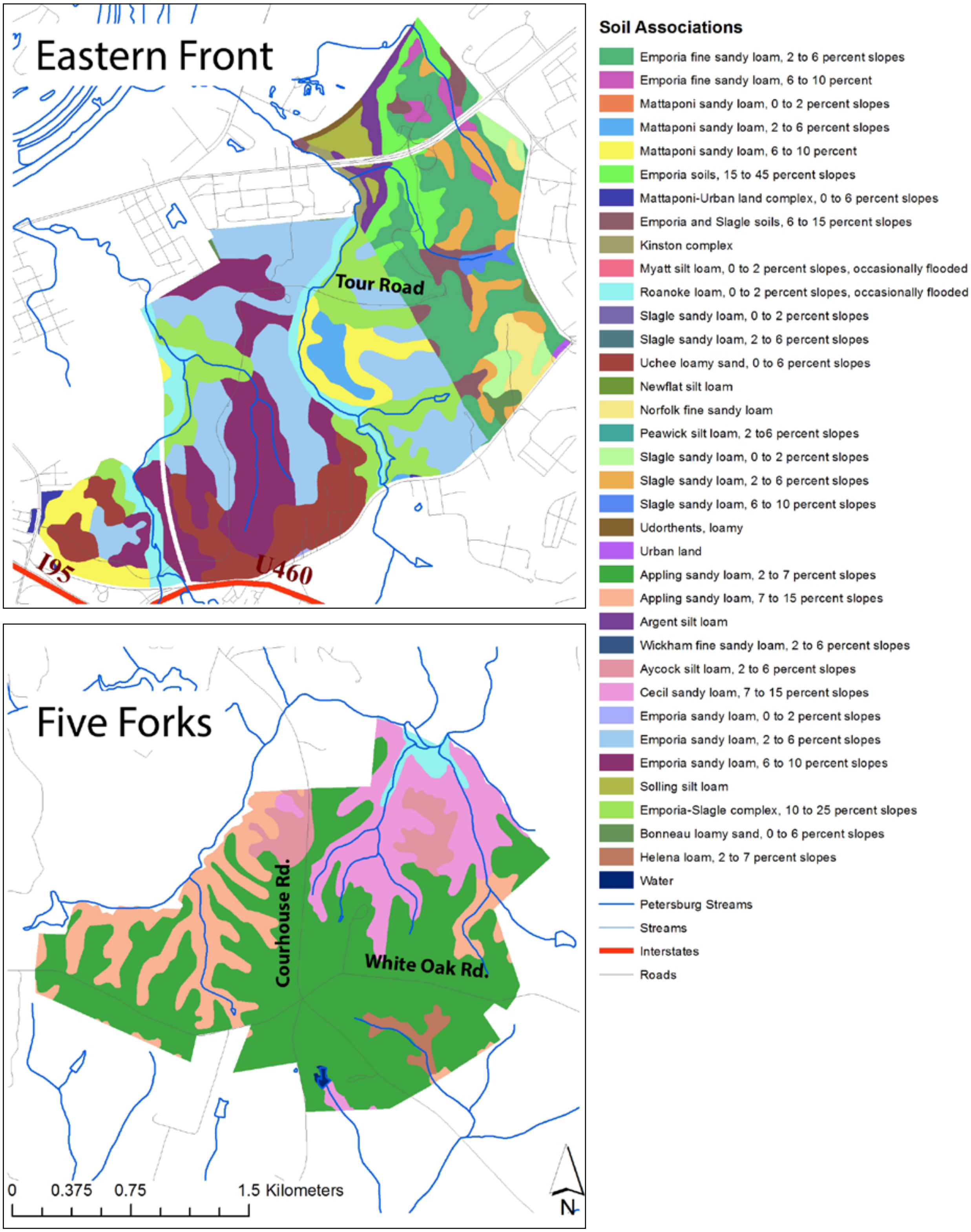
The Soil Survey Geographic (SSURGO) database includes two surveys that cover Petersburg NB; one for Dinwiddie County, Virginia, (Clausen et al. 1996; USDA NRCS 2004) and a second for Prince George County, Virginia (Jones et al. 1985; USDA NRCS 2006). Most of the 19 unique soils series are from the Ultisol soil order, with two series classed as Alfisols, and two small areas mapped as Entisols.

Upland soils are primarily Appling or Emporia series. Appling soils are very deep, well-drained soils developed from felsic crystalline rocks of the Piedmont region. They have a yellowish-brown sandy loam surface layer and a multicolored saprolite subsoil with a sandy clay loam texture. The Emporia series consists of very deep, well-drained soils of the upper Coastal Plain formed in loamy and clayey fluvial or marine sediments. Typically, these soils have a pale brown fine sandy loam surface layer and subsoil that is mottled yellowish-brown sandy clay loam and clay loam. Both soil series have a soil reaction that is very strongly to moderately acidic (pH values 4.5–5.5) and a low organic matter content.

Hydric soils include Argent silt loam, Kinston complex, Myatt silt loam, and Roanoke loam. The Argent series is found on poorly drained stream terraces that are saturated, but do not flood. The others are all found in areas that occasionally to frequently flood.

Soils series of well-drained to somewhat poorly drained stream terraces include Bolling silt loam, Newflat silt loam, Peawick silt loam, and Wickham fine sandy loam. Other soil series mapped in the park include Cecil, Mattaponi, Slagle, and Uchee, each mapped as 5–9% of the park. Bonneau, Helena, and Norfolk are mapped as less than one percent of the park (Figure 2.7).

Figure 2.7 *Soil associations for two largest units of Petersburg National Battlefield (Jones et al. 1985; Clausen et al. 1996; USDA NRCS 2004; USDA NRCS 2006).*



Surface waters

Five streams drain the Eastern Front unit and are all within the Chesapeake Bay drainage basin (Figure 2.8). Descriptions of the streams can be found in the park's General Management Plan (NPS 2004). Poor Creek and Harrison Creek are the largest. Taylor's Creek is a small tributary of Poor Creek, and Branch Creek is a tributary of Harrison Creek. Poor Creek flows through the park east of the Crater. Harrison Creek enters the park near the park headquarters and exits at the northern boundary. Branch Creek, a tributary to Harrison Creek, originates from storm drains in the Fort Lee Military Base. In high water seasons, surface water can appear in the adjacent trenches, but it quickly drains into the creek. The creeks and streams of the Five Forks unit are largely unnamed (Figure 2.8).

Many of the rivers and streams surrounding the park (including the James River, Appomattox River, and Hatchers Run) are considered impaired under section 303(d) of the Clean Water Act (Figure 2.9). Chemical water analyses are conducted monthly at nine sites in the park and at Hatcher's Run near the Five Forks unit. The analyses include the testing of pH, conductivity,

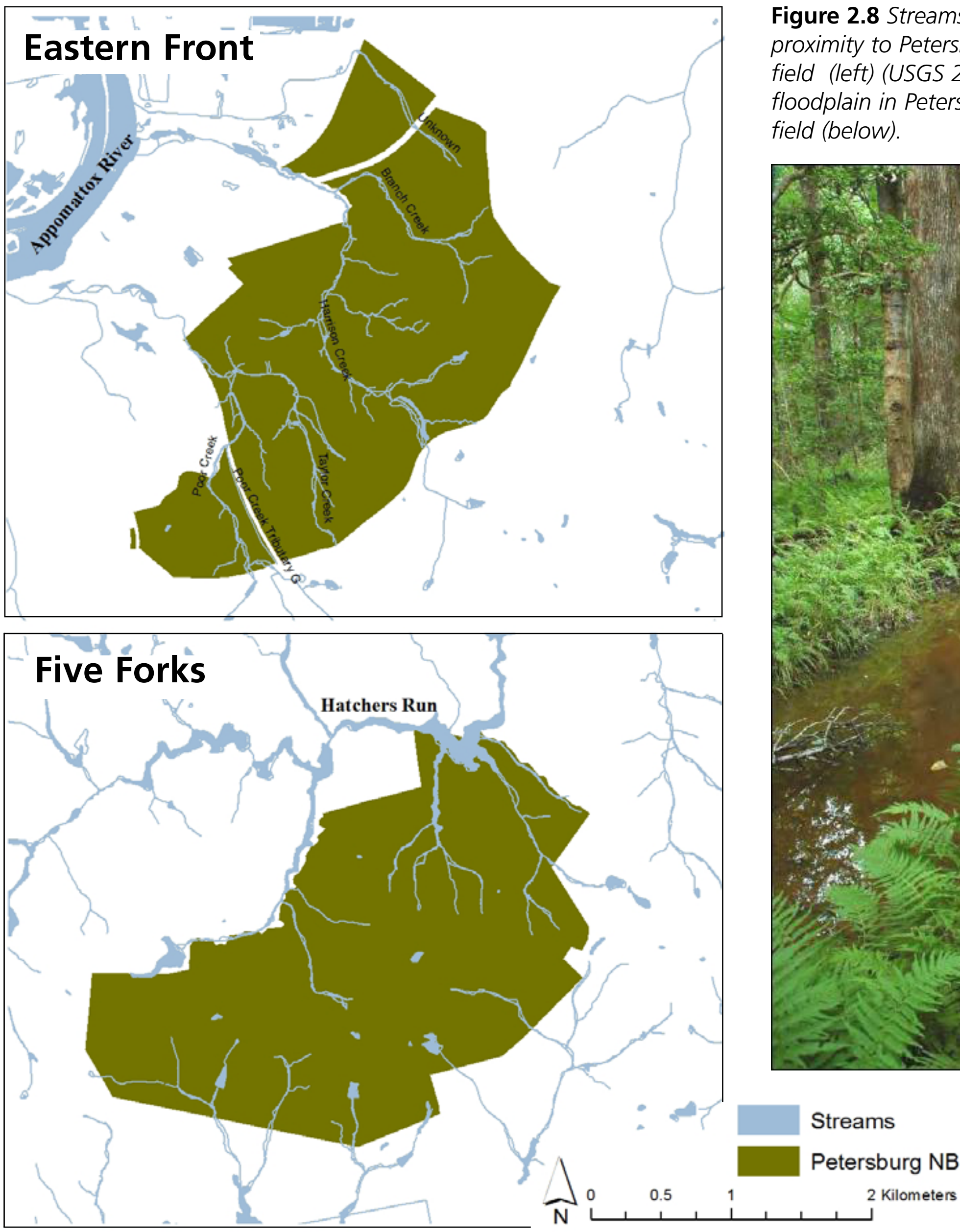
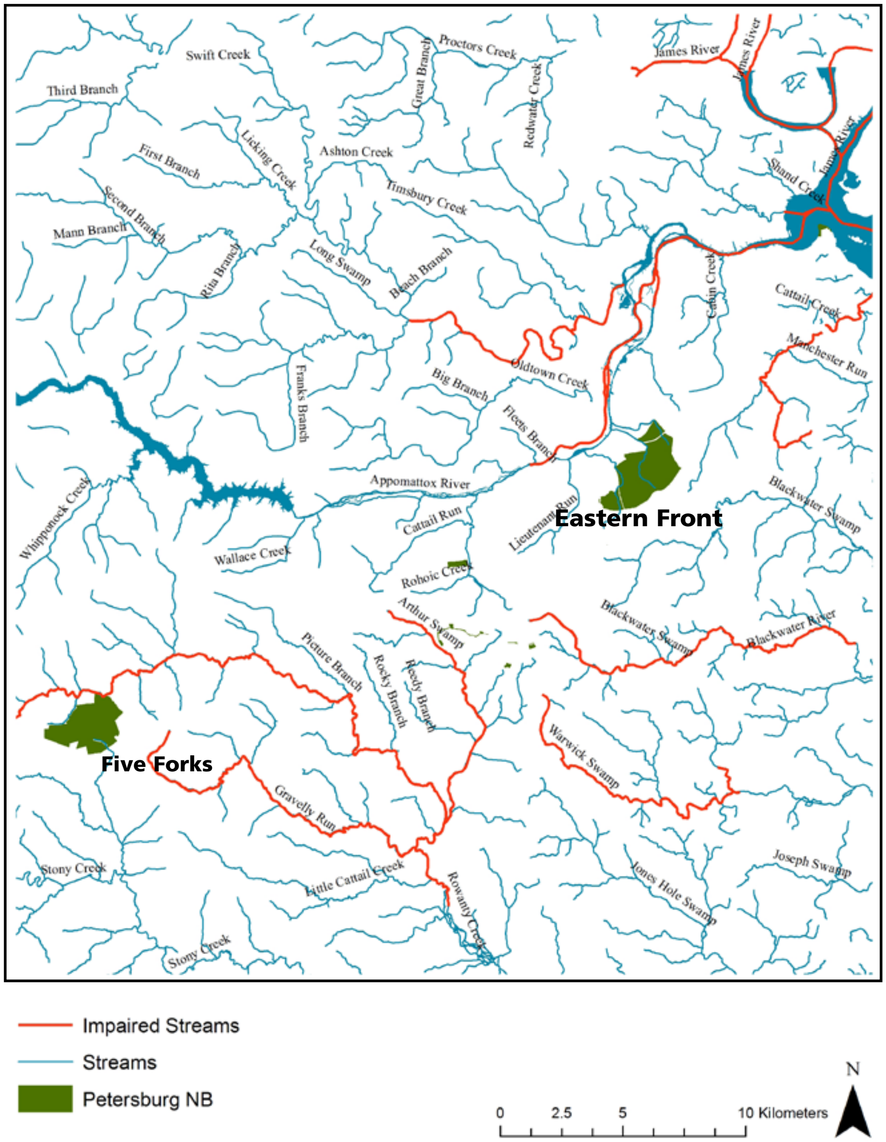


Figure 2.8 *Streams located in and in close proximity to Petersburg National Battlefield (left) (USGS 2012b). Small stream in floodplain in Petersburg National Battlefield (below).*

Photo Courtesy of Petersburg National Battlefield, NPS

Figure 2.9 *Impaired streams within and surrounding Petersburg National Battlefield (USGS BRD 2011).*



temperature, and dissolved oxygen. The park no longer tests for fecal coliform as the city has updated their equipment and procedures so that accidental pollutant discharge is no longer a concern.

Potentially serious threats to water resources include degradation of aquatic ecosystems and stream channelization (NPS 2004). High runoff due to upstream manipulation of the Poor Creek watershed has altered the natural configuration of the streambed. The lower part of Poor Creek has had extensive lateral and vertical channel erosion. It now runs through a steep-walled gully 4.5 m(15 ft) deep and 9 m (30 ft) wide. Similar, but less severe, channel erosion has occurred in Harrison Creek. While the Poor Creek channel has been scoured of most major sediment deposits, Harrison Creek has extensive sediment deposits and appears to be much more stable than Poor Creek.

Rare, Threatened, and Endangered Species

The Division of Natural Heritage of the Virginia Department of Conservation and Recreation did not identify any Virginia state listed rare plants occurring in Petersburg NB during their 1990-1991 assessment (Ludwig and Pague 1993). Historically, two listed plant species may have been present in the park; Swamp Pink (*Helonias bullata*) and Small Whorled Pogonia (*Isotria medeoloides*). Centuries ago, long-leaf pine communities were more dominant in the region and additional listed species associated with that habitat also may have been present (e.g., *Picoides borealis, Schwalbea americana,* etc.). Very little work has been done by the state to identify non-floral listed species (Christopher Ludwig personal communication).

In January 2004, a pair of Bald Eagles (*Haliaeetus leucocephalus*) was observed in the Colquitt Salient area of the Eastern Front unit working on a nest. The Bald Eagle is protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, however it should be noted that it was removed from the Federal List of Endangered and Threatened Species in 2007. As a precaution, a 750-foot buffer was established around the nest site and all access points into the area were clearly marked as closed. In February 2004, park resource management staff consulted with a U.S. Fish and Wildlife Service (USFWS) representative to determine Primary and Secondary Management Zones around the nest as outlined in the Bald Eagle Protection Guidelines of Virginia. NPS agreed that during the nesting and breeding season (December 15th – July 15th) the primary zone would be closed to all human activity. However, activities in the secondary zone would continue as usual (NPS 2004). For any new planned activities within either the primary or secondary zones, NPS will consult with USFWS.

The park followed the management guidelines during the 2004 nesting season, allowing its first known eaglets (3) to hatch. The park continues to close the area during the nesting and breeding seasons, and the breeding pair has reared 1-2 hatchlings every year since. From 2004-2012 the park protected the 750-foot buffer zone. The park is now in the process of refining the closure period to only coincide with the Bald Eagles' sensitive periods (i.e., when the female is preparing to lay eggs and just before the young fledge and would be susceptible to falling out).

Vegetation

Vegetation mapping completed by the Virginia Division of Natural Heritage in Petersburg NB yielded 20 map classes representing 12 United States National Vegetation Classification (USNVC) associations, five nonstandard, park-specific vegetation classes, and three Anderson Level II land-use categories (Figure 2.10). Classification was based on leaf-on aerial photography from 2001, leaf-off aerial photography from 2002, and field sampling from 2002-2006 with an assessment of overall accuracy of thematic classes of 85.7% (Patterson 2008).

Photo Courtesy of Petersburg National Battlefield, NPS

Bald Eagles, although removed from the Federal List of Endangered and Threatened Species, are still protected in Petersburg National Battlefield.

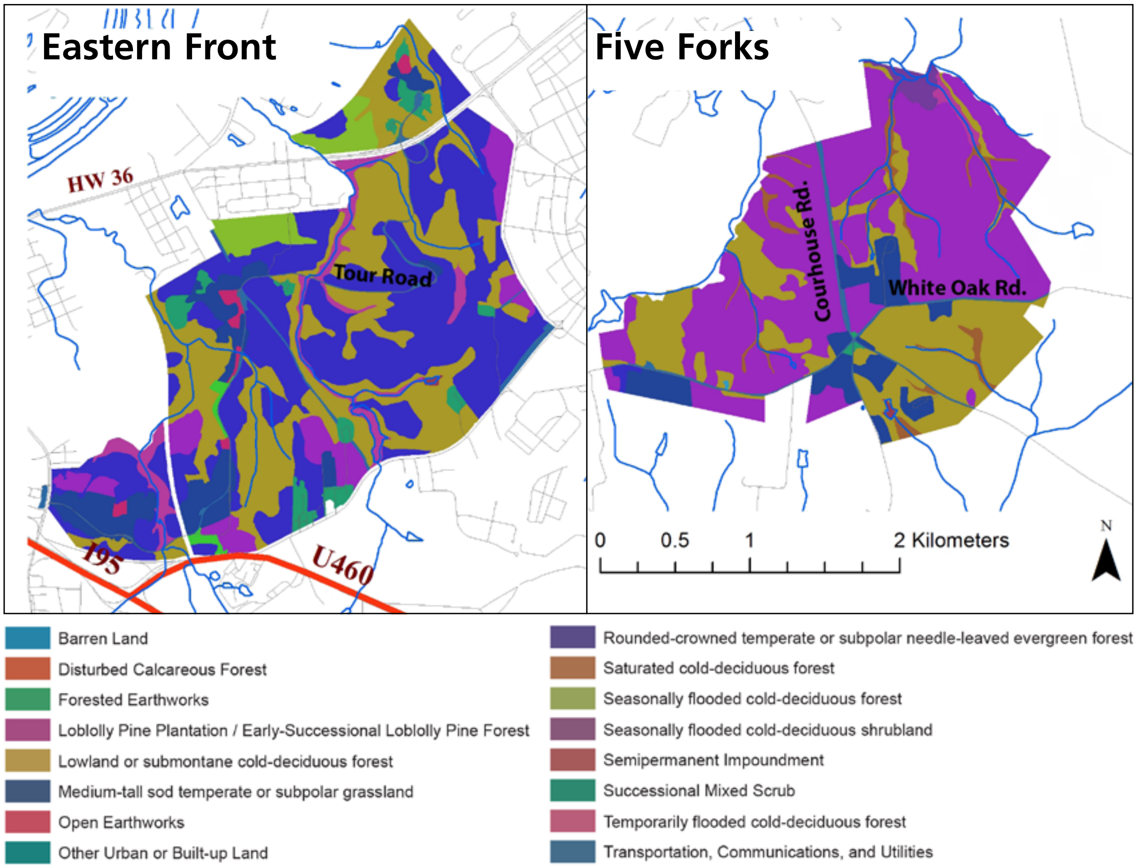


Figure 2.10 *Vegetation associations for the two main units of Petersburg National Battlefield (Patterson 2008).*

2.2.3 Resource Descriptions by Habitat

Petersburg NB consists of a variety of habitat types including varied categories of forest (e.g., upland coastal plain and piedmont forest, riverine forest) and grassland (e.g., old-field, managed field, earthworks). The extent of wetland habitat is extremely limited within the park boundaries. With the exception of the City Point unit, the park is more wooded than it was at the time of the War in 1865 or at the time when the park was established in 1933. Trees covered less than half of the park in 1865; approximately three-quarters of the land is now forested. Information on vegetation is contained in the 1995 Forest Management Plan for the Five Forks unit and the Eastern Front unit, which describes forest health, composition, distribution and hazard fuel loading. The data on forested conditions in 1865 is from the Historic Maps of the Petersburg Area (Michler Maps). Further data comes from a botanical inventory of the park conducted in the summer of 1990 (Rosenzweig and Porter 1991). Patterson's (2008) mapping of vegetation associations was the primary basis for the habitat classification used in this NRCA (see chapter 3).

Forests

Forested areas range from pine to mixed pine and hardwood in composition. Many forested areas are approximately 75 years old, and dominant species include Tulip Tree (*Liriodendron tulipfera*), Sweet Gum (*Liquidambar styraciflua*), White Oak (*Quercus alba*), Blackgum (*Nyssa sylvatica*) and Loblolly Pine (*Pinus taeda*). The Western Front unit is the most forested unit in the park. Dense natural reforestation and undergrowth cover most of the Long Flank, Fishhook and Fort Wheaton sites within the Western Front. Most of the woods are young second growth pine. Logging roads have been cleared through the wooded areas, and many of the cleared fields are the result of recent timbering. The unit contains a young, dense, evenly spaced loblolly pine plantation. A marshy habitat in the northeastern portion of the Five Forks unit, the result of an active beaver population, contains a diversity of wetland plants. Areas along the edge of the marsh consist of young trees, shrubs, and herbs. Dominant trees include: Sweetgum (*Liquidambar styraciflua*), Tulip Tree (*Liriodendron tulipfera)*, and Shining Sumac (*Rhus copalina*). Shrubs inventoried include the dominant species Blueberry (*Vaccinium corymbosum*), Tall Alder (*Alnus rugosa*), Button Bush (*Cephalanthus occidentalis*), and Lizard's Tail (*Saururus cernuus*).

The Eastern Front unit is dominated by second and third growth, mid-successional stage forests. Loblolly Pine plantations have been used as forested buffer in some areas along the park boundary. Four "pest species" have been identified: Poison Ivy (*Rhus radicans*), Poison Sumac (*Rhus toxicodendron*), Japanese Honeysuckle (*Lonicera japonica*), and Poison Oak (*Rhus vernix*). Poison Ivy and Japanese Honeysuckle dominate the vegetation in some areas. Grant's Headquarters at City Point contains wild growth riverbanks and some original tree plantings by the Eppes family over 300 years ago. The park also supports one specimen of Water Hickory (*Carya aquatic*), thus hosting the inland limit for the species (NPS 2004).

Park forests are exposed to multiple potential stressors. Southern Pine Bark Beetle has infested small portions of some of the pine stands, but the damage has been minimal. Forests have been disturbed periodically throughout the park, providing opportunities for the invasion of nonnative (exotic) plant species such as Tree-of-Heaven (*Ailanthus altissima*) and Japanese Honeysuckle (*Lonicera japonica*). Kudzu vine (*Pueraria lobata*), an extremely invasive plant, has been identified close to the park, but not yet within its boundaries. The Petersburg National Battlefield General Management Plan includes a strategic plan to actively manage invasive species (NPS 2004).

Grasslands

Areas used in interpretive programming, including roadsides and walking areas near tour-stops, have been planted with grasses and are actively maintained by mowing. Old-field and cut fields surround most of the tour route through the Eastern Front unit. Grant's Headquarters at City Point includes managed, park-like grounds. The Confederate Fort Gregg fields are maintained under an agricultural leasing program. Poplar Grove National Cemetery is maintained with turf and ornamental plantings. A historic vegetation study of the Five Forks unit ascertained that substantial change in the location and configuration of fields had occurred since the Civil War (NPS 2004). In 1865, 76 ha (188 acres) were managed as fields, while 40.5 ha (100 acres) were managed as fields in 1998. There is some overlap in the field configurations, but most of the current fields were forested during the war. The open acreage at the Five Forks unit is generally included in the agricultural leasing program as pasture or for field crops (NPS

Photo Courtesy of Petersburg National Battlefield, NPS

Coastal Plain-mixed oak heath forest in Petersburg National Battlefield

Forested Earthworks in Petersburg National Battlefield.

Photo Courtesy of Petersburg National Battlefield, NPS

2004).

In general, earthworks, forts and earthen remnants of the Petersburg campaign are maintained in tall grass in an attempt to deter trespassing on the fragile structures (NPS 2004). Dominant herbaceous vegetation in the area surrounding the earthworks including marsh habitats include: St. John's Wort (*Hypericum mutilum*), Arrow Arum (*Peltandra virginica)*, Marsh Fern (T*helypteris palustris*), Sweet Goldenrod (*Solidago odorata*), Broom Sedge (*Andropogon virginicus*), Water Lily (*Nymphea odorata*), Spatterdock (*Nuphar luteum*), Pickerelweed (*Pontederia cordata)*, Yellow-eyed Grass (*Xyris platylepis*), and Bladderwort (*Utricularia fibrosa*). Grassland disturbance is a concern for the park, as it can detract from the cultural landscape and facilitate the spread of invasive species.

At times, extreme weather conditions have resulted in damage to the park's earthen structures (NPS 2004). High winds and ice throughout the park have periodically uprooted isolated trees on earthworks or at the edge of the forests. Battery XIII, Forts Fisher and Conahey have been particularly affected. On the sides of large earthen forts where the slopes are steep, uprooting can occur more easily and the damage can be extensive because of the way the root mass extends into the earthwork. In 1983 a tornado ripped through Grant's Headquarters at City Point, destroying some of the trees. Some have been replaced by the NPS. The 1990 botanical inventory found that herbs, vines, and shrubs dominated the flora cover on the banks leading to the river (Rosensweig and Porter 1991). Dominant taxa included: Japanese Honeysuckle (*Lonicera japonica*), Vicia (*Vicia angustifolia*), Asiatic Dayflower (*Commelina communis*), Tree-of-Heaven (*Ailanthus altissima*), American Elm (*Ulmus americana)*, River Birch (*Betula nigra*), Hackberry shrub (*Celtis occidentalis*), and Paper Mulberry (*Broussonetia papyrifera*).

2.2.4 Resource Issues Overview

Threats to Petersburg NB come from within the park (Internal), outside and around park boundaries (Watershed), and the region at large (Regional). Stressors of special concern are described below for each of these three categories.

Internal park threats

Invasive species

Vegetation mapping in Petersburg NB yielded 19 nonnative species, 11 of which are considered invasive by the Virginia Department of Conservation and Recreation (VADCR 2003, Patterson 2008). According to Patterson (2008), forested wetlands had the highest cover by invasive, nonnative species. The most common and problematic species include Japanese Honeysuckle

(*Lonicera japonica*) and Nepalese Browntop (*Microstegium vimineum*). These species are particularly troublesome because of their shade tolerance and aggressive growth habits. These species can be opportunistic invaders of the older, more intact forest communities, getting a foothold where roads, trails, tip-up mounds, downfalls, and other gap-disturbances have affected mineral soil. Once established, colonies are able to more easily expand or spread into nearby microhabitats.

Japanese Honeysuckle is especially destructive to native vegetation because of its rapid, twining growth and dense, semi-evergreen foliage that shades out competitors. Its vines frequently strangle shrubs and tree saplings and over-grow more delicate herbs in a variety of settings. In the last two decades Nepalese Browntop has invaded moist, openly shaded habitats throughout the mid-Atlantic region. The species commonly forms monospecific carpets of tangled culms that tend to crowd out competing herbaceous species (Tu 2000). Studies have demonstrated that once established, Nepalese Browntop overruns native herbaceous competitors and leads to dramatic declines of herb richness within a few years (Barden 1987, Hunt and Zaremba 1992). Another recent study found that Nepalese Browntop responds to forest canopy disturbances with a sudden increase in biomass that impedes woody regeneration and lowers overall species diversity and stem densities (Oswalt et al. 2007).

Other highly invasive nonnative species noted in the park include Tree-of-Heaven (*Ailanthus altissima*), Chinese Lespedeza (*Lespedeza cuneata*), Chinese Privet (*Ligustrum sinense*), and Wartremoving Herb (*Murdannia keisak*). Canada Bluegrass (*Poa compressa*) and Oriental Ladysthumb (*Polygonum caespitosum var. longisetum*) are considered moderately invasive, while Orchardgrass (*Dactylis glomerata*) and Bigleaf Periwinkle (*Vinca major*) are considered occasionally invasive species by the Virginia Department of Conservation and Recreation (VADCR 2003). Coralberry (*Symphoricarpos orbiculatus*), while technically native to Virginia, is considered an invasive, naturalized species east of the mountains in Virginia based on historical botanical literature. It is a highly aggressive shrub that competes with native species in disturbed areas as well as in the understory of dry habitats such as rocky outcrops and rocky forests. The species has a preference for more basic soils and is thus not abundant in Petersburg NB. However, it has been observed in less abundance in the Five Forks unit in Loblolly Pine Plantation / Early- Successional Loblolly Pine Forest, Successional Tuliptree Forest, and Successional Sweetgum Forest (Patterson 2008).

Bank erosion at City Point

There is a negligible quantity of natural resources at City Point, which is a small, primarily landscaped unit. The bluff is 90 percent covered in invasive species, including Paper Mulberry (*Broussonetia papyrifera*), Tree-of-Heaven, and Privet, but cannot be treated properly because this would result in major erosion problems. Since the storm surge on the James River created by Hurricane Isabel in 2003 there have been bank stabilization projects along the James and Appomattox Rivers at City Point. The entire bank will eventually be reinforced with mitigation measures to protect the bluff.

Invasive Japanese Honeysuckle in Petersburg National Battlefield

Photo Courtesy of Petersburg National Battlefield, NPS

Deer overbrowse

Deer monitoring within Petersburg NB has been conducted for approximately the last ten years. In 2011, three deer exclosures were set up within the park, co-located at NPS Inventory and Monitoring vegetation plots. Populations may be labeled as overabundant if any of the following four requirements are fulfilled: (1) if the population threatens human life/livelihoods, (2) if the species is too numerous for its "own good", (3) if the population depresses the densities of other economically or aesthetically important species, and (4) if the population contributes to ecosystem dysfunction (Côté et al. 2004). Negative impacts of overabundant deer populations include reducing species richness and abundance of herbs and shrubs, reducing sensitive songbird populations, inhibiting the regeneration of understory trees, and changing competitive balances to favor nonnative plants (Decalesta 1997, McShea & Rappole 1997, Côté et al. 2004).

Deer commonly browse upon oaks (*sp. Quercus*) throughout the eastern United States, finding the species especially palatable. Deer feed selectively on the acorns and saplings of oak trees, often resulting in direct impacts on forest composition. In several case studies, deer browsing has interrupted oak stand development by preventing understory growth and directing succession away from oak forests towards sparser conditions (Healy 1997). Similarly, land managers in the eastern United States have observed a significant reduction in Eastern Hemlock (*Tsuga canadensis*) regeneration that may be partially attributable to overabundant deer herds. Deer browsing negatively affects the height and growth of Eastern Hemlock seedlings as well as increases the mortality of hemlock saplings (Alverson & Waller 1997, McShea & Rappole 1997).

Photo Courtesy of Petersburg National Battlefield, NPS

Photo Courtesy of Petersburg National Battlefield, NPS

(top) Soil erosion on the bluff at city point. (right) Deer browsing during winter in Petersburg National Battlefield.

Watershed Threats

Urban growth and development

Petersburg National Battlefield is embedded within a largely forested landscape (Figure 2.11). Urban growth surrounding the park is a major influence and the source of significant development-related stressors. Though the populations of the Cities of Petersburg and Hopewell are actually declining, the suburban population has been on the rise for the last 20 years, driving significant population growth in both Prince George and Dinwiddie Counties (NPS 2004) (Figure 2.12). The 2010 US Census showed that Prince George County doubled the 2000 population growth estimate from the Virginia Employment Commission, growing by eight percent to a total of 35,725. Dinwiddie County also over-performed the Virginia Employment

Commission's 2000 projection, growing 14 percent to 28,001 (NPS 2004).

Population-related stressors include a waste-water pumping station immediately adjacent to the park which created major problems with fecal contamination in the park until the facilities were upgraded. A nearby motor pool maintenance yard historically drained into the park before a $3 million oil-water separation system was installed. Increasing impervious surfaces, including the expansion from two to four lanes of roads surrounding the park, has led to additional isolation of parks as these roads are more difficult for animals to cross. A Seven-Eleven store at the park exit has been a source of litter within the park. Furthermore, in the winter months the neighboring Lowes store is visible despite a buffer of trees that the developer planted in the area.

The Eastern Front unit shares a 2.5 km (1.5 mi) border with the Fort Lee United States Army Base (Figure 2.2). Since 2005 the population of Fort Lee has grown to nearly 45,000, almost doubling in size due to the Base Realignment and Closure Act (BRAC) (Slayton 2011). A 15-story, 1,500-room hotel on the base required extensive study to determine that the structure's height would not diminish the quality of the park's viewshed. Additionally, a post 9/11 fence between the park and the base potentially disrupts the movement of wildlife and should be considered for further study.

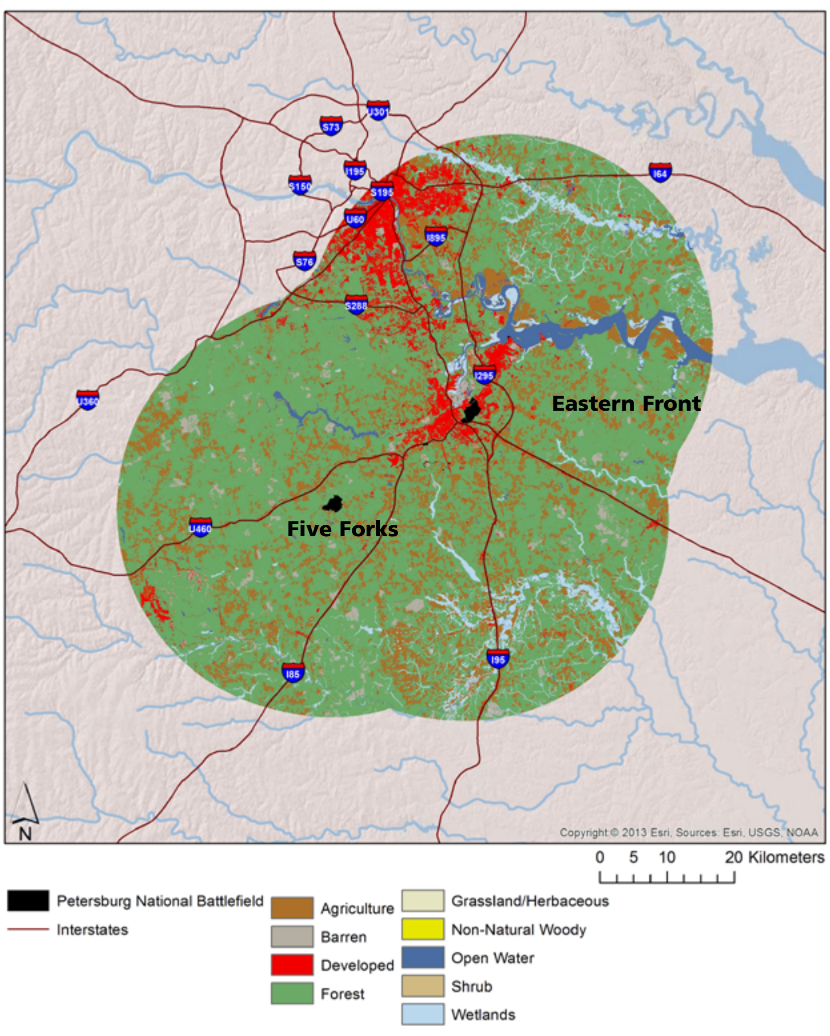


Figure 2.11 *Land cover data from NLCD 1992, showing a 30 km (19 mi) buffer around Petersburg National Battlefield. Adapted from NPScape products (Budde et al. 2009).*

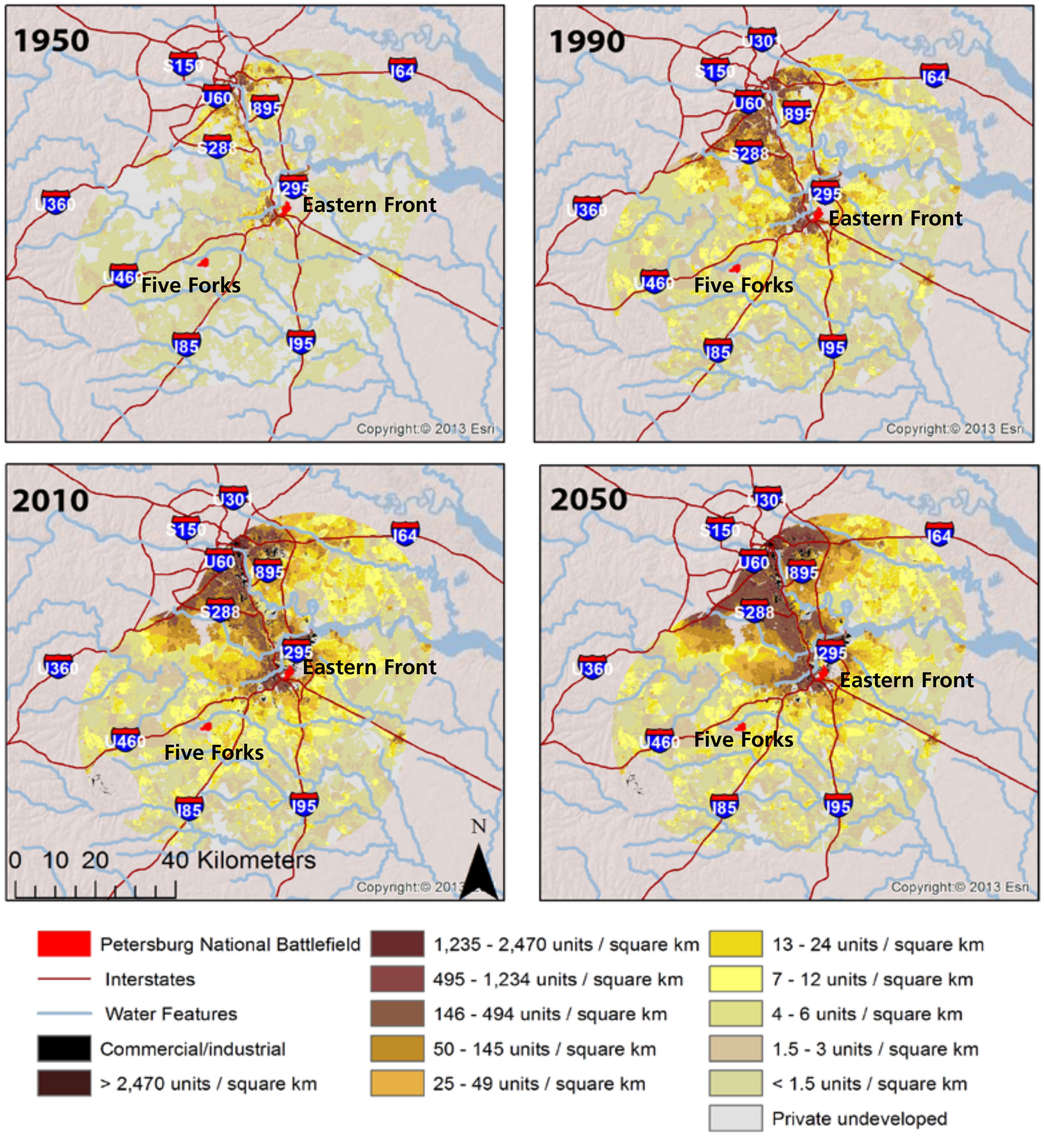


Figure 2.12 *Housing density from 1950 and 1990 and projections to 2010 and 2050 showing a 30 km (19 mi) buffer around Petersburg National Battlefield. Adapted from NPScape products (Budde et al. 2009).*

Regional threats

Regional threats to eastern Virginia that influence Petersburg NB's natural resources include poor air quality, changes in climate, and increasing light and sound pollution.

Degraded air quality

The East Coast has some of the worst air pollution in the U.S., with poor visibility, elevated ozone concentrations, and elevated rates of nitrogen and sulfur deposition (Driscoll et al. 2001, NPS ARD 2010). Air quality affects the health of humans, and terrestrial and aquatic ecosystems. It is largely influenced by fossil fuel combustion (e.g., cars or coal power generation), as well as other factors such as smelters and forest fires. Elevated ozone concentrations are known to cause premature defoliation of plants (Kline et al. 2008). Nitrogen and sulfur deposition can acidify and fertilize waters and soils, which affects nutrient cycling, vegetation structure, stream biodiversity and surface water eutrophication (Sullivan et al. 2011). Air pollutants can be transported long distances (e.g., sulfate can be transported more than 500 km [300 mi]) making management of these threats difficult at the local scale.

Climate, sea level rise, and increased storm activity

Sea level rise and an increased frequency of hurricanes and other large storms associated with climate change have the potential to damage park structures and natural resources such as park wetlands and tidal freshwater swamps (Karl et al. 2009). Grant's headquarters at City Point is especially vulernable due to its close proximity to the James and Appomattox Rivers. Sea level rise results in greater storm surge heights leading to shoreline erosion and loss of habitat, infrastructure, and archaeological and cultural sites. Combined with increased erosion, elevated sea levels can lead to greater saltwater intrusion that would affect groundwater salinity (Werner and Simmons 2009). This would affect vegetation and organisms that depend on low salinity for habitat or reproduction. Furthermore, increased storm activity can directly alter habitat structure and the succession of plant communities.

Light and sound pollution

The lower 48 states of the U.S. have some of the highest levels of artificial lighting in the world. The lack of dark night skies has ecological impacts on wildlife habitat quality, species interactions, and migration patterns (Rich and Longcore 2006). Park soundscapes have also been highly degraded throughout the U.S. due to development outside park boundaries (Miller 2008). Properly functioning soundscapes are important for intraspecies communication, territory establishment, courting and mating, nurturing and protecting young, predation and predator avoidance, and effective use of habitat. Both light and noise pollution can also distract visitors from their appreciation of the park's natural resources and the purpose of its cultural areas—the tranquility of historic settings and the solemnity of memorials, battlefields, prehistoric ruins, and sacred sites.

2.3 RESOURCE STEWARDSHIP

2.3.1 Management Directives and Planning Guidance

"The mission of Petersburg National Battlefield is to preserve the nationally significant resources associated with the campaign, siege and defense of Petersburg and Poplar Grove National Cemetery, and to provide an understanding of the events and their causes, impacts and legacy to individuals, the community and the nation in the full context of American history." (NPS 2004)

Fundamental resources

Fundamental resources and values are the features, systems, processes, experiences, scenes, sounds, or other resources that collectively capture the essence of the park and warrant primary consideration by managers because they are critical to achieving the park's purpose (Carruthers et al. 2012). The National Park Service is steward to many of America's most important natural and cultural resources and is charged with their preservation for the enjoyment of present and future generations.

Petersburg NB, like many other units in the National Park System, has highly valued cultural resources - i.e., the material evidence of past human activities. These resources are finite and nonrenewable and begin to deteriorate almost from the moment

Photo Courtesy of Petersburg National Battlefield, NPS

Taylor house during winter at Petersburg National Battlefield.

Many tourists use Petersburg National Battlefield for recreational bike riding routes

Photo Courtesy of Petersburg National Battlefield, NPS

of their creation. Conforming to the spirit of the NPS Organic Act of 1916 and various historic preservation laws, park management activities must reflect awareness of the irreplaceable nature of these material resources. Under the guidance of the NPS Natural Inventory and Monitoring Program, the park also has begun a major undertaking to develop baseline data for fish, reptiles and amphibians, birds, mammals and vascular plants. Park cultural and natural resource management involves research, evaluation, documentation, registration of park resources, and setting priorities that ensure these resources are preserved, protected, and interpreted to the public.

The Petersburg National Battlefield General Management Plan (NPS 2004) describes the park's vision for preserving nationally significant battlefields, expanding stories associated with the Petersburg Campaign and providing services and facilities that enhance the visitor experience. To meet these goals, four alternative management options are described. Each alternative provides a different approach for protecting and preserving resources, providing a high quality visitor experience and facilities, and creating partnerships. The alternatives are organized by mission goals, management zones, and management prescriptions.

Alternative A: Continuation of Current Management

Alternative A, the no action alternative, identifies the current management direction and provides a baseline with which to compare the other alternatives, as required by the National Environmental Policy Act. It retains the management guidance and direction of the 1965 Master Plan, including its identification of significant resources, its boundaries as modified by legislation, and its policies for battlefields and historic properties. The visitor experience begins with an overview of the events at the Eastern Front unit and continues with a tour of the NPS sites: major fortifications, portions of four battlefields and the Appomattox Manor. This alternative focuses on the existing park resources and relies entirely on NPS to conserve resources, interpret the story and develop and manage the facilities. Partnerships continue to be developed with individuals, organizations or agencies to conserve Civil War resources outside the park.

Alternative B: Saving the Battlefields

Under Alternative B, the park places the highest value for staffing and financial resources on battlefield preservation both inside and outside current park boundaries. A boundary expansion of 7,238 acres is proposed (Figure 2.13). The majority of the park's activities are directed towards protecting battlefield lands through easements, partnership efforts, landowner outreach and education efforts and direct purchase. The historical and contextual importance of Petersburg NB, the surrounding battlefield lands, and the need to protect the "blood-soaked ground" for future generations is emphasized and expanded. Visitor services currently underway remain as is, with the addition of another program component regarding the importance of the park's preservation efforts and strategies. Educational outreach targets both students and adults for innovative learning. Visitors continue to use the Eastern Front Visitor Center as the main point of entry and orientation. Since the highest concentration of important battlefields is located here, visitor contact and resources can be maximized. Appomattox Manor provides limited visitor services. The visitor contact station at Five Forks Battlefield is removed and relocated. Partnerships that promote battlefield preservation receive the most consideration in terms of outreach and staff efforts. Technical assistance to surrounding localities and local landowners are an integral part of the park's advocacy role in achieving resource protection.

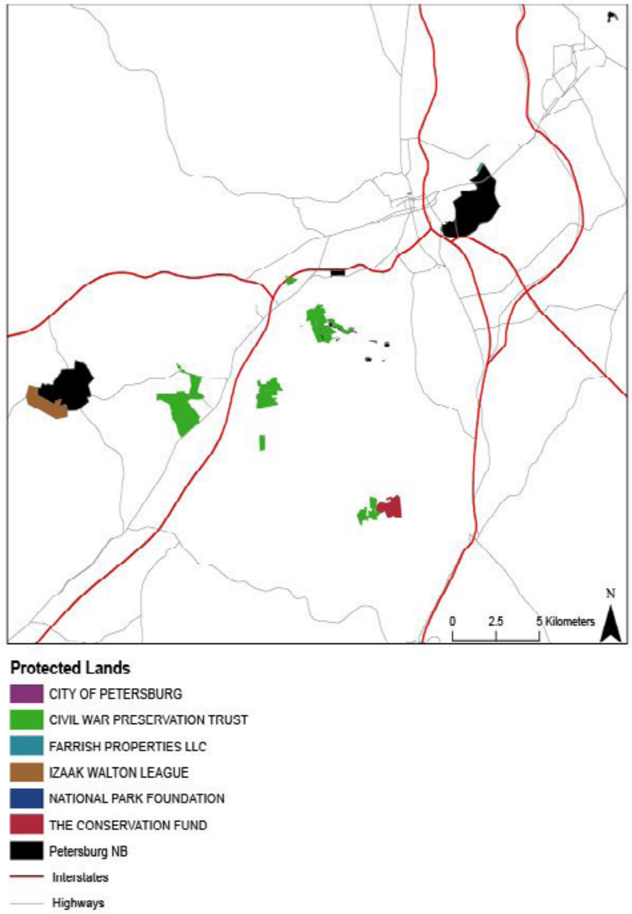


Figure 2.13 *Proposed boundary expansion in Petersburg National Battlefield.*

Alternative C: Telling the Stories

Alternative C focuses the park's priorities on creating dynamic interpretation with resources geared towards interactive and animated programs using modern technology where appropriate, the latest interpretive tools, and staff. At each unit, a full and comprehensive interpretive program is available, meaning that each unit's story is explained within the context of the overall campaign. There is a limited boundary expansion of 2,030 acres for protecting existing resources and providing better access for interpretation. A more complete understanding of the Civil War is emphasized, including causes and experiences during the War, reconciliation after the War, and the relevance of the War to people today. The existing visitor center is upgraded to provide for more interpretive media and exhibits. Visitors begin by being oriented to the Petersburg Campaign at any of the park units. At each unit, a full and comprehensive interpretive program is available. New programs and expanded facilities are developed at Grant's Headquarters at City Point, the Home Front in Old Town Petersburg, Poplar Grove National Cemetery and Five Forks Battlefield. Partnerships with Civil War organizations and sites are the mechanism by which nationally significant battlefields outside the park's boundary are preserved. Park staff provides technical assistance and increases its advocacy role in the community. Partnerships with scholars, historians and educational institutions are also pursued.

Alternative D: The Landscapes Tell the Stories

In Alternative D, the cultural landscape is the mechanism by which the Civil War stories are told. A boundary expansion of 7,238 acres preserves nationally significant battlefields, protects existing park resources and creates opportunities for visitors to access these significant Civil War landscapes and resources. The interpretive program is dynamic and interactive, conveying a more comprehensive Civil War story by making full use of battlefield resources. The visitor experience is much more compelling, as they are immersed in the landscape upon which battles were fought. The efforts of NPS and others to protect battlefields and other Civil War-related resources are emphasized. Visitors can begin and be fully oriented at any of the park units. New programs and expanded facilities are developed at Grant's Headquarters at City Point, the Home Front in Old Town Petersburg, Poplar Grove National Cemetery and Five Forks Battlefield. Partnerships with localities and organizations that promote battlefield preservation and further Civil War education and interpretation are pursued.

2.4 LITERATURE CITED

Alverson WS, and DM Waller. 1997. Deer populations and the widespread failure of hemlock regeneration in northern forests. Pages 280-297 in The science of overabundance: Deer ecology and population management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, D.C.

Auwaerter J. 2009. Cultural Landscape Report for Poplar Grove National Cemetary, Petersburg National Battlefield, Dinwiddie County, Virginia. National Park Service. Boston, MA.

Barden LS. 1987. Invasion of *Microstegium vimineum* (Poaceae), an exotic, annual, shade tolerant, C4 grass, into a North Carolina floodplain. American Midland Naturalist 118: 40–45.

Carruthers TJB, SL Carter, TR Lookingbill, LN Florkowski, JM Hawkey, and WC Dennison, 2012. A habitat-based framework for communicating natural resource condition. ISRN Ecology, vol. 2012, Article ID 384892, 13 pages. doi:10.5402/2012/384892

Chesapeake Bay Program. 2012. Accessed 21 March 2012. The Chesapeake Bay watershed. http://www.chesapeakebay.net/discover/baywatershed

Clausen JA, DJ Crowner, JB Dixon, and JS Quesenberry. 1996. Soil Survey of Dinwiddie Area, Virginia. United States Department of Agriculture. Natural Resources Conservation Service.

Commonwealth of Virginia. 2005. Chesapeake Bay nutrient and sediment reduction tributary strategy for the James River, Lynnhaven and Poquoson coastal basins.

Photo Courtesy of Petersburg National Battlefield, NPS

Poplar Grove National Cemetary Petersburg National Battlefield.

Côté SD, TP Rooney, JP Tremblay, C Dussault, and DM Waller. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology, Evolution, and Systematics 35: 113-147.

DeCalesta DS. 1997. Deer and ecosystem management. Pages 267-279 in The Science of Overabundance: Deer Ecology and Population Management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, D.C.

Driscoll, CT, GB Lawrence, AJ Bulger, TJ Butler, CS Cronan, C Eagar, KF Lambert, GE Likens, JL Stoddard, and KC Weathers. 2001. Acidic deposition in the northeastern United States: sources and inputs, ecosystem effects, and management strategies. Bioscience 51(3): 180-198.

Healy WH. 1997. Influence of deer on the structure and composition of oak forests in central Massachusetts. Pages 249-266 in The Science of Overabundance: Deer Ecology and Population Management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, D.C.

Horning, AJ. 2004. Cultural Overview of City Point, Petersburg National Battlefield, Hopewell, Virginia. The Colonial Williamsburg Foundation, Department of Archaeological Research. Williamsburg, VA.

Hunt, DM, and RE Zaremba. 1992. The northeastward spread of *Microstegium vimineum* (Poaceae) into New York and adjacent states. Rhodora 94:167–170.

Jones DJ, IA Rodihan, LE Cullipher, JW Clay, and MJ Marks. 1985. Soil Survey of Prince George County, Virginia. United States Department of Agriculture, Soil Conservation Service.

Karl TR, JM Mellio, and TC Peterson. 2009. Global Change Impacts in teh United States. Cambridge Unversity Press, Cambridge, UK.

Keys JE, CA Carpenter, SL Hooks, FG Koenig, WH McNab, WE Russell, and ML Smith. 1995. Ecological Units of the Eastern United States. First Approximation. CD-ROM Digital Data. USDA Forest Service. Geometronics Southern Region

Kline LJ, DD Davis, JM Skelly, JE Savage, and J Ferdinand. 2008. Ozone sensitivity of 28 plants selections exposed to ozone under controlled conditions. Northeastern Naturalist 15(1): 57-66.

Ludwig CJ and CA Pague. 1993. A natural heritage inventory of Mid-Atlantic region national parks in Virginia: Petersburg National Battlefield. Cooperative Agreement 4000-8-8018. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA

Madison DL. 1991. Visitor Services Project, Petersburg National Battlefield. Report 33. Cooperative Park Studies Unit. University of Idaho.

McShea WJ and JH Rappole. 1997. Herbivores and the ecology of forest understory birds. Pages 298-309 in The Science of Overabundance: Deer Ecology and Population Management Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, D.C.

Miller NP. 2008. U.S. National Parks and management of park soundscapes: A review. Applied Acoustics 69: 77-92.

National Park Service. 2004. General Management Plan/Environmental Impact Statement. Petersburg National Battlefield, Petersburg, Virginia.

National Park Service. 2011. Current Administrative Boundaries of National Park System Units 06/21/2010. http://nrdata.nps.gov/programs/lands/nps_boundary.xml

National Park Service, Air Resources Division. 2010. Air quality in national parks: 2009 annual performance and progress report. Natural Resource Report NPS/NRPC/ARD/NRR—2010/266. National Park Service, Denver, Colorado.

National Park Service, Land Resources Division, Northeast Land Resources Program Center. Accessed 8 August 2011. http://nrdata.nps.gov/programs/Lands/nps_boundary.zip.

Stynes DJ. 2011. Economic benefits to local communities from national park visitation and payroll 2010. Natural Resource Report NPS/NRSS/EQ/NRR-2011/481. National Park Service, Fort Collins Colorado.

U.S. Geological Survey Biological Resources Division-Contaminants Section and Environmental Protection Agency's Office of Water. 2011. Impaired Streams of Petersburg National Battlefield. Courtesy of National Park Service, Water Resources Division.

U.S. Geological Survey. 2012a. HydroUnits USGS Combined Central Virginia. http://science.nature.nps.gov/nrdata

U.S. Geological Survey. 2012b. NHD Virginia Hydrography Polygons. http://gisdata.virginia.gov/downloads/NHD_VA_Hydrography.zip

Office of Inventory, Monitoring, and Evaluation, NPS Natural Resource Stewardship and Science. 2012. NPS Boundary Polygons (OIME). http://science.nature.nps.gov/im/monitor/npscape/index.cfm

Oswalt CM, SN Oswalt, and WK Clatterbuck. 2007. Effects of *Microstegium vimineum* (Trin.) A. Camus on native woody species density and diversity in a productive mixedhardwood forest in Tennessee. Forest Ecology and Management 242: 727–732.

Pagels, JF, AD Chupp, and AM Roder. 2005. Survey of Mammals at Petersburg National Battlefield. Technical Report NPS/NER/NRTR--2005/027. National Park Service. Philadelphia, PA.

Patterson KD. 2008. Vegetation Classification and Mapping at Petersburg National Battlefield, Virginia. Technical Report NPS/NER/NRTR—2008/127. National Park Service. Philadelphia, PA.

Rich C and T Longcore. (eds). 2006. Ecological consequences of artificial night lighting. Island Press, Washington, DC.

Rosenzweig MS and DM Porter. 1991. Flora of Petersburg National Battlefield. Technical Report NPS/MAR/NRTR 90/048. National Park Service. University Park, PA.

Slayton J. 2011. Fort Lee's BRAC expansion nearly done. Richmond Times-Dispatch. 5 Sept. Last accessed 21 March 2012 from http://www2.timesdispatch.com/news/2011/sep/05/tdmain01-fort-lees-brac-expansion-nearly-done-ar-1285948/.

State Water Control Board. 9 VAC 25-260 Virginia Water Quality Standards. 2011. Statutory Authority: 62.1-44.15 3a of the Code of Virginia.

Sullivan TJ, GT McPherson, TC McDonnell, SD Mackey, and D Moore. 2011. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/349. National Park Service, Denver, Colorado.

Trowbridge JT. 1866. The South: A Tour of its Battlefields and Ruined Cities, A Journey through the Desolated States, and Talks with the People. L. Stebbing. Hartford, CN.

Tu M. 2000. Element stewardship abstract for *Microstegium vimineum*: Japanese stilt grass, Nepalese browntop, Chinese packing grass. The Nature Conservancy, Global Invasive Species Initiative. Arlington, VA.

United States Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS). 2004. Soil Survey Geographic (SSURGO) database for Dinwiddie County, Virginia. Fort Worth, TX. http://SoilDataMart.nrcs.usda.gov.

United States Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS). 2006. Soil Survey Geographic (SSURGO) database for Appomattox County, Virginia. Fort Worth, TX. http://SoilDataMart.nrcs.usda.gov.

United States House of Representatives. 2006. United States Code: Title 16: Conservation.

Virginia Department of Conservation and Recreation (VA DCR). 2003. List of invasive alien plant species in Virginia. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, VA. http://www.dcr.virginia.gov/natural_heritage/invsppdflist.shtml

Virginia Department of Game and Inland Fisheries. 2007. Virginia Deer Management Plan 2006-2015. Wildlife Information Publication No. 07-01.

Werner AD and CT Simmons. 2009. Impact of sea level rise on sea water intrusion in coastal aquifers. Groundwater 47: 197-2004.

West BC and JA Parkhurst. 2002. Interactions between deer damage, deer density, and stakeholder attitudes in Virginia. Wildlife Society Bulletin 30(1): 139-147.

Photo Courtesy of Petersburg National Battlefield, NPS

Chapter 3: Study Approach

3.1 PRELIMINARY SCOPING

3.1.1 Park Involvement

Preliminary scoping for the Petersburg National Battlefield (Petersburg NB) Natural Resource Condition Assessment (NRCA) began in August 2011 with a meeting of all park staff having expertise on the park's resources. At the meeting, park management objectives were discussed in detail and an initial cataloging of natural resource values and stressors to the park began. The Eastern Front unit of the park was also toured, with a follow-up visit to tour the Five Forks unit in October 2011.

The compilation of data began immediately following this kick-off meeting. Archived data for park resources were organized into an electronic library comprised of management reports, hard data files, and geospatial data (GIS), which provided the primary sources for the assessment. Data sets were obtained from multiple divisions within the National Park Service (NPS) including the park, Air Resources Division, Exotic Plant Management Team, NPScape and the Inventory and Monitoring (I&M) Program; U.S. Environmental Protection Agency (EPA); and regional scientific experts who have worked in the park.

Planning and exchange of data continued through a series of follow-up meetings with park staff from Petersburg NB, the Mid-Atlantic Network of the I&M Program, and the University of Richmond. Outcomes of these meetings helped identify natural resources to be included in the assessment, identify key metrics to assess the condition of these resources, and assign desired or target values for the metrics. These meetings also provided the context of current conditions and background information not necessarily available in published form.

Strong collaboration with park natural resource staff was essential to the success of this assessment. Key park staff invested significant time to assist in the development of reference conditions, calculation of metrics, and interpretation of findings.

3.2 STUDY DESIGN

3.2.1 Reporting Areas

The focus of the reporting area for the NRCA was the Petersburg National Battlefield legislative boundary. Petersburg NB is comprised of many separate units including the: Eastern Front, Five Forks, Grant's Headquarters at City Point, Fishhook, Fort Gregg, and Poplar Grove National Cemetery. Data were compiled from all units of Petersburg NB to calculate overall park-level scores. When possible, condition scores also were calculated for the two main units: the Eastern Front and Five Forks units. These two units are significantly larger than other units of the park, and at this time, have significantly more information available on their natural resources.

3.2.2 Assessment Framework

Metrics form the basis of this condition assessment. Efforts were made to integrate NPS I&M ecological monitoring metrics associated with 'vital signs,' into the assessment. Fancy et al. (2009) defines vital

One of the report authors during a site visit.

Photo Courtesy of Todd Lookingbill

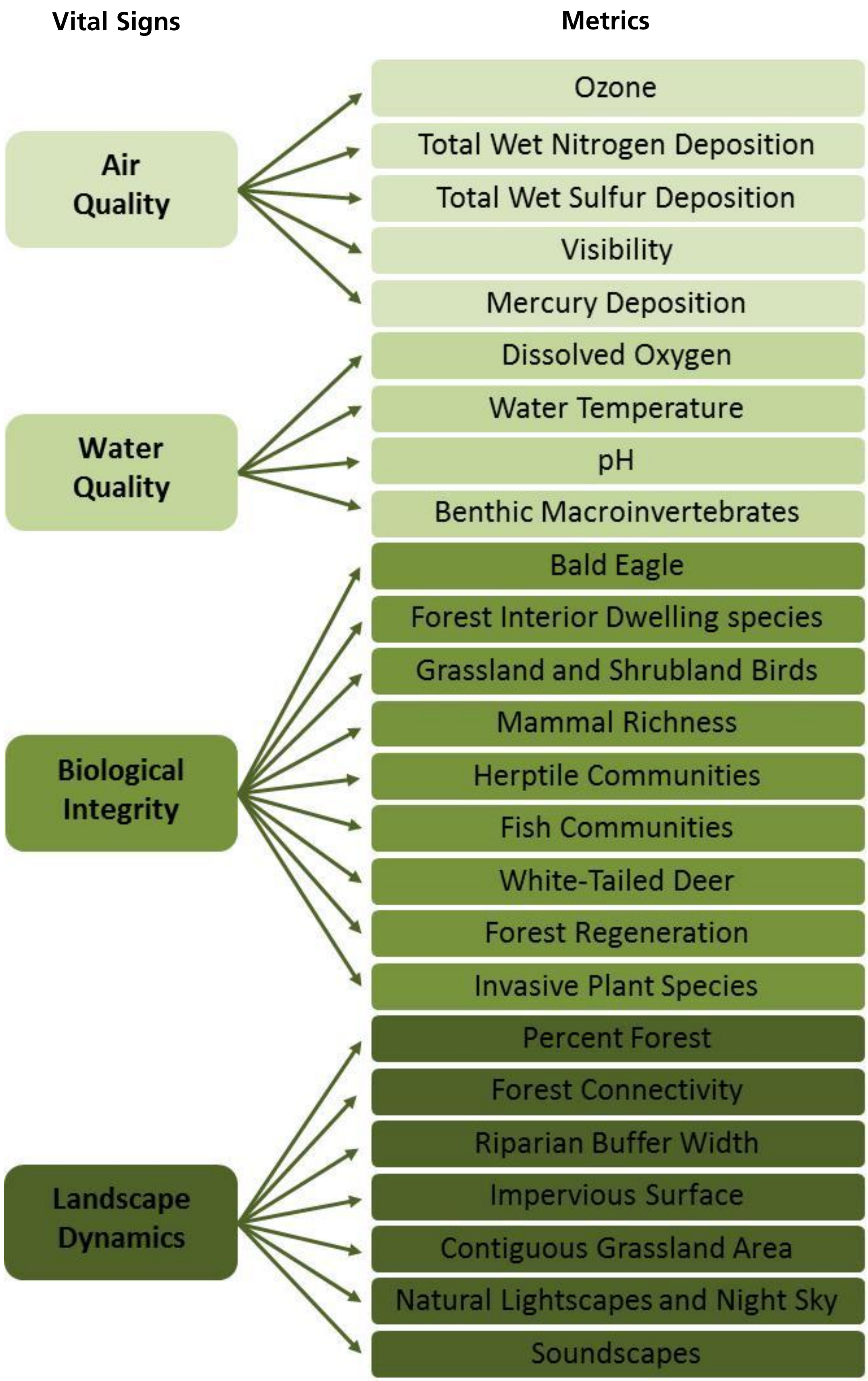


Figure 3.1 *Vital signs categories and metrics used for assessment of Petersburg National Battlefield.*

signs as a "subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of Park resources, known or hypothesized effects of stressors, or elements that have important human values". The I&M vital signs are: Air, Water, Biotic Integrity, Landscapes (pattern and processes), Human use, and Geology and Soil. For the purpose of calculating natural resource condition in Petersburg NB, only the first four vital signs were used, though general features of 'human use' and 'geology and soil' are discussed throughout the report. Vital sign metrics were chosen by the park in collaboration with the University of Richmond and are outlined in Figure 3.1.

Detailed information of relevance, methods, reference condition, current condition, and trend are provided for each metric in Chapter 4. Each indicator also contains a section describing data gaps and level of confidence, which is given as a qualitative rating (i.e., low, fair, high) based on best professional judgment. Confidence in assessment did not influence calculation of attainment of assessment scores.

For assessment of landscape metrics, it was sometimes necessary to categorize the park land cover into general classes, especially forest and grassland habitat types. Using Patterson's (2008) vegetation mapping of the park, we reclassed the 20 vegetation alliances into 5 categories: forest (mixed deciduous and conifer), grassland, wetland, earthworks, and developed (Table 3.1, Figure 3.2).

3.2.3 Condition Assessment Calculations

A total of 25 Vital Sign metrics were reviewed in this assessment (Figure 3.1). The approach for assessing resource condition within Petersburg NB (as separate units and the park as a whole) required establishment of a reference condition (i.e., threshold) for each metric. Thresholds ideally were ecologically based and derived from the scientific literature. However, when data were not available

Table 3.1 *Major vegetation classes for Petersburg National Battlefield (Patterson 2008).*

Map Class	Reclass
Acidic Oak - Hickory Forest (Northern Red Oak, Hickory species) Forest Alliance)	Mixed Deciduous
Coastal Plain Mixed Oak / Heath Forest (Southern Red Oak, Post Oak)	Mixed Deciduous
Disturbed Calcareous Forest	Mixed Deciduous
Forested Earthworks	Earthworks
Loblolly Pine - Hardwood Forest	Conifer Forest
Loblolly Pine Plantation / Early-Successional Loblolly Pine Forest	Conifer Forest
Mesic Mixed Hardwood Forest	Mixed Deciduous
Successional Mixed Scrub	Mixed Deciduous
Successional Sweetgum Forest	Mixed Deciduous
Barren Land	Developed
Beaver Wetland Complex	Wetland
Coastal Plain / Piedmont Acidic Seepage Swamp (Red Maple - Blackgum)	Wetland
Coastal Plain / Piedmont Floodplain Swamp Forest (Mixed Oak - Red Maple Type)	Wetland
Coastal Plain / Piedmont Small-Stream Floodplain Forest (Tuliptree, Red Maple)	Wetland
Cultural Meadow (Orchard Grass - Common Sheep Sorrel)	Grassland
Open Earthworks	Earthworks
Other Urban or Built-up Land	Developed
Semipermanent Impoundment	Wetland
Transportation, Communications, and Utilities	Developed
Successional Tuliptree Forest	Mixed Deciduous

to support peer-reviewed ecological thresholds, regulatory and management-based thresholds were used. Instances when best professional judgment was used in consultation with park staff to define thresholds were clearly identified in the "Data gaps and level of confidence" subsections of Chapter 4.

The attainment of threshold metrics were calculated based on the percentage of sites or samples that met or exceeded threshold values for each metric. A metric attainment score of 100% reflected that the metric at all sites and at all times met the threshold identified to maintain natural resources. Conversely, a score of 0% indicated that no sites at any sampling time met the threshold value. Once attainment was calculated for each metric, an unweighted mean was calculated to determine the condition of each vital sign category for each major park unit and for the park as a whole. Attainment scores were categorized on a scale from very good to very degraded. Metrics were assigned a qualitative rating corresponding to the quantitative score: very degraded (0-20%), degraded (>20-40%), fair (>40-60%), good (>60-80%), and very good (>80-100%).

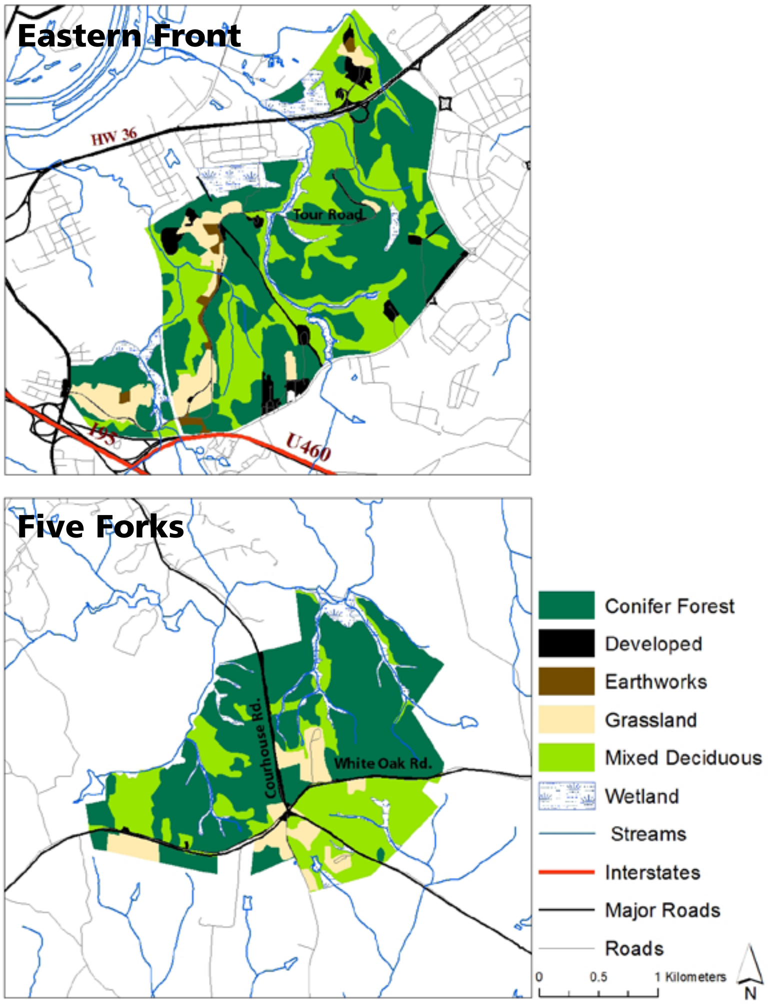
Attainment scores for each metric are presented in Chapter 4 and synthesized further into overall park and unit scores in Chapter 5. Key findings and recommendations are also summarized for each vital sign category in Chapter 5.

3.3 LITERATURE CITED

Fancy SG, JE Gross, and SL Carter. 2009. Monitoring the condition of natural resources in U.S. National Parks. Environmental Monitoring and Assessment 151: 161–174.

Patterson KD. 2008. Vegetation Classification and Mapping at Petersburg National Battlefield, Virginia. Technical Report NPS/NER/NRTR—2008/127. National Park Service. Philadelphia, PA.

Figure 3.2 *General land cover types for the two largest units of Petersburg National Battlefield (Patterson 2008).*



4.1 AIR QUALITY

4.1.1 Ozone

Relevance and context

Ozone, a secondary atmospheric pollutant, is not directly emitted, but is formed by a sunlight driven chemical reaction on nitrous oxides and volatile organic compounds emitted largely from burning fossil fuels (Haagen-Smit and Fox 1956). In humans, ozone can cause a number of health-related issues such as lung inflammation and reduced lung function, which can result in hospitalization. Ozone concentrations of 120 ppb can be harmful with only short exposure during heavy exertion such as jogging. Similar symptoms can occur from prolonged exposure to concentrations of 80 ppb ozone (McKee et al. 1996). One study in which 28 plant species were exposed to ozone for between three and six weeks, showed foliar impacts including premature defoliation in all species at ozone concentrations between 60 and 90 ppb (Kline et al. 2008). Many of these species are found in Petersburg National Battlefield (Petersburg NB) (Table 4.1). Ozone can also negatively affect pollination by destroying the scent-bearing molecules released by flowers to attract pollinators. As a consequence, a wide variety of Eastern U.S. vegetation may be vulnerable on NPS lands (Lovett et al. 2009). Ozone pollution may also be playing a role in the recent collapse of honeybee and bumblebee colonies in the U.S. (McFrederick et al. 2008).

Data and methods

Ozone is not measured within the park boundary but is interpolated from nearby stations, specifically 75-B, by kriging, a statistical interpolation process (Figure 4.1). Data used for the assessment were evaluated as the 5-year average of the 4th highest daily maximum 8-hour average ozone concentration measured between 2006 and 2010 and supplied by NPS Air Resources Division (NPS ARD 2011). There is only one assessment point within the park relevant to our current time period. This value was assessed against the threshold (ozone standard) for

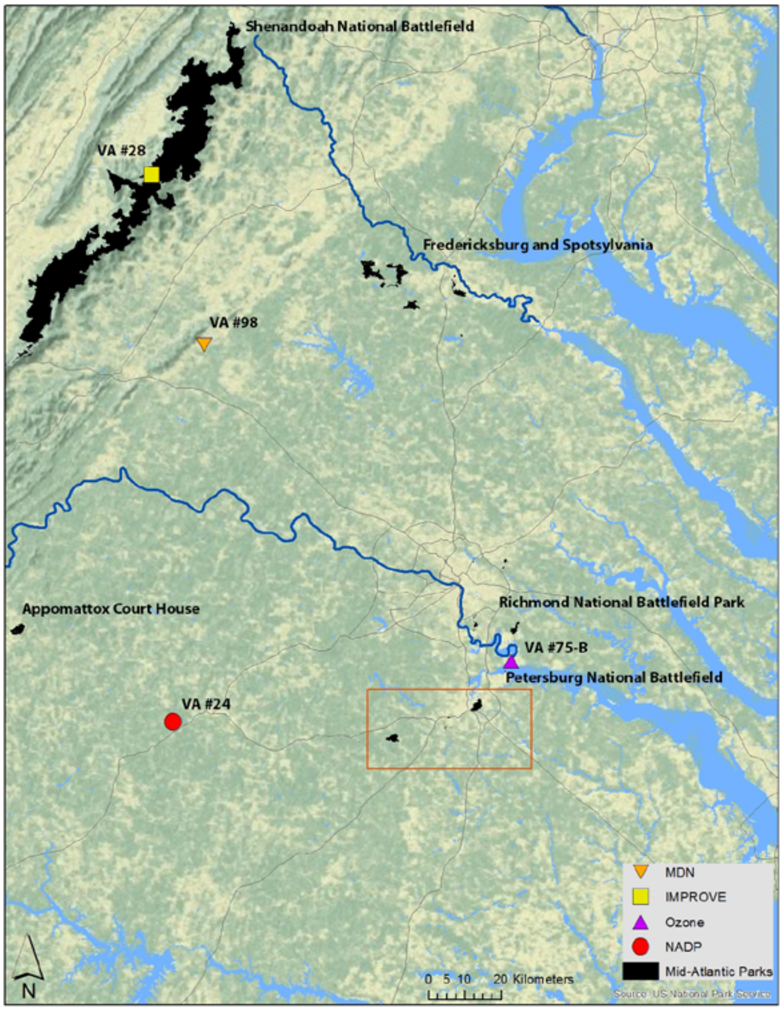


Figure 4.1 *Air quality monitoring in or near the Mid-Atlantic Network (http://www.nature.nps.gov/air/permits/aris/networks/midn.cfm)*

the quantification of current condition. For assessment of trends, NPS ARD estimates of the 5-year average values were considered dating back to the 1999 to 2003 analysis window (NPS ARD 2011).

Threshold

Ground-level ozone is regulated under the Clean Air Act, and the U.S. EPA is required to set standard concentrations for ozone (U.S. EPA 2004). In 1997, the ozone standard was set by the National Ambient Air Quality Standards (NAAQS) as 80 ppb for the 3-year average annual 4th highest daily maximum 8-hour ozone concentrations (U.S. EPA 2006). This standard has subsequently been lowered to 75 ppb (NAAQS 2008), with a current proposal for further reduction to an acceptable range of 60-70 ppb (Federal Register 2010). For this assessment, multiple threshold concentrations were used: >75 ppb was considered to be of significant concern (attainment score of 0%) and concentrations <60 ppb (set as 80% of the standard concentration limit) were considered in good condition (assigned an attainment score of 100). Concentrations between 60-75 ppb were considered in moderate condition (NPS ARD 2010), and condition scores were

Table 4.1 *NPS Ozone Injury Risk Assessment (NPS 2004) listed the following species at risk of foliar injury from ozone in Petersburg National Battlefield*

Name	Common Name	Family
Asclepias syriaca	Common milkweed	Asclepiadaceae
Cercis canadensis	Redbud	Fabaceae
Fraxinus pennsylvanica	Green ash	Oleaceae
Liquidambar styraciflua	Sweetgum	Hamamelidaceae
Liriodendron tulipifera	Yellow-poplar	Magnoliaceae
Parthenocissus quinquefolia	Virginia creeper	Vitaceae
Philadelphus coronarius	Sweet mock-orange	Hydrangeaceae
Pinus taeda	Loblolly pine	Pinaceae
Pinus virginiana	Virginia pine	Pinaceae
Platanus occidentalis	American sycamore	Platanaceae
Prunus serotina	Black cherry	Rosaceae
Rhus copallina	Flameleaf sumac	Anacardiaceae
Robinia pseudoacacia	Black locust	Fabaceae
Rubus allegheniensis	Allegheny blackberry	Rosaceae
Sassafras albidum	Sassafras	Lauraceae
Verbesina occidentalis	Crownbeard	Asteraceae
Vitis labrusca	Northern fox grape	Vitaceae

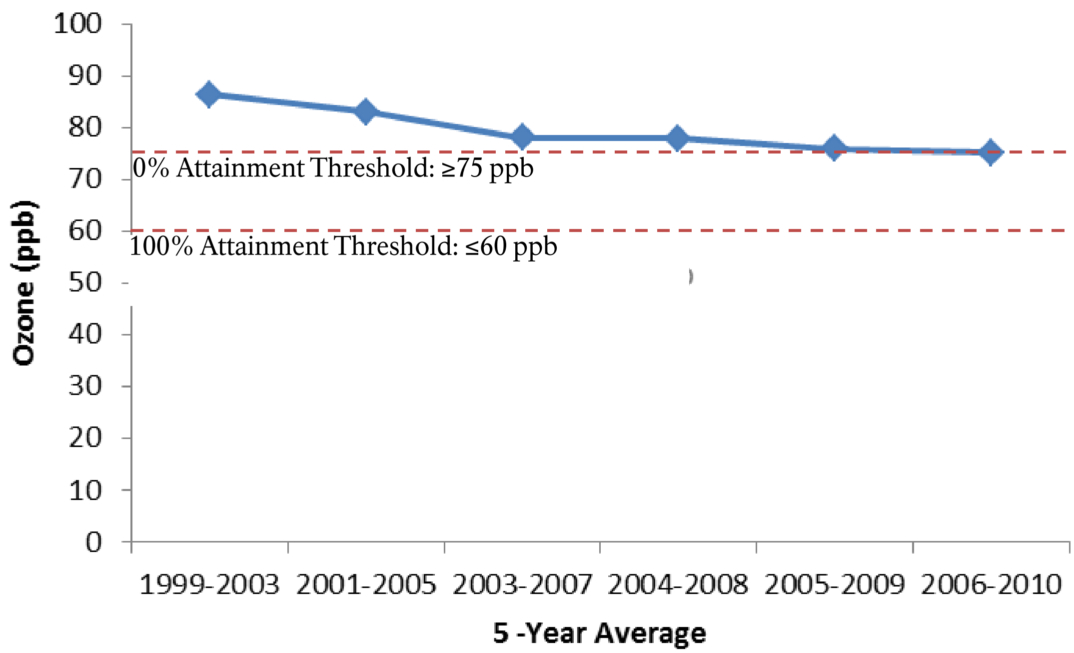


Figure 4.2 *Five-year average values of annual 4th-highest 8-hour ozone concentration for Petersburg National Battlefield (NPS ARD 2011,NPS ARD 2012).*

scaled linearly from 0 to 100% attainment between these two reference points.

Current condition and trend

The 2006-2010 value of 75.1 ppb indicates a significant concern based on comparison to the threshold of 75.0 ppb (NPS ARD 2012). This represents a current attainment of 0% for the park.

Ozone has been improving over the past decade. From the NPS Air Quality estimates (five-year averages), the interpolated 4th highest daily maximum 8-hour ozone concentration for the park has decreased for 6 successive 5-year periods from 88.5 ppb in 1999-2003 to 75.1 ppb in 2006-2010 (Figure 4.2). This reported trend is consistent with the 10-year trend reported in the 2009 Annual Performance and Progress report (NPS ARD 2010), which found that no park units in the Eastern U.S. show a degrading trend, with a majority showing significant or possible improvement in atmospheric ozone concentration (Figure 4.3) (NPS ARD 2010).

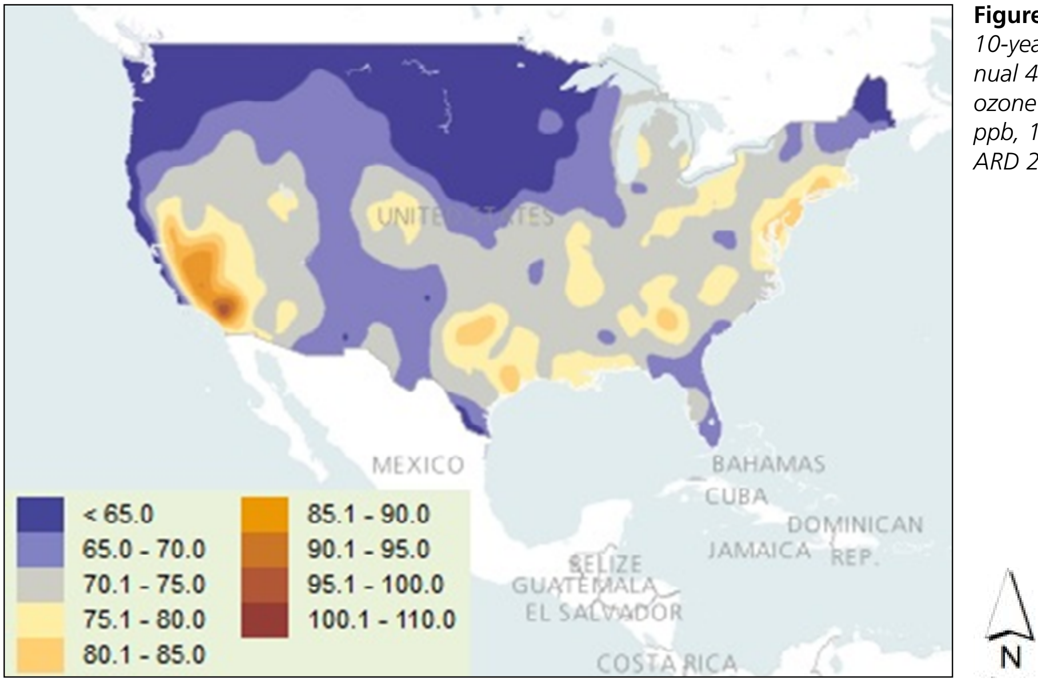


Figure 4.3 *National 10-year trends in annual 4th-highest 8-hour ozone concentration ppb, 1999–2008 (NPS ARD 2010).*

Data gaps and level of confidence

Most parks have no on-site ambient air quality monitoring; however, in most cases, there are nearby monitoring sites. These regional air data must be translated to park-level estimates. Ozone is the most widely distributed air pollutant in the Northeast United States based on current sampling sites (Figure 4.1). Although the data used for the assessment represent 5-year average values, which were compared to thresholds based on 3-year average concentrations, there is no reason to believe this difference would bias the results. Confidence in the current assessment is therefore high.

Sources of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

Literature cited

Federal Register January 19, 2010. National ambient air quality standards for ozone, Proposed Rules Vol 75 No. 11, 40 CFR Parts 50 and 58: 2938

Haagen-Smit AJ and MM Fox. 1956. Ozone formation in photochemical oxidation of organic substances. Industrial and Engineering Chemistry 48(9): 1484-1487

Kline LJ, DD Davis, JM Skelly, JE Savage, and J Ferdinand. 2008. Ozone sensitivity of 28 plants selections exposed to ozone under controlled conditions. Northeastern Naturalist 15(1): 57-66.

Lovett GM, TH Tear, DC Evers, SEG Findlay, BJ Cosby, JK Dunscomb, CT Driscoll, and KC Weathers. 2009. Effects of air pollution on ecosystems and biological diversity in the Eastern United States. The Year in Ecology and Conservation Biology, 2009: Ann. N.Y. Acad. Sci. 1162: 99-135.

Photo Courtesy of Todd Lookingbill

Bluff at Grant's Headquarters at City Point in Petersburg National Battlefield

McFrederick QS, JC Kathilankal, and JD Fuentes. 2008. Air pollution modifies floral scent trails, Atmospheric Environment 42(10): 2336-2348.

McKee DJ, VV Atwell, HM Richmond, WP Freas, and RM Rodriguez. 1996. Review of national ambient air quality standards for ozone, assessment of scientific and technical information. OAQPS Staff Paper. EPA-452/R-96-007.

NAAQS. 2008. National Ambient Air Quality Standards. http://www.epa.gov/air/criteria.html#6

National Park Service. 2004. Northeast Coastal and Barrier Island Network assessing the risk of foliar injury from ozone on vegetation in parks in the Northeast Coastal and Barrier Island Network. October 2004. http://www.nature.nps.gov/air/permits/aris/networks/ncbn.cfm

National Park Service, Air Resources Division. 2010. Air quality in national parks: 2009 annual performance and progress report. Natural Resource Report NPS/NRPC/ARD/NRR—2010/266.

National Park Service, Air Resources Division. 2011. 5-Year average ozone estimates. NPS Air Quality Estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm

National Park Service, Air Resource Division. 2012. 5-year average ozone estimates. NPS Air Quality Estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/docs/Air_Atlas_Values_Tables/Ozone/NPS_AQC_Ozone_0610_web.pdf

U.S. EPA. 2004. The Clean Air Act. Washington United States Environmental Protection Agency, Washington D.C. http://epw.senate.gov/envlaws/cleanair.pdf

U.S. EPA. 2006. Air Quality Criteria for Ozone and Related Photochemical Oxidants. Volume I of III. EPA 600/R-05/004aF.

4.1.2 Total Wet Nitrogen Deposition

Relevance and context

Atmospheric deposition is the accumulation of airborne particles and gases on the earth's surface. This process can occur either through precipitation (wet deposition) or as a result of atmospheric settling, impaction, and adsorption (dry deposition)(Porter and Morris 2007). For this assessment, we considered only wet deposition of total nitrogen and total sulfur. The National Atmospheric Deposition Program (NADP) has monitored wet deposition through testing of snow and rain samples for 20 years (Sullivan 2011b). Deposited material includes a wide variety of natural and anthropogenic pollutants, including inorganic elements and compounds (e.g., nitrogen, sulfur, basic cations, mercury and other metals) and organic compounds (e.g., pesticides and herbicides). Once deposited, pollutants can have significant ecosystem effects (Porter and Morris 2007).

Both terrestrial and aquatic ecosystems effects of atmospheric nitrogen (N) deposition have become increasingly recognized (NPS ARD 2010). These impacts result largely from the acidification and nutrient fertilization of waters and soils, and include such measurable effects as the disruption of nutrient cycling, changes to vegetation structure, loss of stream biodiversity and the eutrophication of streams and coastal waters (Driscoll et al. 2001; Porter and Johnson 2007). During the 1940s and 1950s the United States and Britain recognized that coal burning emissions from large scale industry, such as power plants and steel mills, were causing severely degraded air quality in major cities. This was resulting in significant impacts to human health. By the early 1970s, the US EPA had established the National Ambient Air Quality Standards (NAAQS) (Porter and Johnson 2007).

Data and methods

Data used for the assessment were deposition concentrations kriged from nearby stations (Figure 4.1) and multiplied by normalized precipitation (PRISM 1971-2000 30-year average; Daly et al. 2002) to interpolate total N deposited between 2006 and 2010 for the central point within Petersburg NB. These data were supplied by NPS Air Resources Division (NPS ARD 2012). There is currently only one assessment point relevant for our time period, so this value was assessed against the reference condition. For assessment of trends, NPS ARD estimates of the five-year average values were considered dating back to the 2001 to 2005 analysis window (NPS ARD 2011).

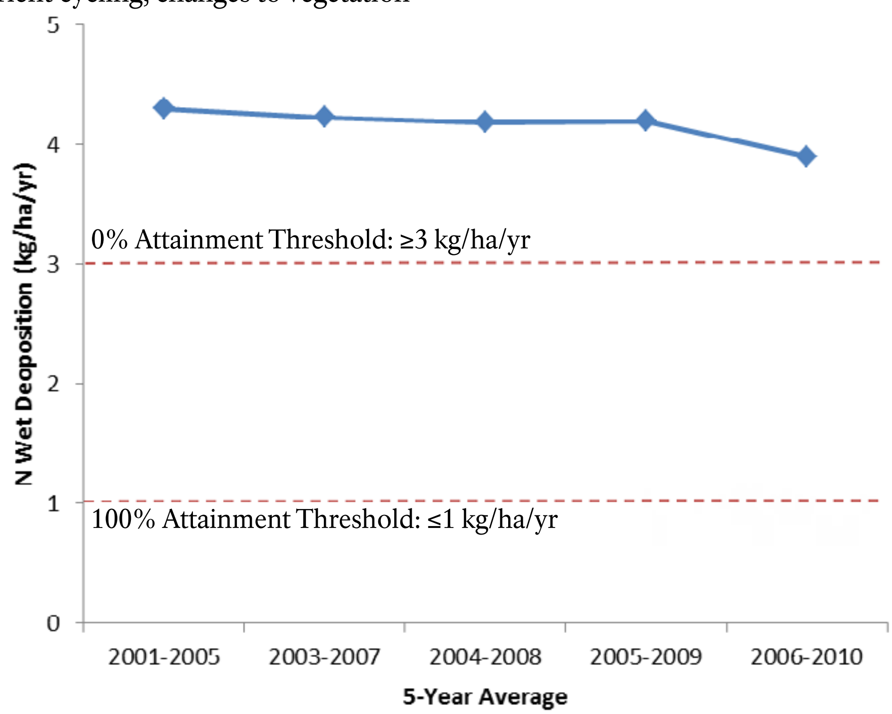


Figure 4.4 *Five-year average values of in total nitrogen wet deposition (kg/ha/yr) for Petersburg NB (NPS ARD 2012).*

Threshold

The total natural background nitrogen deposition in the Eastern U.S. is 0.5 kg/ha/yr, which equates to a wet deposition of approximately 0.25 kg/ha/yr (Porter and Morris 2007; NPS ARD 2011b). The NPS Air Resources Division has established wet nitrogen deposition guidelines as <1 kg/ha/yr indicating good condition, 1-3 kg/ha/yr indicating moderate, and >3 kg/ha/yr indicating significant concern (NPS ARD 2011). While there is no evidence of ecosystem harm at deposition rates less than 1 kg/ha/yr, sensitive ecosystems show responses to wet nitrogen deposition rates as little as 1.5 kg/ha/yr (Fenn et al. 2003). For this assessment, multiple thresholds were used; ≥3 kg/ha/yr was considered to be of significant concern (score of 0%), deposition rates ≤ 1 kg/ha/year was considered in good condition (attainment score of 100%), and deposition between 3 kg/ha/yr and 1 kg/ha/yr was considered in moderate condition and attainment scores were scaled linearly from 0 to 100 between these two reference points.

Current condition and trend

The 2006-2010 value of total N wet deposition (3.90 kg/ha/yr), indicates a significant concern based on comparison to the threshold of 3 kg/ha/yr. This represents a condition of 0% attainment (NPS ARD 2012).

Total N wet deposition has been decreasing from a value of 4.30 kg/ha/yr for 2001-2005 to 3.90 kg/ha/yr for 2006-2010(Figure 4.4; NPS ARD 2012). This change reflects an improving trend consistent with U.S.-wide reductions in emissions over the past decades (Driscoll et al. 2001), and is consistent with decreasing trends in most parks in the eastern U.S. (NPS ARD 2010). However, large reductions in nitrogen wet deposition are still required to reduce negative impacts on natural resource condition (Porter and Johnson 2007). Sullivan et al. (2011b) found Petersburg NB to be at a very high pollutant exposure and at moderate summary risk for acidification damage.

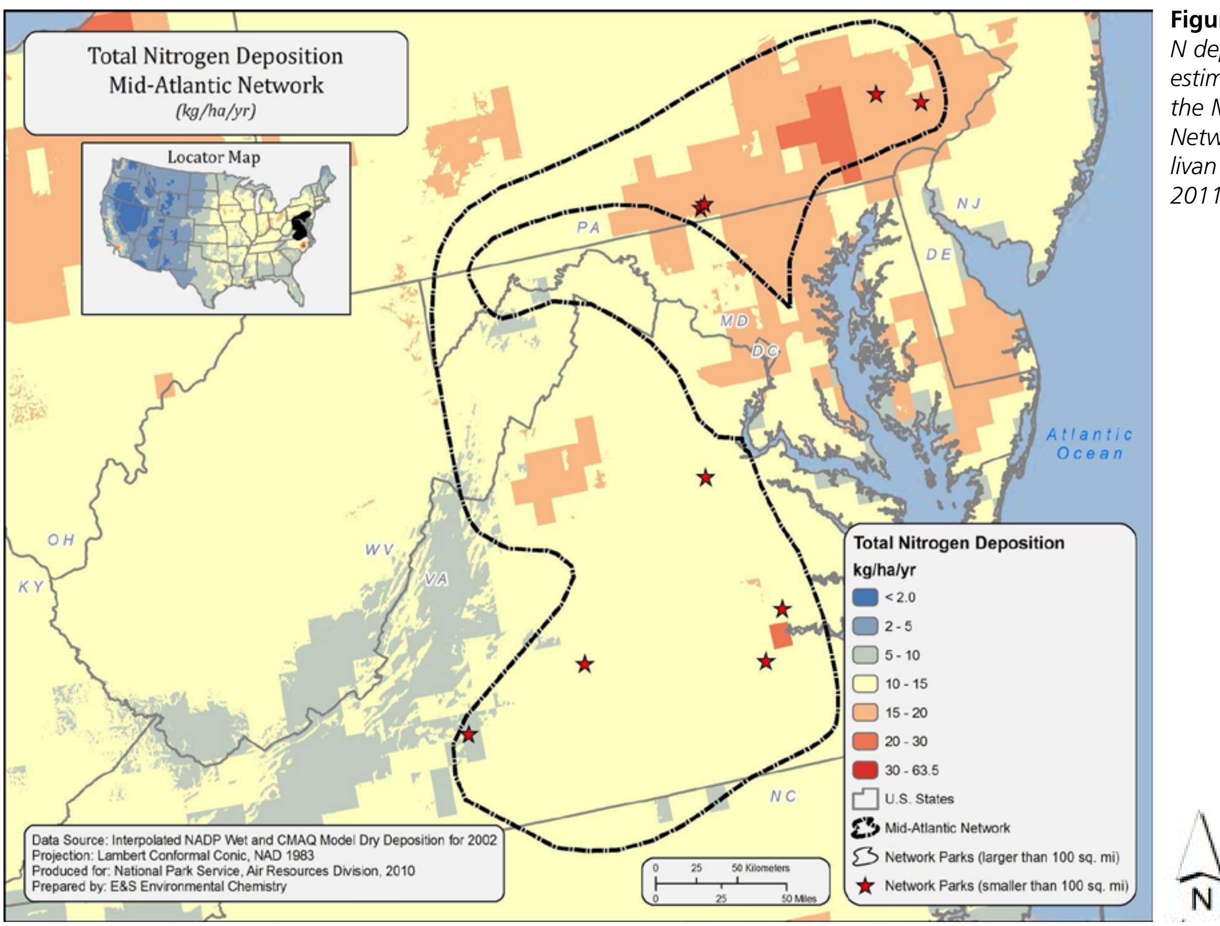


Figure 4.5 *Total N deposition estimates for the Mid-Atlantic Network (Sullivan et al. 2011a).*

Data gaps and level of confidence

Many of the Mid-Atlantic Network parks are miles from the closest NADP/National Trends Network monitoring stations requiring considerable interpolation to derive park-based estimates (Figures 4.1 and 4.5). The distance between monitoring station and park is problematic because variability in wind patterns and localized meteorology may significantly affect pollutant deposition. The closest monitoring site to Petersburg NB was installed in 1999 in Prince Edward County, VA (site #VA24) approximately 100 km (62 miles) from the park. In addition to the spatial interpolation concerns, a clear set of ecosystem thresholds is also required (Porter and Johnson 2007). Confidence in the current assessment is fair.

Sources of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

Literature cited

Daly C, WP Gibson, GH Taylor, GL Johnson, and P Pasteris. 2002. A knowledge-based approach to the statistical mapping of climate. Climate Research 22: 99-113. http://www.prism.oregonstate.edu

Driscoll CT, GB Lawrence, AJ Bulger, TJ Butler, CS Cronan, C Eagar, KF Lambert, GE Likens, JL Stoddard, and KC Weathers. 2001. Acidic deposition in the northeastern United States: sources and inputs, ecosystem effects, and management strategies. Bioscience 51(3): 180-198

Fenn ME, R Haeuber, GS Tonnesen, JS Baron, S Grossman-Clarke, D Hope, DA Jaffe, S Copeland, L Geiser, HM Rueth, and JO Sickman. 2003. Nitrogen emissions, deposition, and monitoring in the Western United States. BioScience 53(4): 391-403.

National Park Service, Air Resource Division. 2012. 5-year average wet deposition estimates. NPS Air Quality Estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/docs/Air_Atlas_Values_Tables/Wet_Deposition/NPS_AQC_WetDep_0610_PRISM_web.pdf

National Park Service, Air Resources Division. 2011. Rating air quality conditions. Natural Resource Report NPS/NRPC/ARD/NRR—2011/266. National Park Service, Denver, Colorado. Available at:http://www.nature.nps.gov/air/planning/docs/20111122_Rating-AQ-Conditions.pdf

National Park Service, Air Resources Division. 2010. Air quality in national parks: 2009 annual performance and progress report. Natural Resource Report NPS/NRPC/ARD/NRR—2010/266. National Park Service, Denver, Colorado.

Porter E and S Johnson. 2007. Translating science into policy: using ecosystem thresholds to protect resources in Rocky Mountain National Park. Environmental Pollution 149: 268-280

Porter E, and K Morris. 2007. Wet deposition monitoring protocol: monitoring atmospheric pollutants in wet deposition. Natural Resource Technical Report NPS/NRPC/ARD/NRTR— 2007/004. National Park Service, Fort Collins, Colorado.

Sullivan TJ, TC McDonnell, GT McPherson, SD Mackey, and D Moore. 2011a. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: Mid-Atlantic Network (MIDN). Natural Resource Report NPS/NRPC/ARD/NRR—2011/315. National Park Service, Denver, Colorado. http://nature.nps.gov/air/Pubs/pdf/n-sensitivity/midn_n_sensitivity_2011-02.pdf

SullivanTJ, GT McPherson, TC McDonnell, SD Mackey, and D Moore. 2011b. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/349. National Park Service, Denver, Colorado.

4.1.3 Total Wet Sulfur Deposition

Relevance and context

Sixty percent of U.S. emissions of sulfate (SO_2) come from electric utilities and 41% come from the seven Midwest states centered on the Ohio Valley (Driscoll et al. 2001). Once in the atmosphere, SO_2 is highly mobile and can be transported distances greater than 500 km (311 miles) (Driscoll et al. 2001). As a consequence, sulfur deposition is higher in the Eastern United States than the Western United States, although deposition estimates are complex due to meteorology, atmospheric transport, atmospheric chemistry, precipitation patterns, and vegetation cover (Sullivan et al. 2011). Emissions of SO_2 in the U.S. increased from 9 million metric tons in 1900 up to 28.8 million metric tons by 1973. After the establishment of the Clean Air Act regulations, emissions of SO_2 were reduced to 17.8 million metric tons by 1996 (Driscoll et al. 2001). The effect of this emission reduction on deposition rates was substantial. However, large areas of the Eastern U.S. remain well above natural background levels for sulfur wet deposition (Driscoll et al. 2001).Wet sulfur deposition can cause acidification of soil, soil water, lakes, and streams (Sullivan et al. 2011).

Data and methods

Data used for the assessment were statistically interpolated by NPS Air Resources Division from the closest NADP/NTN monitoring stations for the central point within Petersburg NB (NPS ARD 2012). The closest monitoring site to Petersburg NB is in Prince Edward County, VA (site #VA24) (Figure 4.1). Because there is only one assessment point for the park per time period, this single value was assessed against the reference condition. For current condition, the average annual total sulfur wet deposition for the five-year period from 2006-2010 was used (NPS ARD 2012). For assessment of trends, five year average values dating back from 2001 to 2005 were also analyzed (NPS ARD, 2011a).

Threshold

Natural background sulfur deposition in the Eastern U.S. is 0.5 kg/ha/yr, which equates to a wet deposition of approximately 0.25 kg/ha/yr (Porter and Morris 2007; NPS ARD 2010). NPS Air Resources Division has established wet sulfur deposition guidelines of <1 kg/ha/yr indicating good condition, 1-3 kg/ha/yr indicating moderate, and >3 kg/ha/yr indicating significant concern. For this assessment, multiple thresholds were used; ≥3

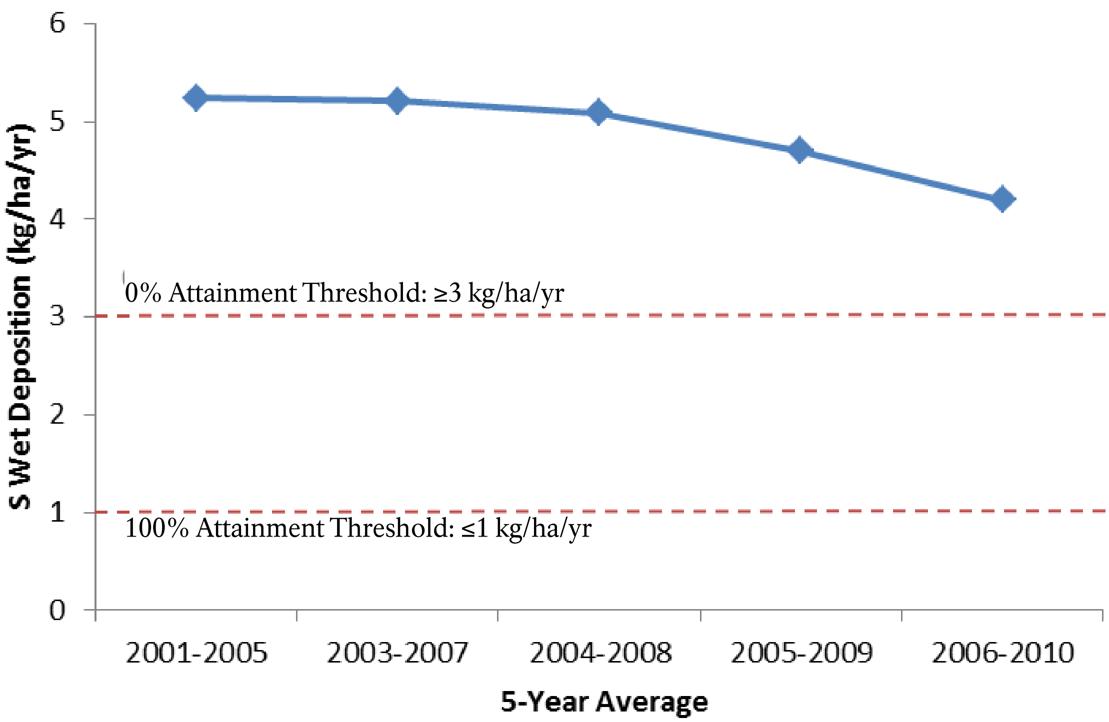


Figure 4.6 *Five-year average values of total sulfur wet deposition (kg/ha/yr) for Petersburg National Battlefield (NPS ARD 2012).*

kg/ha/yr was considered to be of significant concern (score of 0%), deposition rates ≤ 1 kg/ha/year was considered in good condition (attainment score of 100%), and deposition between 3 kg/ha/yr and 1 kg/ha/yr was considered in moderate condition and attainment scores were scaled linearly from 0 to 100 between these two reference points.

Current condition and trend

The 2006-2010 average annual sulfur wet deposition rate was 4.20 kg/ha/yr, indicating a significant concern based on comparison to the threshold of <1 kg/ha/yr (Figure 4.6). This represents a current condition of 0% attainment.

Total sulfur wet deposition has decreased slightly from a value of 5.24 kg/ha/yr for 2001-2005 (NPS ARD 2012). Phase I of the sulfate reduction provision of the Clean Air Act ran from 1995 through 1999 and affected roughly 440 of the largest emitting utility facilities, primarily in the Eastern United States. Phase II began in 2000, extending to all affected sources throughout the country (Driscoll et al. 2001).

Data gaps and level of confidence

Many of the closest NADP/NTN monitoring stations within the Mid-Atlantic Network are located far from the parks (Figure 4.1). The distance to, and location of these sites is problematic, because wind patterns and localized meteorology may significantly affect pollutant deposition. The closest monitoring site to Petersburg NB was installed in Prince Edward County, VA (site #VA24) in 1999. A clear set of ecosystem thresholds is also required (Porter and Johnson 2007). Confidence in the current assessment is fair.

Sources of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

Literature cited

Driscoll CT, GB Lawrence, AJ Bulger, TJ Butler, CS Cronan, C Eagar, KF Lambert, GE Likens, JL Stoddard, and KC Weathers. 2001. Acidic deposition in the northeastern United States: sources and inputs, ecosystem effects, and management strategies. Bioscience 51(3): 180-198

National Park Service, Air Resources Division. 2010. Air quality in national parks: 2009 annual performance and progress report. Natural Resource Report NPS/NRPC/ARD/NRR—2010/266. National Park Service, Denver, Colorado.

National Park Service, Air Resources Division. 2011a. 5-Year average wet deposition estimates. NPS Air Quality Estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm

National Park Service, Air Resources Division. 2011b. Rating air quality conditions. Natural Resource Report NPS/NRPC/ARD/NRR—2011/266. National Park Service, Denver, Colorado. Available at: http://www.nature.nps.gov/air/planning/docs/20111122_Rating-AQ-Conditions.pdf

National Park Service, Air Resources Division. 2012. 5-year average wet deposition estimates. NPS Air Quality Estimates. National Park Service. Denver, CO. Available at http://www.nature.nps.gov/air/Maps/AirAtlas/docs/Air_Atlas_Values_Tables/Wet_Deposition/NPS_AQC_WetDep_0610_PRISM_web.pdf

Porter E and K Morris. 2007. Wet deposition monitoring protocol: Monitoring atmospheric pollutants in wet deposition. Natural Resource Technical Report NPS/NRPC/ARD/NRTR— 2007/004. National Park Service, Fort Collins, CO.

Sullivan TJ, GT McPherson, TC McDonnell, SD Mackey, and D Moore. 2011. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/349. National Park Service, Denver, Colorado.

4.1.4 Visibility

Relevance and context

Improving visibility in national parks and wilderness areas has been of special concern to protect the scenic vistas expected by visitors. Particles less than 2.5 m diameter (PM 2.5) are emitted as smoke from power plants, gasoline and diesel engines, wood combustion, steel mills, forest fires, and chemical reactions (U.S. EPA 2006). These particles can have significant health impacts and negatively effect visibility (U.S. EPA 2004b, Cheung et al 2005). Although the presence of organic matter, soot, nitrates, and soil dust all impair visibility, the major cause of reduced visibility in the Eastern U.S. is sulfate particles formed from coal combustion (National Research Council 1993). The Clean Air Act includes visibility as an indicator of broader air quality degradation linked to human activities (U.S. EPA 2004a).

Data and methods

Data used for the assessment were statistically interpolated from nearby haze monitoring stations (IMPROVE Station #28) to the central point within Petersburg NB (NPS ARD 2012). The haze index in deciviews (dv) indicates the difference between current group 50 visibility (mean of the 40th – 60th percentile data) and the natural group 50 visibility (estimated visibility in the absence of human caused visibility impairment) (U.S. EPA 2003; NPS ARD 2011). Current condition was assessed using the average haze index value for the five-year period from 2006-2010. For assessment of trend, data dating back to 2001 were also analyzed.

Threshold

A calculated haze index where the visibility is ≥8 dv above a natural visibility condition was considered of significant concern (score of 0% attainment). Concentrations ≤ 2 dv above a natural visibility condition were considered as in good condition (score of 100% attainment)(NPS ARD 2010). Concentrations between 2-8 dv above a natural visibility condition were scaled linearly from 0 to 100% between these two reference points.

Current condition and trend

The 2006-2010 value of 11.2 dv indicates a significant concern (Figure 4.7). This represents a current condition of 0% attainment. The trend in these data indicate improving conditions in recent years (Figure 4.7). A national assessment of 10-year trends in visibility within 163 National Park units found that, throughout the country, 12 park units showed significant improvement, five significant decline and the remaining 146 showed no trend (NPS ARD 2010). Considering data from the haziest days in the eastern U.S., several of the parks in Virginia showed possible or significant improvement from 1999 to 2008 (Figure 4.8).

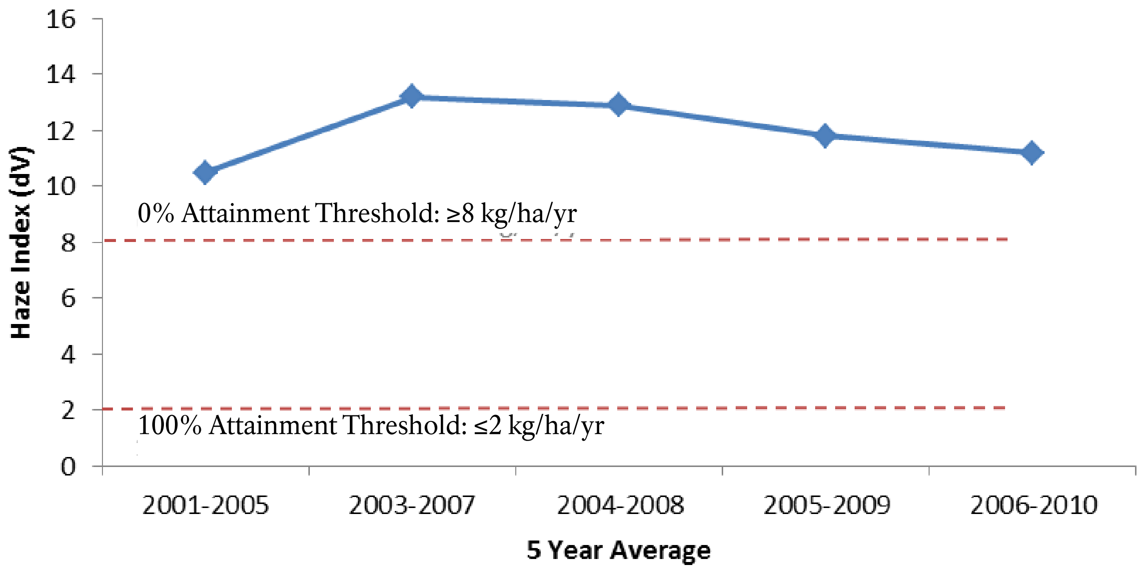
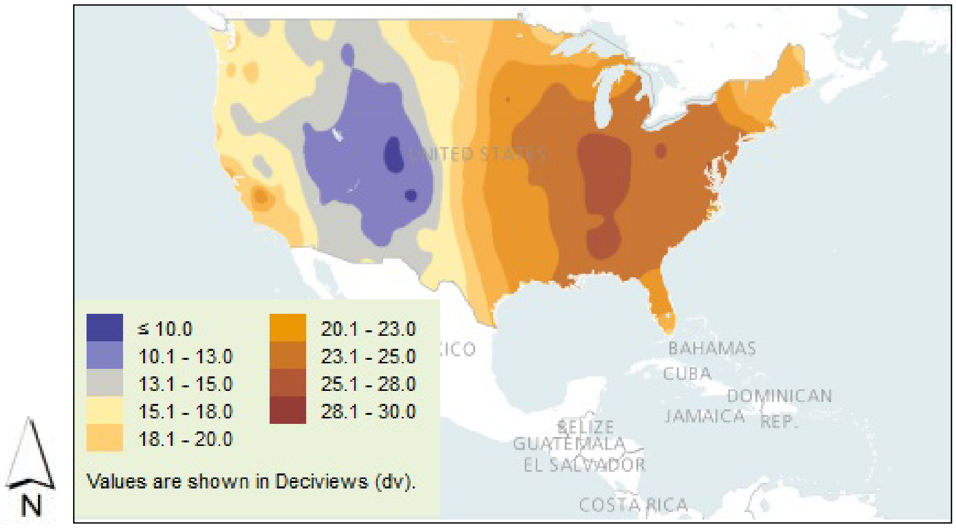


Figure 4.7 *Five-year average values of haze index (dv) for Petersburg National Battlefield (NPS ARD 2012).*

Figure 4.8 *Ten-year trends(1999-2008) in haziest day haze index (dv) for the United States (NPS ARD 2010).*



Data gaps and level of confidence

Data were collected from nearby stations rather than in the park, which contributes to the uncertainty of the assessment. Up to five IMPROVE (Interagency Monitoring of Protected Visual Environments) sites have been recommended in or near parks in the Mid-Atlantic Network. It is unlikely that any of these would be in Petersburg NB; however, all parks in the Mid-Atlantic Network will have an IMPROVE monitoring station within 115 miles. Confidence in the current assessment is fair.

Sources of expertise

Holly Salazer, NPS Northeast Region Air Resources Coordinator

Literature cited

Cheung HC, T Wang, K Baumann, H Guo. 2005. Influence of regional pollution outflow on the concentrations of fine particulate matter and visibility in the coastal area of southern China. Atmospheric Environmental. 39: 6463-6474.

National Park Service, Air Resources Division. 2010. Air quality in national parks: 2009 annual performance and progress report. Natural Resource Report NPS/NRPC/ARD/NRR—2010/266. National Park Service, Denver, CO. Available at http://www.nature.nps.gov/air/pubs/pdf/gpra/AQ_Trends_In_Parks_2009_Final_Web.pdf

National Park Service, Air Resources Division. 2011b. Rating air quality conditions. Natural Resource Report NPS/NRPC/ARD/NRR—2011/266. National Park Service, Denver, CO. Available at http://www.nature.nps.gov/air/planning/docs/20111122_Rating-AQ-Conditions.pdf

National Research Council. 1993. Protecting visibility in national parks and wilderness areas. Committee on Haze in National Parks and Wilderness Areas, National Academies Press. http://www.nap.edu/catalog/2097.html.

U.S. EPA. 2003. Guidance for estimating natural visibility conditions under the regional haze program. EPA-454/B-03-005

U.S. EPA. 2004a. The Clean Air Act. Washington United States Environmental Protection Agency, Washington D.C. http://epw.senate.gov/envlaws/cleanair.pdf

U.S. EPA. 2004b. Air Quality Criteria for Particulate Matter. Vol I of II. EPA/600/P-99/002aF. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

U.S EPA. 2006. Provisional Assessment of Recent Studies on Health Effects of Particulate Matter Exposure. http://cfpub.epa.gov/ncea/CFM/recordisplay.cfm?deid=151826

4.1.5 Mercury Deposition

Relevance and context

Atmospheric Mercury (Hg) comes from natural sources (e.g. volcanoes, geothermal activity, and geological weathering) and anthropogenic sources (e.g. burning of fossil fuels), processing of mineral ores, and incineration of certain waste products (UNEP 2008). At a global scale, annual anthropogenic emissions of mercury approximately equal all natural marine and terrestrial emissions. Anthropogenic emissions in North America amounted to approximately 153 tonnes (168.7 tons) in 2005 (UNEP 2008). Exposure of humans and other mammals to mercury in utero can result in mental retardation, cerebral palsy, deafness, blindness and dysarthria (speech disorder). Exposure as adults can lead to motor dysfunction and other neurological and mental impacts (U.S. EPA 2001). Terrestrial vertebrates are often exposed to mercury through the ingestion of food, water, and soil (Rattner and Ackerson 2006). Avian species' reproductive potential is negatively impacted by Hg. Measured trends in Hg deposition from west to east across North America can be observed in the common loon (*Gavia immer*), and throughout North America in mosquitoes (Evers et al. 1998, Hammerschmidt and Fitzgerald 2006). Mercury is also known to have a toxic effect on soil micro-flora (Meili et al. 2003). Although no ecological depositional threshold is currently established, the accumulation of mercury in organisms may effect key ecosystem processes (NPS 2013).

Data and methods

Data were obtained from the National Atmospheric Deposition Program, Mercury Deposition Network (MDN) for two sites; Harcum (VA98) in Gloucester County, Virginia (Figure 4.1) (http://nadp.sws.uiuc.edu/nadpdata/mdnsites.asp). Samples were collected weekly and within 24-hours of a precipitation event and analyzed for mercury concentration (measured in ng/L). Annual mean mercury concentrations were calculated for each sample site and compared to the threshold. Current condition was assessed for the year 2011. Trend was assessed from 2005 to 2011.

Threshold

The indirect regulatory threshold of 2 ng/L in rainwater is a modeled estimate of mercury in rainfall that may result in an Hg concentration of 0.5 mg/kg wet weight in inland fish (Meili et al. 2003). This threshold was estimated under a condition of low organic soils. It should be noted that highly humic soils in contrast are known to store large amounts of Hg that may later leach into inland waters, supplementing current atmospheric deposition (Meili et al. 2003). The threshold used for this assessment was 2 ng/L.

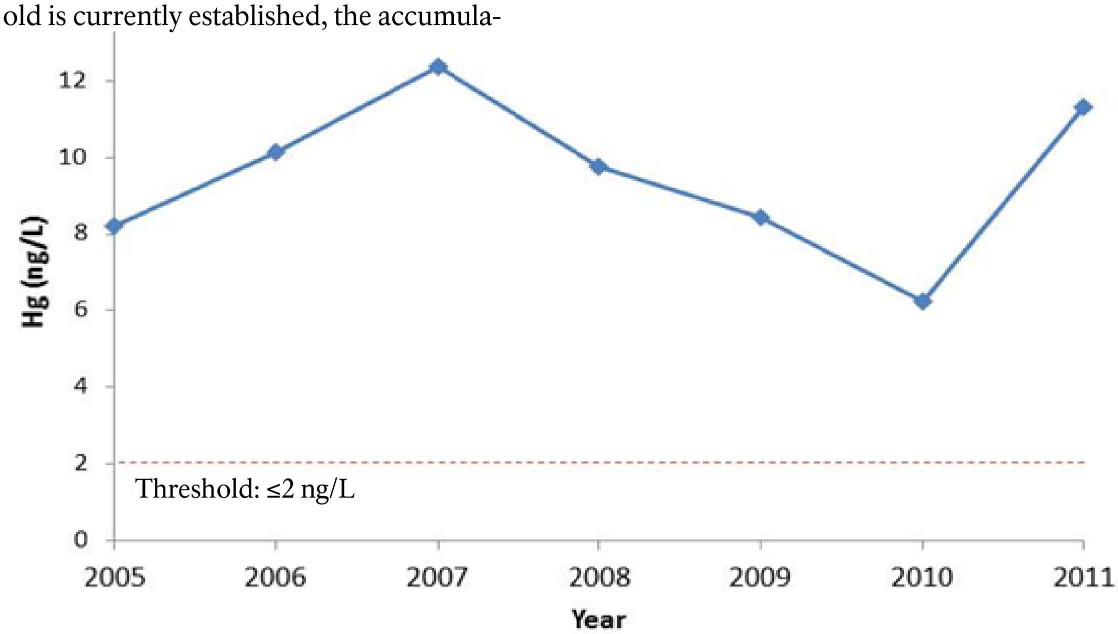


Figure 4.9 *Trends in mercury deposition in Petersburg National Battlefield from 2005-2011 (NADP MDN 2012; http://nadp.sws.uiuc.edu/nadpdata/mdnsites.asp).*

Current condition and trend

The 2011 value of 11.3 n/L indicates a significant concern (Figure 4.9). This represents a current condition of 0% attainment. From 2005 to 2011, no temporal trend was observed.

Data gaps and confidence in assessment

Data were collected from nearby stations and not from within the park. The seven years of data available do not indicate a significant trend. Confidence in the assessment is fair.

Sources of expertise

Peter Sharpe, Northeast Regional NRCA Coordinator

Literature cited

Evers DC, JD Kaplan, WM Meyer, PS Reaman, A Major, N Burgess, and WE Braselton. 1998b.Geographic trends of mercury measured in Common Loon feathers and blood across North America. Environ. Tox. Chem. 17:173-183.

Hammerschmidt CR, WF Fitzgerald (2006) Methylmercury in freshwater fish linked to atmospheric mercury deposition. Environmental Science and Technology 40: 7764-7770.

Meili M, K Bishop, L Bringmark, K Johansson, J Muthe, H Sverdrup, and W de Vries. 2003. Critical levels of atmospheric pollution: Criteria and concepts for operational modeling of mercury in forest and lake ecosystems. Science of the Total Environment 304: 83-106.

National Park Service. 2013. Effects of air toxics/mercury on ecosystems. http://www.nature.nps.gov/air/AQBasics/mercury.cfm

Rattner BA and BK Ackerson. 2006. Contaminant exposure and potential effects on terrestrial vertebrates residing in the National Capital region network and Mid-Atlantic network.National Park Service, National Capital Region, Center for Urban Ecology. Washington, D.C.

UNEP 2008 Annual Report. Rep. no. 978-92-807-2007-9. UNEP Division of Communication and Public Information, 2009.

U.S. EPA. 2004. The Clean Air Act. Washington United States Environmental Protection Agency, Washington D.C. http://epw.senate.gov/envlaws/cleanair.pdf

4.2 WATER QUALITY

4.2.1 Dissolved Oxygen

Relevance and context

Dissolved oxygen (DO) is a measure of the amount of oxygen contained in a body of water. Low DO concentrations can limit growth, species and population size, community richness, and ecosystem diversity (Breitburg 2002). The amount of oxygen in streams is inversely correlated with anthropogenic stresses such as fertilizer runoff and the dumping of sewage into waterways (Correll 1988, Prasad et al. 2011). As nutrient levels increase in aquatic systems due to these types of human activities, algae populations can proliferate leading to a depletion of oxygen in the water. The anoxic conditions that result affect nutrient cycling and stream biogeochemistry in potentially toxic ways (Brush 2009). The Chesapeake Bay has experienced significant eutrophication from prolonged anoxic conditions over the past 50 years (Cooper and Brush 1991, Murphy et al. 2011).

Data and methods

DO data were collected in accordance with the Mid-Atlantic Network's Vital Signs Monitoring Protocol using the YSI Pro Plus water quality meter (NPS 2008). Samples were collected monthly from June 2010 to April 2012. For some sites an additional sample was available from August 2009. Five sample sites were located within the park's Eastern Front unit: one site along Poor Creek just before the creek exits the park, one site along Harrison Creek just before the creek is intersected by Washington Street, one site on Branch Creek near the confluence with Harrison Creek, one site on Taylor's Creek near the confluence with Poor Creek, and one sample site on the northernmost point of an unnamed stream near Mortar Loop Trail (Figure 4.10a). The Five Forks unit has four sample sites within the park and one outside the park boundary within Hatcher's Run (Figure 4.10b). Percent attainment was calculated for this metric as the percent of DO measurements that were above the regulatory threshold value.

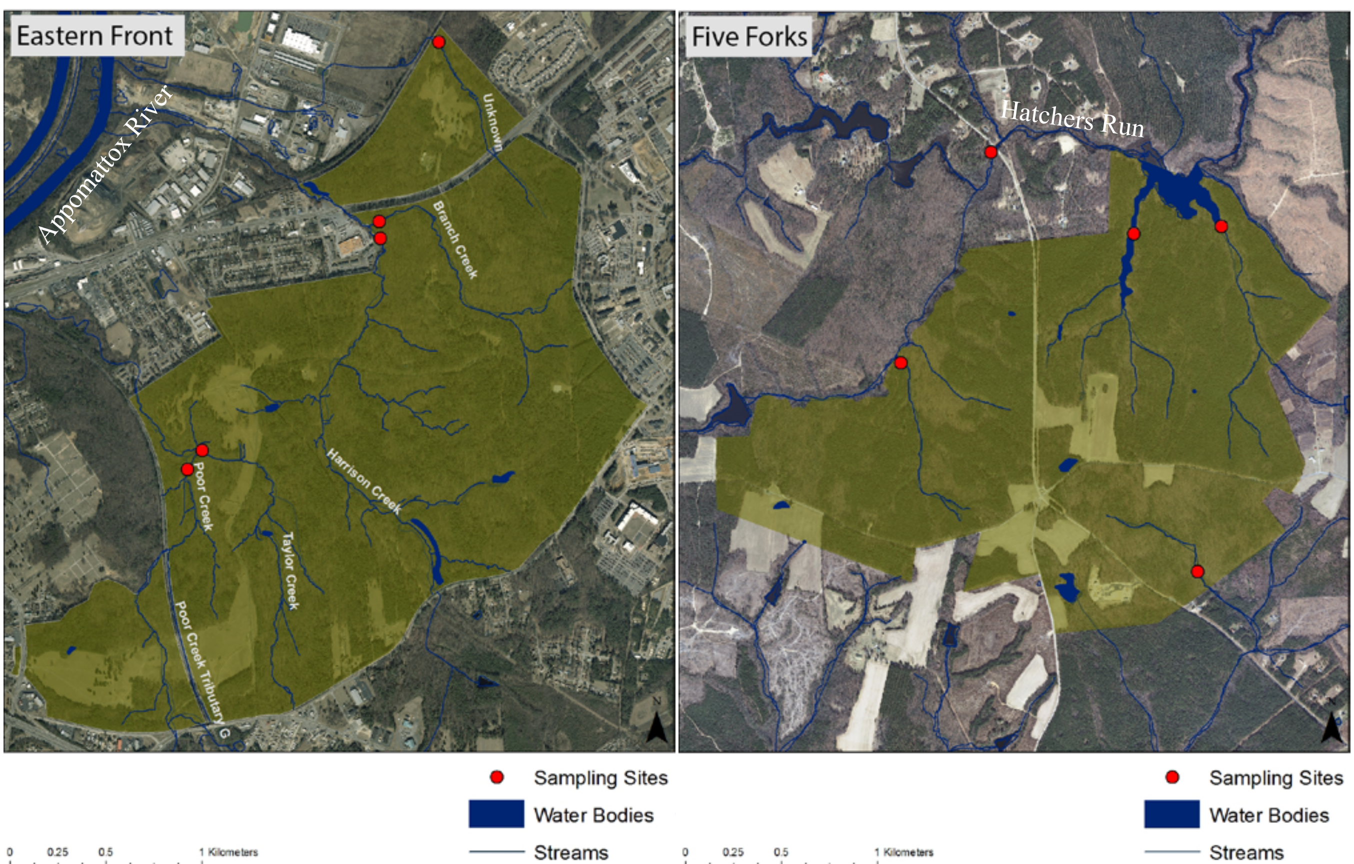


Figure 4.10 (a) *Water quality sampling locations for all indicators except benthic macroinvertebrates in the Eastern Front unit (left) and* **(b)** *Five Forks unit (right) (NPS 2008).*

Threshold

The Virginia Department of Environmental Quality sets regulatory threshold levels for DO with enforcement consequences when not enforced (DEQ 2010). Within Class III non-tidal waters of the Coastal Plain and Piedmont, DO levels during the day should never drop below 4.0 mg/L and the average for a 24 hour period should not be less than 5.0 mg/L. Because the data collected in the park are not collected continuously throughout the day, the 5.0 mg/L value is used as the minimal threshold for the assessment.

Current condition and trend

Levels of DO within the park are in good condition, receiving high attainment rates (81% threshold attainment). DO is highly correlated with temperature. It fluctuates seasonally, peaking in winter months. The majority of the samples that had DO levels below the threshold were observed during the months of May through October , which is when water bodies are typically warmest (Figure 4.11). Spatially, the majority of the samples that had DO levels below the threshold were observed in the Five Forks unit. This is also an area where many sampling locations dry out during the summer and become isolated pools. Only 23 of the 48 samples (48%) collected in Five Forks unit had DO concentrations above 5.0 mg/L. The data show no long-term trend in DO levels in streams of Petersburg NB.

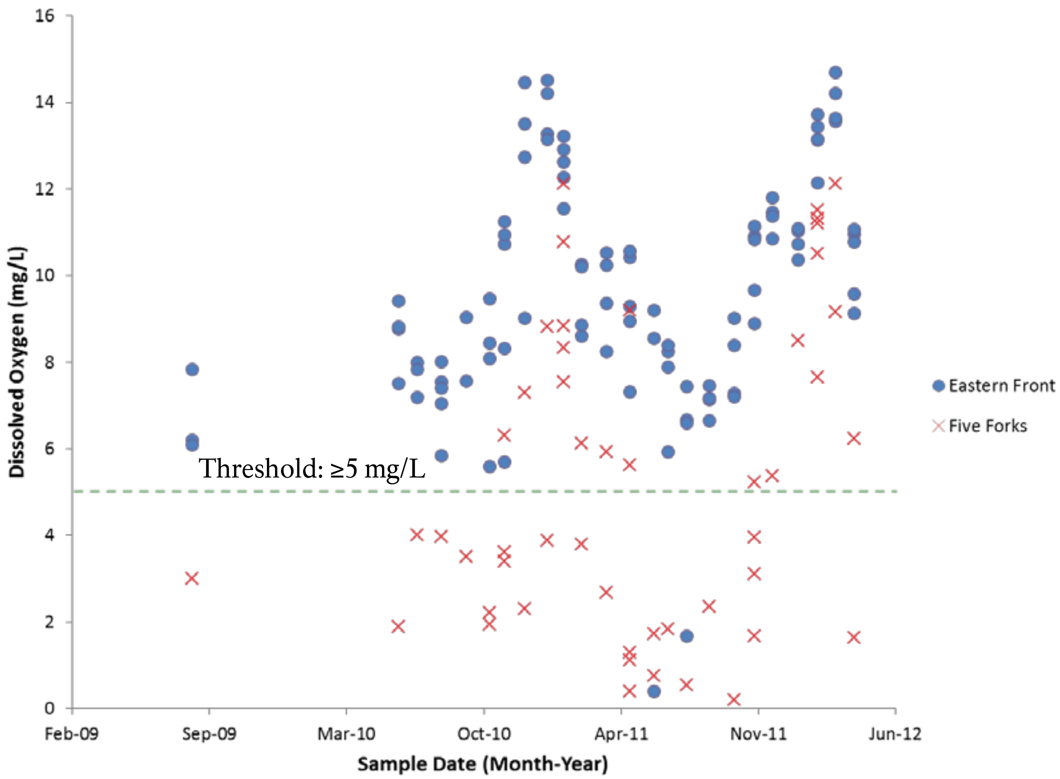
Data gaps and level of confidence

A total of 146 samples were collected: 48 from the Five Forks unit and 98 from the Eastern Front unit. However, the spatial coverage is sparse (5 sites per unit) and samples are collected only once per month. Monitoring of DO also has only recently been initiated in the park. Therefore, confidence in the trend assessment is low due to the short duration of the sample period. Confidence in the assessment of current condition is high due to the relatively large number of data points.

Sources of expertise

Nathan Dammeyer, Hydrologic Technician, Mid-Atlantic Network, Inventory and Monitoring Program, National Park Service

Figure 4.11 *Dissolved Oxygen levels from 10 sites within Petersburg National Battlefield (data from NPS Mid-Atlantic I&M Network 2012).*



Literature cited

Brush GS. 2009. Historical land use, nitrogen, and coastal eutrophication: A paleoecological perspective. Estuaries and Coasts 32:18-28.

Breitburg D. 2002. Effects of hypoxia and the balance between hypoxia and enrichment on coastal fishes and fisheries. Estuaries 25: 767-781.

Cooper SR and GS Brush. 1991. Long-term history of Chesapeake Bay anoxia. Science 254: 992-96.

Correll DL. 1998. The role of phosphorus in the eutrophication of receiving waters: A review. Journal of Environment Quality 27(2): 261-66.

Murphy RR, WM Kemp, and WP Ball. 2011. Long-term trends in Chesapeake Bay seasonal hypoxia, stratification, and nutrient loading. Estuaries and Coasts 34: 1293-1309.

National Park Service. 2008. Mid-Atlantic Network Vital Signs Monitoring Plan. Natural Resource Report NPS/MIDN/NRR—2008/071.

Prasad M, B Krishna, W Long, X Zhang, RJ Wood, and R Murtugudde. 2011. Predicting dissolved oxygen in the Chesapeake Bay: Applications and implications. Aquatic Sciences 73: 437-352.

Virginia Department of Environmental Quality. 2010. 9VAC25-260-50. Numerical criteria for dissolved oxygen, pH, and maximum temperature. Richmond.

4.2.2 Water Temperature

Relevance and context

Water temperature strongly influences aquatic processes and biota. The mean temperature of Mid-Atlantic streams has increased significantly over the past 50 years (Isaac and Wijingaarden 2012). Changes in water temperature can be triggered by anthropogenic disturbances associated with climate change, urbanization, and deforestation among others (Klein 1979, Nelson and Palmer 2007, Okazi et al. 2008, Najjar et al. 2009). Stream temperatures in urban settings can be elevated by heating of runoff from paved surfaces and by the lack of canopy shading along stream riparian areas (LeBlanc et al. 1997, Herb et al. 2008). Some evidence suggests that stream temperatures are more affected by impervious surfaces in the Piedmont region than the Coastal Plain (Utz et al. 2011). If water temperatures change too rapidly or drastically, fish and macroinvertebrate survival can be reduced (Morgan and Cushman 2005, Utz et al. 2009).

Data and methods

Water temperature data were collected in accordance with the Mid-Atlantic Network's Vital Signs Monitoring Protocol using the YSI Pro Plus water quality meter (NPS 2008). Samples were collected monthly from June 2010 to April 2012. For some sites an additional sample was available from August 2009. Five sample sites were within the park's Eastern Front unit: one site along Poor Creek just before the creek exits the park, one site along Harrison Creek just before the creek is intersected by Washington Street, one site on Branch Creek near the confluence with Harrison Creek, one site on Taylor's Creek near the confluence with Poor Creek, and one sample site on the northernmost point of an unnamed stream near Mortar Loop Trail (Figure 4.10a). The Five Forks unit has four sample sites within the park and one outside the park boundary on Hatcher's run (Figure 4.10b). Percent attainment was calculated for this metric as the percent of temperature measurements that were lower than the threshold value.

Threshold

The criteria for maximum stream temperature is at the discretion of the state. The Virginia Department of Environmental Quality determined the maximum stream temperature outside of the mixing zone is 32˚C (89.6˚F) for Class III non-tidal waters (VA DEQ 2010). Streams found to exceed this maximal value are classified to be "endangered" systems.

Current condition and trend

Water temperature within the park is in very good condition (Figure 4.12). All temperature measurements were less than the established threshold (100% threshold attainment). The highest recorded temperatures were 29.9˚C in the Five Forks unit and 26.7˚C in the Eastern Front unit. These temperatures indicate that the park's water bodies are well within the recommended limits defined by the Commonwealth. Seasonal fluctuations are apparent in Figure 4.12, but the time-series is of insufficient length to assess annual trend with any confidence.

Data gaps and level of confidence

The spatial coverage is sparse (5 sites per unit) and data collection was initiated relatively recently. However, all of the 144 samples were well under the threshold value. Confidence in the trend assessment is low due to the short duration of monitoring. Confidence in the assessment of current condition is high due to the relatively large number of data points.

Sources of expertise

Nathan Dammeyer, Hydrologic Technician, Mid-Atlantic Network, Inventory and Monitoring Program, National Park Service

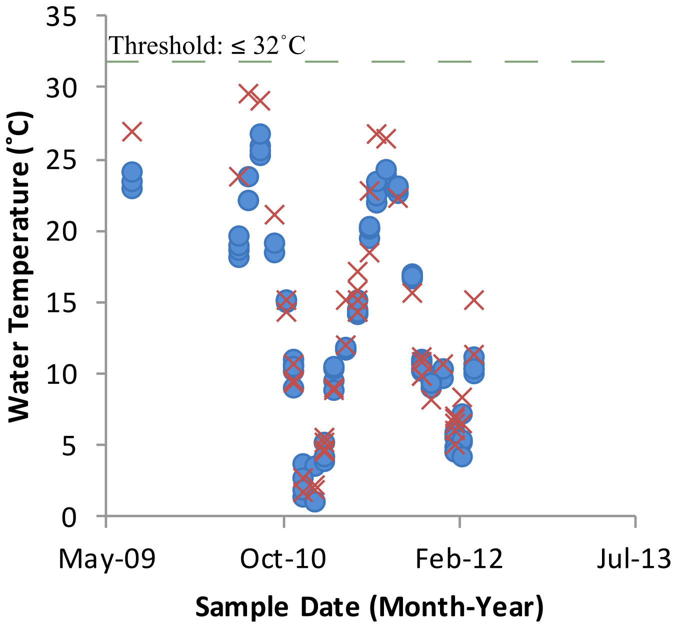


Figure 4.12 *Stream temperatures over time from 10 sites within Petersburg National Battlefield (data from NPS Mid-Atlantic I&M Network 2012).*

Literature cited

Herb WR, B Janke, O Mohseni, and HG Stefan. 2008. Thermal pollution of streams by runoff from paved surfaces. Hydrological Processes 22: 987-999.

Isaac V, and WA Van Wijingaarden. 2012. Surface water vapor pressure and temperature trends in North America during 1948-2010. Journal of Climate 25(10): 3599-609.

Klein RD. 1979.Urbanization and stream quality impairment. Journal of the America Water Resources Association 15(4):948-63.

LeBlanc RT, RD Brown, and JE Fitzgibbon. 1997. Modeling the effects of land use change on the water temperature in unregulated urban streams. Journal of Environmental Management 49:445-469.

Morgan RP, and SE Cushman. 2005. Urbanization effects on stream fish assemblages in Maryland, USA. Journal of the North American Benthological Society 24: 643-655.

Najjar R, CR Pyke, MB Adams, D Breitburg, C Hershner, M Kemp, R Howarth, MR Mulholland, M Paolisso, and D Secor. 2009. Potential climate-change impacts on the Chesapeake Bay. Estuarine, Coastal and Shelf Science 86: 1-20.

National Park Service. 2008. Mid-Atlantic Network Vital Signs Monitoring Plan. Natural Resource Report NPS/MIDN/NRR—2008/071.

Nelson KC, and MA Palmer. 2007. Stream temperature surges under urbanization and climate change: Data, models, and responses. Journal of the American Water Resources Association 43(2): 440-52.

Ozaki N, T Fukushima, and T Kojiri. 2008. Simulation of the effects of the alteration of the river basin land use on river water temperature using the multi-layer mesh-typed runoff model. Ecological Modelling 215(1-3): 159-69.

Utz RM, RH Hilderbrand, and DM Boward. 2009. Identifying regional differences in threshold responses of aquatic invertebrates to land cover gradients. Ecological Indicators 9: 556-567.

Utz RM, KN Eshleman, and RH Hilderbrand. 2011. Variation in physicochemical responses to urbanization in streams between two Mid-Atlantic physiographic regions. Ecological Applications 21: 402-415.

Virginia Department of Environmental Quality. 2010. 9VAC25-260-50. Numerical criteria for dissolved oxygen, pH, and maximum temperature. Richmond, VA.

4.2.3 Water pH

Relevance and context

Aquatic biota are sensitive to fluctuations in pH level. Water with either low pH (acidic) or high pH (basic) can be lethal by making toxic compounds more soluble (Sherman and Munster 2012, Driscoll et al. 2001). Acidic or basic environments also interfere with molecule structure and can render proteins and enzymes inactive (Driscoll et al. 2001). Aquatic system acidification is a concern in the region because of high levels of acid deposition, which is caused by sulfur and nitrogen emissions (Lovett et al. 2009).

Data and methods

Water pH data were measured in situ in accordance with the Mid-Atlantic Network's Vital Signs Monitoring Protocol using the YSI Pro Plus water quality meter (NPS 2008). Samples were collected from August 2009 to April 2012. Five sample sites were within the park's Eastern Front unit: one site along Poor Creek just before the creek exits the park, one site along Harrison Creek just before the creek is intersected by Washington Street, one site on Branch Creek near the confluence with Harrison Creek, one site on Taylor's Creek near the confluence with Poor Creek, and one sample site on the northernmost point of an unnamed stream near Mortar Loop Trail (Figure 4.10a). The Five Forks unit has four sample sites within the park and one outside the park boundary on Hatchers Run (Figure 4.10b). Percent attainment was calculated for this metric as the percent of pH measurements that were within an optimal pH range.

Threshold

The Environmental Protection agency (EPA) recommends an optimal range of 6.5-9.0 for in-situ measures of pH to be protective of aquatic life. The Virginia Department of Environmental Quality (DEQ) requires a slightly broader pH range from 6.0-9.0 for Class III non-tidal water of the Coastal Plain and Piedmont regions. This assessment uses the range of 6.0-9.0 as the state-specific criterion (NPS 1997; VADEQ 2010; EPA 2012).

Current condition and trend

The overall pH levels within Petersburg NB's waterways are in very good condition. Petersburg had a very high threshold attainment rate (83%). The streams of the Five Forks unit are generally more acidic that those of the Eastern Front unit. The data indicate a stable trend (Figure 4.13.

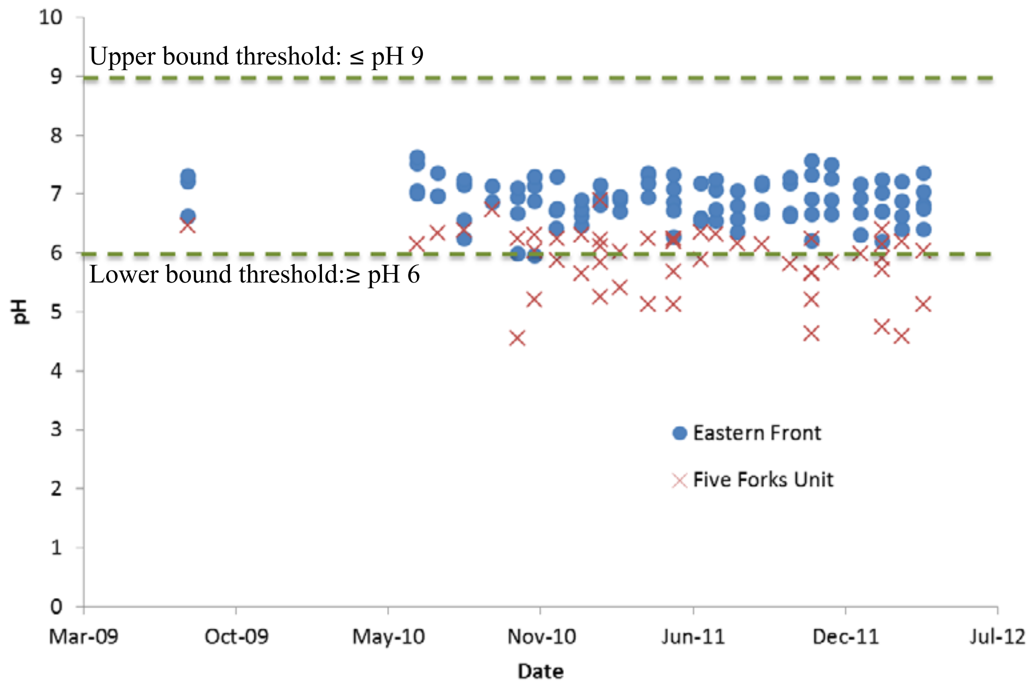


Figure 4.13 *pH levels from 10 water bodies within Petersburg National Battlefield. The green lines represent the maximal and minimal threshold values of 6.0 and 9.0 (data from NPS Mid-Atlantic I&M Network 2012).*

Data gaps and level of confidence

Both temporal and spatial variability in the measured values are relatively low, and nearly 100% of the measurements are within the desired range. The streams of the Eastern Front are better represented in the data than the streams of the Five Forks unit. Twenty-four of the 50 samples from the Five Forks unit were taken from Hatchers Run. Confidence in the trend assessment is low due to the short duration of monitoring. Confidence in the assessment of current condition is high due to the relatively large number of data points.

Sources of expertise

Nathan Dammeyer, Hydrologic Technician, Mid-Atlantic Network, Inventory and Monitoring Program, National Park Service

Literature cited

Driscoll CT, GB Lawrence, AJ Bulger, TJ Butler, CS Cronan, C Eagar, KF Lambert, GE Likens, JL Stoddard, and KC Weathers. 2001. Acidic deposition in the Northeastern United States: Sources and inputs, ecosystem effects, and management strategies. BioScience. 51(3):180.

Environmental Protection Agency. 2012. Clean Water Act: Aquatic life criteria table. Washington DC: GPO.

Lovett GM, TH Tear, DC Evers, SEG Findlay, BJ Cosby, JK Dunscomb, CT Driscoll, and KC Weathers. 2009. Effects of Air Pollution on Ecosystems and Biological Diversity in the Eastern United States. Pages 99-135 in Year in Ecology and Conservation Biology 2009. Blackwell Publishing, Oxford.

National Park Service. 2008. Mid-Atlantic Network Vital Signs Monitoring Plan. Natural Resource Report NPS/MIDN/NRR—2008/071.

National Park Service. 1997. Baseline water quality data inventory and analyses: Petersburg National Battlefield. Washington DC: GPO.

Sherman E and K Van Munster. 2012. Pond pH, acid tolerance, and water preference in newts of Vermont. Northeastern Naturalist 19(1): 111-22.

Virginia Department of Environmental Quality. 2010. 9VAC25-260-50. Numerical criteria for dissolved oxygen, pH, and maximum temperature. Richmond, VA.

4.2.4 Benthic Macroinvertebrates

Relevance and context

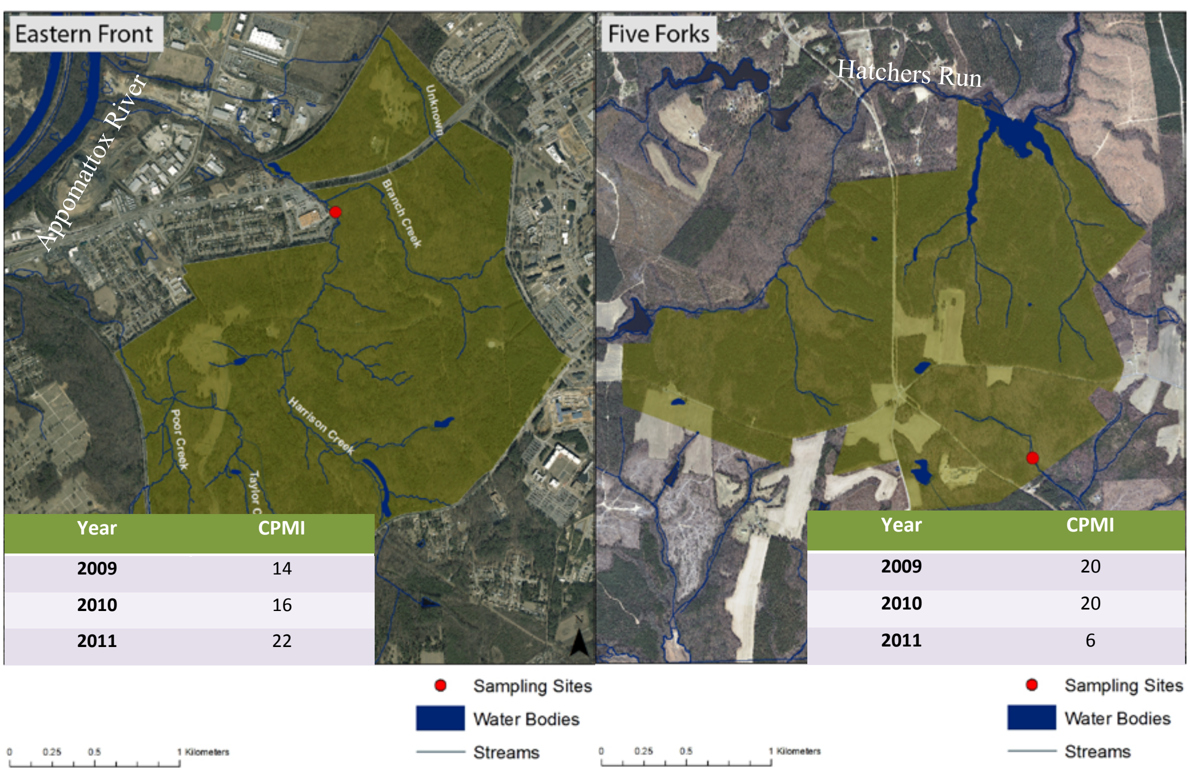
Benthic macroinvertebrates are aquatic organisms that are visible to the eye and lack an internal skeleton. They serve as useful bio-indicators of ecosystem health because they typically have limited mobility, have known and differing tolerances to various toxic compounds, live in water for the majority of their lives, are relatively easy to collect and often live for more than a year (Gaufin and Tarzwell 1952, EPA 1990, Utz et al. 2009). They are also easily collected in the field (Klauda et al. 1998). Common measures that have been used to report on ecosystem health include benthic macroinvertebrate abundance, diversity, location and spatial configuration (Barbour et al. 1999, Maloney and Feminella 2006).

Data and methods

Benthic macroinvertebrate monitoring was conducted by the Mid-Atlantic Inventory and Monitoring Network from 2009 to 2011 at two of the 10 water quality sample sites (NPS 2011). One site was located on Harrison Creek in the Eastern Front unit (Figure 4.14a), and one was located on Gravelly Brook in the Five Forks unit (Figure 4.14b). A 100-m stream reach was sampled at each site using a dip net in microhabitats where benthic macroinvertebrates would ordinarily flourish. In Virginia, the Coastal Plain Macroinvertebrate Index (CPMI) is typically used to assess benthic macroinvertebrates in the Coastal Plain physiographic region. Streams were given a numerical score in accordance with the CPMI (Voshell and Hiner 2012).

Threshold

The CPMI scale varies from 0-30. The scale does not incorporate odd numbers, only even numbered scores can be determined. For the purpose of this assessment, all scores 16 and above were given a 100% attainment, and any scores less than 16 were given a 0% attainment (Voshell and Hiner 2012). Within this classification scheme, scores could be further refined by assessing any values 24 or above as in "very good" condition and streams with scores of 6 or lower as in "very poor condition" (Maxted et al. 1999).



Year	CPMI
2009	14
2010	16
2011	22

Year	CPMI
2009	20
2010	20
2011	6

Figure 4.14 (a) *Sample locations and CPMI scores for benthic macroinvertebrates in the Eastern Front unit (left) and* **(b)** *the Five Forks unit (right) (NPS 2008).*

Current condition and trend

The site located within the Eastern Front unit on Harrison Creek received a score of 16 or greater for 2010 and 2011 but not 2009 (67% attainment). The site located within the Five Forks unit received a CPMI score of 20 in 2009 and 2010 but dropped to 6 in 2011 (67% attainment). A score of 67% was given to the entire park based on two of the six samples falling below the threshold. The data do not indicate a consistent temporal trend for the park.

Data gaps and level of confidence

Confidence in these findings is limited. Only two sites were tested, and each site was only sampled three times. Findings are subject to inter and intra-annual fluctuations. The spatial resolution of the data set is also very poor.

Sources of expertise

Reese Voshell, Jr., Appalachian Aquatic Consultants

Literature cited

Barbour MT, J Gerritsen, BD Snyder, and JB Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Gaufin AR and CM Tarzwell. 1952. Aquatic invertebrates as indicators of stream pollution. Public Health Reports 67: 57-64.

Klauda R, P Kazyak, S Stranko, M Southerland, N Roth, and J Chaillou. 1998. Maryland Biological Stream Survey: A state agency program to assess the impact of anthropogenic stresses on stream habitat quality and biota. Environmental Monitoring and Assessment 51: 299-316.

Maloney K and J Feminella. 2006. Evaluation of single-and multi-metric benthic macroinvertebrate indicators of catchment disturbance over time at the Fort Benning Military Installation, Georgia, USA. Ecological Indicators 6(3): 469-84.

Maxted JR, MT Barbour, J Gerritsen, V Poretti, N Primrose, A Silvia, D Penrose, and R Renfrow. 1999. Assessment framework for the Mid-Atlantic coastal plain streams using benthic macroinvertebrates. US EPA. Fort Meade, Maryland: Mid-Atlantic Integrated Assessment Programs.

National Park Service. 2011. Macroinvertebrate resource brief. Fredericksburg: Mid-Atlantic Network. US EPA. 1990. Impacts on quality of inland wetlands of the United States: A survey of indicators, techniques, and applications of community level biomonitoring data. Washington DC: GPO.

Utz RM, RH Hilderbrand, and DM Boward. 2009. Identifying regional differences in threshold responses of aquatic invertebrates to land cover gradients. Ecological Indicators 9: 556-567.

Voshell Jr JR and S Hiner. 2012. Draft Benthic macroinvertebrate monitoring protocol for the Mid-Atlantic Network. Natural Resource Technical Report. National Park Service, Fort Collins, Colorado.

4.3 BIOLOGICAL INTEGRITY

4.3.1 Bald Eagles (Species of Special Concern)

Relevance and Context

Bald Eagles are a culturally significant but historically threatened species. Before the human colonization of the Chesapeake Bay region, it is estimated that the Bald Eagle population was approximately 3,000 breeding pairs. By 1970 the Bald Eagle had declined to an estimated 60 breeding pairs. They were listed as endangered in March 1967. The decline in population is attributed mainly to contamination by dichlorodephenyl trichloroethane (DDT), but also to land clearing, overfishing, land development, and other habitat disturbances (Watts et al. 2007). Bald Eagles require large trees for nesting, access to water, and open mature vegetation structure because of their large wing-span and size (Andrew and Mosher 1982). Human disruption of foraging or nesting areas may lead to a complete abandonment of an area. Bald Eagles prey on predominately fish, but also mammals, birds, and reptiles(Watts et al. 2007).

As of August 2007, the Bald Eagle is no longer listed on the Endangered and Threatened Wildlife and Plants List, with over 9,000 breeding pairs in the continental United States (Figure 4.15) (USFWS 2007). The successful recovery has exceeded all goals and is attributed to the elimination of pesticides (specifically DDT) and territory management (Watts et al. 2008). Offspring survival has also increased in the Chesapeake Bay Region, as the population doubles every 8.2 years (Watts et al. 2008).

The Chesapeake Bay region is important in the success of all Atlantic Coast Bald Eagles; it serves as a migratory destination for both the Southern and Northern Bald Eagle populations. Maryland and Virginia support more than 90% of the over 600 breeding pairs currently residing in the Bay watershed (Watts et al. 2007). In Virginia, Bald Eagle populations have been increasing since 1977, except for 2004 which saw a decrease of 2% in population size (Figure 4.16 and Figure 4.17) (Watts and Byrd 2011).Although the Bald Eagle has been removed from the Threatened and Endangered Species list, they must be protected and monitored for 20 years with updates every 5 years in accordance with the U.S. Fish and Wildlife Service. The Bald Eagle is still protected under the Bald and Golden Eagle Protection Act of 1940 and the Migratory Bird Treaty Act of 1972 (USFWS 2007).

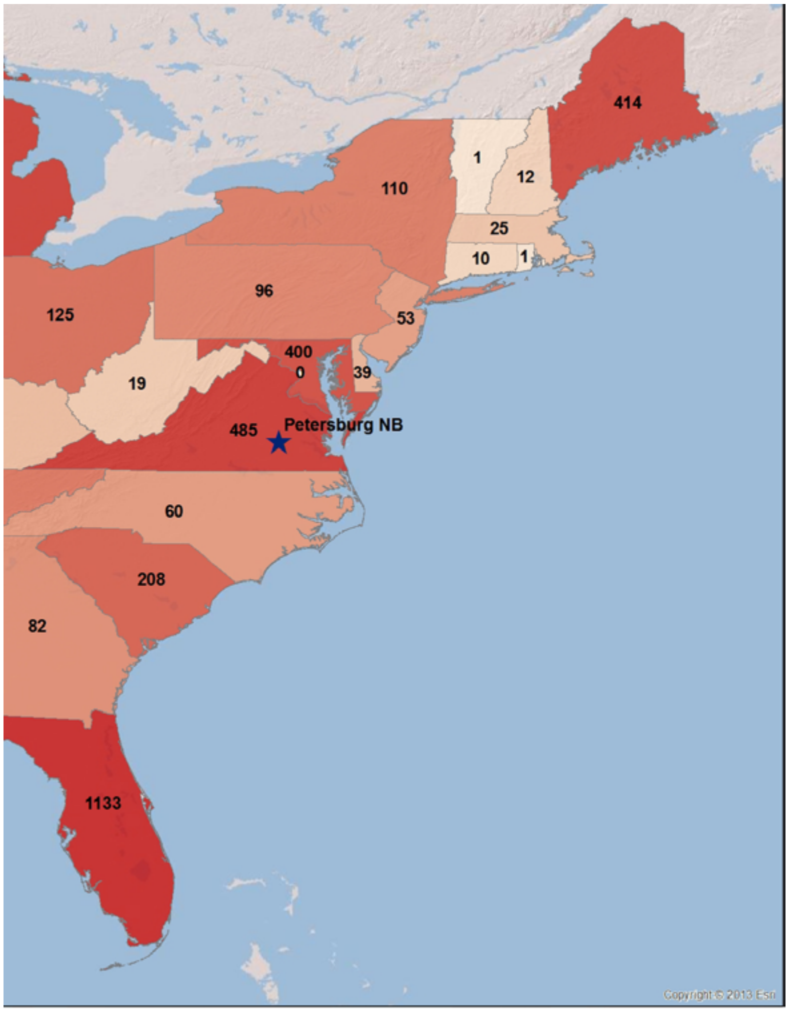
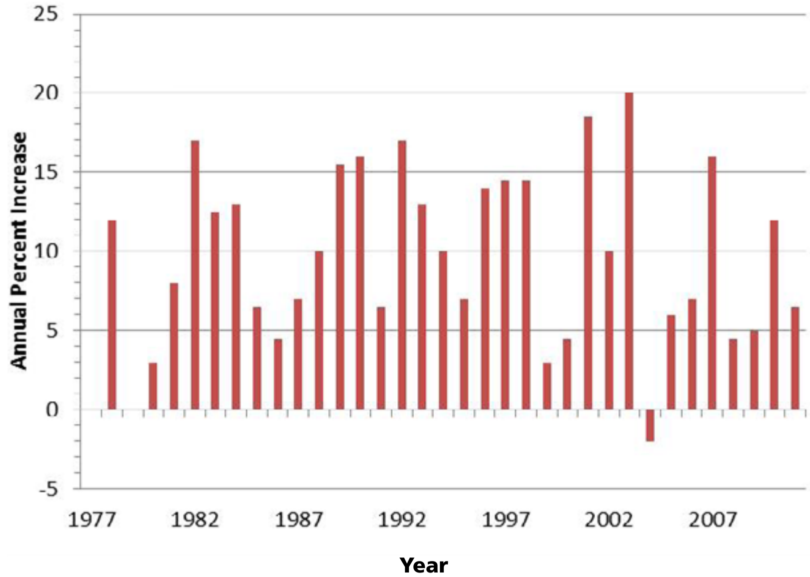


Figure 4.15 *Bald Eagle breeding pair distributions in the eastern United States as of 2004 (USFWS 2007).*



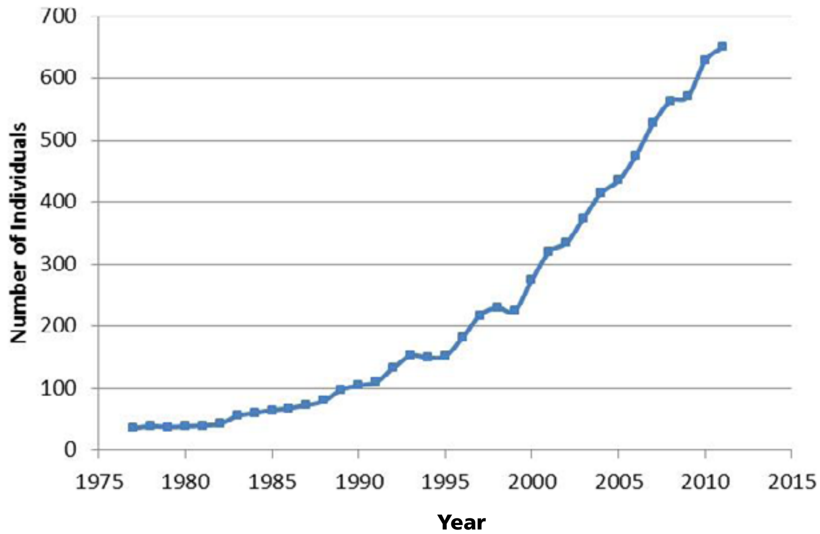


Figure 4.16 (Top) *Annual percent increase in Virginia Bald Eagle population 1977-2011 (Watts and Byrd 2011).*

Figure 4.17 (Bottom) *Increase in Bald Eagle population size in Virginia from 1977-2011 (Watts and Byrd 2011).*

Data and methods

Bald Eagle densities have not been estimated directly for Petersburg NB. Data for the assessment of Bald Eagles was based on qualitative park staff observations from December 2003 to 2011. A breeding pair of eagles has been observed to have 1-2 hatchlings every year since their arrival at the park. The park closes off a 750-foot perimeter around the nest from December 15 to July 15 to support breeding success, as recommended by the Virginia Department of Game and Inland Fisheries and US Fish and Wildlife Service (Figure 4.18).

Threshold

The reference condition for Bald Eagles was based on the presence or absence of a breeding pair in the park. Less than 5% of Virginia's known breeding pairs exist in the Piedmont and Appalachian Mountain regions (Watts et al. 2011). A key requirement for Bald Eagles is nesting proximity to waterfront habitat (Andrew and Mosher 1982). Because of Petersburg's distance from coastal habitat and its location at the edge of the Piedmont region, the presence of a nesting pair of Bald Eagles in the park is significant. The park was given a rating of either 100% or 0% attainment based on the presence or absence of a breeding pair.

Current condition and trend

There has been a nesting pair of Bald Eagles observed in the Eastern Front unit every year since December of 2003. The pair is suspected of having previously nested in neighboring Fort Lee until their nest was destroyed in September 2003 by Hurricane Isabel. The presence of the breeding pair gives Petersburg NB an attainment of 100%.

National trends show Bald Eagle improvement due to an overall increase in population. During the 1970s, 417 breeding pairs were recorded; this number increased to 9,789 by 2007 in the contiguous United States (USFWS 2007). Estimates from the 1930s for the Chesapeake Bay Region were 600 to 800 breeding pairs, and today the region has 646 breeding pairs (Watts et al. 2008). Of all the chicks hatched in the state of Virginia over the past 35 years, 73% hatched within the past decade (Watts et al. 2011). Bald Eagle populations within Petersburg NB are stable with one breeding pair, while regional populations are increasing.

Data gaps and level of confidence

Despite no quantitative data for Bald Eagles in Petersburg NB, confidence is high that the current trend is stable due to the staff observations of the breeding pair for the past 9 years. However, further and more detailed monitoring of the pair and their breeding would be necessary to make a more accurate assessment of Bald Eagle reproductive success in the park.

Sources of expertise

Dana Bradshaw, Senior Biologist, Center for Conservation Biology, College of William and Mary.

Literature cited

Andrew JM and JA Mosher. 1982. Bald eagle nest site selection and nesting habitat in Maryland. The Journal of Wildlife Management 46(2):382-390.

U.S. Fish and Wildlife Services. 2007. Endangered and threatened wildlife and plants: Removing the Bald Eagle in the lower 48 states from the list of endangered and threatened wildlife. Department of Interior. 50 CFR Part 17(72):130.

Watts BD, GD Therres, and MA Byrd. 2007. Status, distribution, and the future of Bald Eagles in the Chesapeake Bay area. The Waterbird Society. 30:25-38.

Watts BD, GD Therres, and MA Byrd. 2008. Recovery of the Chesapeake Bay Bald Eagle nesting population. The Journal of Wildlife Management. 72(1):152-158.

Watts, BD and MA Byrd. 2011. Virginia Bald Eagle nest and productivity survey: Year 2011 report. Center for Conservation Biology Technical Report Series, CCBTR-11-11. College of William and Mary and Virginia Commonwealth University, Williamsburg, VA. 42 pp.

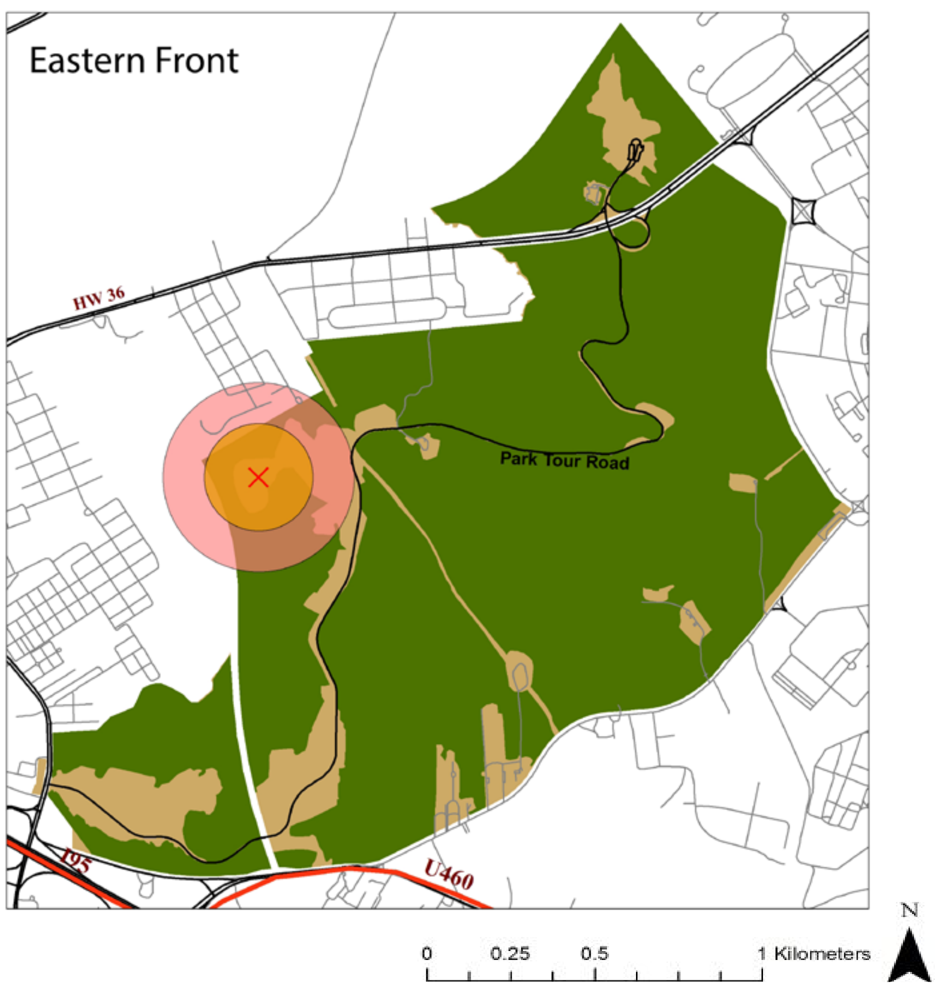


Figure 4.18 *The Bald Eagle nest and management buffers within Petersburg National Battlefield (December-July) (Watts and Byrd 2011).*

4.3.2 Forest Interior Dwelling Species

Relevance and context

Bird communities are often used as general indicators of ecosystem structure, function, and composition (Johnson and Patil 2007). Forest Interior Dwelling Species (FIDS) require dense, large areas of continuous mature forest cover. Therefore they are useful indicators of the health of forest ecosystems. FIDS are especially sensitive to the effects of disturbances (Canterbury et al. 2000). FIDS are also excellent indicators of ecosystem health because their habitat requirements correspond with those of many other species (Jones et al. 2000). Twenty-five species of FIDS breed in the Chesapeake Bay Critical Area, of which 13 species are highly area-sensitive and susceptible to forest loss, fragmentation, and habitat degradation (Jones 2000). The remaining twelve species of FIDS are still area-sensitive but can withstand more habitat degradation and fragmentation.

Data and methods

Data for the assessment were comprised of an 2003-2004 avian inventory of the park (Bradshaw 2008). The inventory survey data (Figure 4.19) were compared to a list of expected species developed from the Virginia Breeding Bird Atlas Project 1985-1989, the four nearest Breeding Bird Surveys over the last 20 years, and 10 years of Christmas Bird Count data. The park inventory data also were analyzed for the presence of critical and highly area-sensitive species as defined by Jones et al. (2000).

Threshold

The reference conditions for FIDS are the requirements set by Jones et al. (2000) related to overall forest habitat and quality. Presence of one highly area-sensitive FIDS is an indication of high quality habitat. Presence of six highly area-sensitive FIDS is considered exceptional habitat. A forest with less than four of the critical species (species that are not highly area-sensitive but still require large unfragmented forests) is considered poor quality habitat and a sign of significant habitat fragmentation (Jones et al. 2000). The presence, not breeding, of the birds was analyzed for this assessment. The park was given a rating of 100% or 0% based on the presence of one highly area-sensitive species or at least four critical species.

Current condition and trend

Of the 99 forest interior dwelling birds expected to occur in Petersburg NB, 96 were detected in the park inventory (Bradshaw 2008) (Appendix A). Of the 18 critical FIDS expected in the park, 17 were detected. The one critical species expected but not observed in the park was the Kentucky Warbler (*Oporornis formosus*). One highly

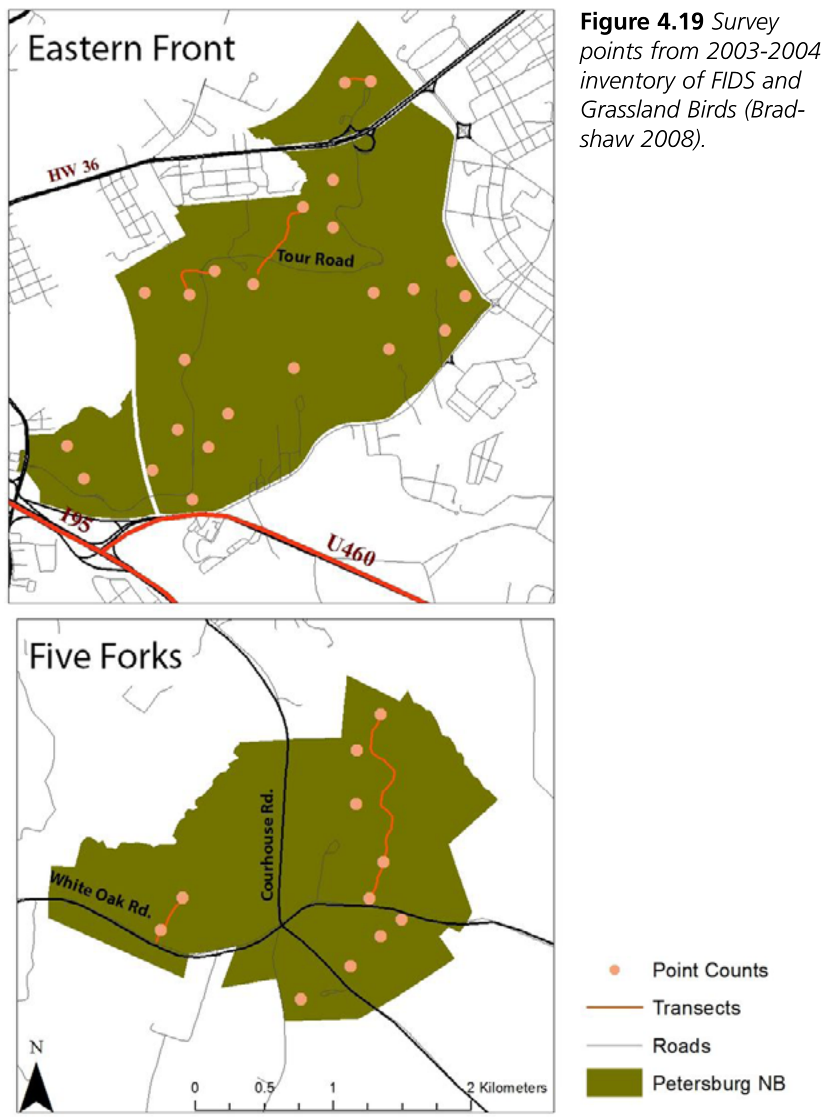


Figure 4.19 *Survey points from 2003-2004 inventory of FIDS and Grassland Birds (Bradshaw 2008).*

area-sensitive species that was unexpected was also detected: the Broad-winged Hawk (*Buteo platypterus*). Of the 18 species observed FIDS, eight were highly area-sensitive species (Table 4.2). These observations exceeded the threshold and the resource was considered in very good condition (100% attainment).

Sensitive species that were not expected nor found in the park were the Whip-poor-will (*Caprimulgus vociferous*) and the Veery (*Catharus fuscescens)*. Highly area-sensitive species that were not expected nor found in the park were Cerulean Warbler (*Dendroica cerulea)*, Worm-eating Warbler (*Helmitheros vermivorus*), and Swainson's Warbler (*Limnothlypis swainsonii*) (Bradshaw 2008).

Based on the first year of a new bird monitoring program just begun in the park (Figure 4.20), three highly area-sensitive species and six sensitive species were found. Based on these data, the score for the park in 2011 is also 100% (Goodwin and Wakamiya 2011).

Table 4.2 *Critical Forest Interior Dwelling Species observed in Petersburg National Battlefield during 2003-2004 inventory (Bradshaw 2008).*

Taxonomic Name	Common Name	Classification
Buteo lineatus	red-shouldered hawk	Highly Area-Sensitive
Buteo platypterus	broad-winged hawk	Highly Area-Sensitive
Certhia americana	brown creeper	Highly Area-Sensitive
Dendroica virens	black-throated green warbler	Highly Area-Sensitive
Dryocopus pileatus	pileated woodpecke	Sensitive
Empidonax virescens	Acadian flycatcher	Sensitive
Hylocichla mustelina	wood thrush	Sensitive
Mniotilta varia	black-and-white warbler	Highly Area-Sensitive
Parula americana	northern parula	Highly-Area Sensitive
Picoides villosus	hairy woodpecker	Sensitive
Piranga olivacea	scarlet tanager	Sensitive
Protonotaria citrea	prothonotary warbler	Sensitive
Seiurus aurocapillus	ovenbird	Sensitive
Seiurus motacilla	Louisiana waterthrush	Highly-Area-Sensitive
Setophaga ruticilla	American redstart	Highly-Area-Sensitive
Strix varia	barred owl	Highly-Area-Sensitive
Wilsonia citrina	hooded warbler	Highly-Area-Sensitive
Vireo olivaceus	red-eyed vireo	Sensitive

Figure 4.20 *Breeding Bird survey points established by NPS Inventory and Monitoring (Goodwin and Wakamiya 2011).*

Data gaps and level of confidence

Confidence in the current condition is high as it is supported by multiple measures and data sets. Surveying for the NPS I&M bird monitoring (Goodwin and Wakamiya 2011) took place during a different time period than the Bradshaw (2008) inventory. There were also differences in survey methods and frequency of surveying. The two data sets are not directly comparable, and a trend assessment of stable is made with these caveats.

Sources of expertise

Dana Bradshaw, Senior Biologist, Center for Conservation Biology, College of William and Mary

Literature cited

Bradshaw D. 2008. Petersburg national battlefield avian inventory. Technical Report NPS/NER/NRTR—2008/108. National Park Service, Philadelphia, PA.

Canterbury GE, TE Martin, DR Petit, LJ Petit, and DF Bradford. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. Conservation Biology 14: 2 544-558

Goodwin SE and Wakamiya, SM 2011. Breeding bird monitoring, Mid-Atlantic Network 2009 annual report. Natural Resource Data Series NPS/MIDN/ NRDS- 2011/142. National Park Service, Fort Collins, CO.

Johnson GD and GP Patil. 2007. Predictability of bird community-based ecological integrity using landscape variables. Cooperative Wetlands Center. 79-108

Jones C, J McCann, and S McConville. 2000. A guide to the conservation of forest interior dwelling birds in the Chesapeake Bay critical area. Report to the Critical Area Commission for the Chesapeake and Atlantic Coastal Bays. http://www.dnr.state.md.us/criticalarea/ tweetyjune_2000.pdf

4.3.3 Grassland and Shrubland Birds

Relevance and context

Individual species may not adequately reflect the overall health of an ecosystem. However, groups such as grassland and shrubland birds can effectively convey the health of an ecosystem and the effect of disturbances (Canterbury et al. 2000). Different grassland and shrubland species of birds require varying successional stages of vegetation. Grassland birds are defined as species that are dependent on grassland habitat for any part of their life (Vickery et al. 1999).Grassland birds are declining at a faster rate than any other group of birds in North America (Vickery et al. 1999). Species can be divided into at least 4 groups based on their habitat preferences (Peterjohn 2006a). Similarly, shrubland birds are defined as reliant on shrubby habitats for all or part of their life cycle (Peterjohn 2006b). Shrubland communities are generally dominated by shrubby or sapling vegetation and can be divided into three groups: transitional shrublands, young shrublands, and older shrublands.

Successional mixed shrubland in Petersburg National Battlefield

Photo Courtesy of Petersburg National Battlefield, NPS

Data and methods

Grassland bird species were categorized based on their habitat preferences as (1) cultivated fields or grazed pastures: highly disturbed areas; (2) young grasslands: transition areas between disturbed habitat and mature grasslands with taller, dense vegetation and a sparse litter layer; (3) mature grasslands: tall dense grasslands with a thick litter layer; and (4) other grasslands: areas that are affected by adverse weather conditions and support species that are rarely encountered in the Mid-Atlantic (Peterjohn 2006a). Shrubland species were divided into three categories based on their habitat preferences: (1) transitional shrublands have the youngest communities and represent the transition from bare soil to vegetation less than one meter tall; (2) young shrublands have woody vegetation less than three meters tall; and (3) older shrublands have greater than 90% cover by woody vegetation (Peterjohn 2006b).

Data were attained from the 2003-2004 avian inventory of the park (Figure 4.19; Bradshaw 2008). A list of expected species by each of the seven categories defined above was compiled from Peterjohn (2006a,b). The list of species detected at Petersburg NB was then compared to the list of species that should have been found in the parks' shrubland and grassland communities. It should be noted that the Eastern Front unit lacks grasslands although shrubland is present.

Supplemental data were attained from the recent NPS Inventory and Monitoring (I&M) breeding bird monitoring for the park (Goodwin and Wakamiya 2011).

Threshold

The attainment for grassland and shrubland birds was derived directly from the percentage of the seven functional groups present. The seven functional groups were defined as species with preferences for disturbed grasslands, young grasslands, mature grasslands, other grasslands, transitional shrubland, young shrubland, and older shrublands (Peterjohn 2006). Based on the avian inventory data, the park was given a rating of 0%, 14.3%, 28.6%, 42.9%, 57.2%, 71.5%, 85.5%, or 100% for the number of functional groups observed.

Current condition and trend

Five out of the seven functional groups were found in the 2003-2004 inventory (Table 4.3) (Bradshaw 2008); disturbed grasslands, young grasslands, transitional shrublands, young shrublands, and older shrublands. The park scored a 71.5% attainment, which is defined as in good condition. Each functional group, except for disturbed grasslands, had at least two species detected. The young shrubland group was best represented with 9 species found. Species that prefer mature and rare or other grassland habitats were not observed.

Table 4.3 *Petersburg National Battlefield grassland bird species observed in 2003-2004 by Bradshaw (2008) listed by their functional group.*

Taxonomic Name	Common Name	Functional Group
Passerculus sandwichensis	Savannah Sparrow	Disturbance Tolerant
Ammodramus savannarum	Grasshopper Sparrow	Young Grasslands
Sturnella magna	Eastern Meadowlark	Young Grasslands
Geothlypis trichas	Common Yellowthroat	Transitional Shrubland
Spizella pusilla	Field Sparrow	Transitional Shrubland
Melospiza melodia	Song Sparrow	Transitional Shrubland
Passerina cyanea	Indigo Bunting	Transitional Shrubland
Colinus virginianus	Northern Bobwhite	Transitional Shrubland
Vireo griseus	White- eyed Vireo	Young Shrubland
Dendroica discolor	Prairie Warbler	Young Shrubland
Icteria virens	Yellow-breasted chat	Young Shrubland
Thryothorus ludovicianus	Carolina Wren	Young Shrubland
Dumetella carolinensis	Gray Catbird	Young Shrubland
Toxostoma rufum	Brown Thrasher	Young Shrubland
Pipilo erythrophthalmus	Eastern Towhee	Young Shrubland
Cardinalis cardinalis	Northern Cardinal	Young Shrubland
Guiraca caerulea	Blue Grosbeak	Young Shrubland
Dendroica petechia	Yellow Warbler	Older Shrubland
Dendroica pensylvanica	Chestnut sided Warbler	Older Shrubland
Coccyzus americanus	Yellow-billed cuckoos	Older Shrubland

Data collected in 2011 during the first year of breeding bird monitoring by Petersburg NB (Figure 4.20) indicate the presence of four functional groups. Disturbed grasslands, young grasslands, and rare or other grasslands were not found. Young grassland species which were found in the 2003-2004 avian inventory were absent in the 2011 monitoring data. However, no trend assessment is made because of the disparity between the two data sets.

Data gaps and level of confidence

Confidence in the assessment of current condition was high. The 2003-2004 attainment level of 71.5% should be used as the current condition of the park because of the more in-depth and detailed nature of the inventory data which was collected in multiple seasons and included fixed point counts and opportunistic transect data collection (Bradshaw 2008). The 2011 monitoring survey differed in its methodology and was conducted only in the breeding season. The absence of young grassland species is notable in the 2011 monitoring data. However, any judgement of trend is reserved until additional years of monitoring data become available.

Sources of expertise

Dana Bradshaw, Senior Biologist, Center for Conservation Biology, College of William and Mary

Literature cited

Bradshaw D. 2008. Petersburg national battlefield avian inventory. Technical Report NPS/NER/NRTR—2008/108. National Park Service, Philadelphia, PA.

Cantebury GE, TE Martin, DR Petit, LJ Petit, DF Bradford. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. Conservation Biology 14: 2 544-558

Goodwin SE and Wakamiya, SM 2011. Breeding bird monitoring, Mid-Atlantic Network 2009 annual report. Natural Resource Data Series NPS/MIDN/NRDS- 2011/142. National Park Service, Fort Collins, CO.

Peterjohn B. 2006a. Conceptual ecological model for management of breeding grassland birds in the Mid-Atlantic region. Natural Resources Report NPS/NER/NRR—2006/005. National Park Service, Philadelphia, PA.

Peterjohn B. 2006b. Conceptual ecological model for management of breeding shrubland birds in the Mid-Atlantic region. Natural Resources Report NPS/NER/NRR—2006/005. National Park Service, Philadelphia, PA.

Vickery PD, PL Tubaro, JM Cardoso da Silva, PG Peterjohn, JR Herkert, and RB Cavalcanti. 1999. Conservation of grassland birds in the Western Hemisphere. Studies in Avian Biology 19: 2-26.

4.3.4 Mammal Richness

Relevance and context

Climatic and landscape change over prehistoric, historic, and modern time frames has altered the viability of animal species and other habitat within the Mid-Atlantic region (Bellows et al. 2001). Disturbance from natural and anthropogenic sources interrupted forest succession, affecting interior forest dwelling species. Grassland habitats, typically ephemeral due to forest succession, were maintained through anthropogenic disturbances such as fire. Habitat generalist species adapted to thrive in a landscape fragmented by development, agriculture, logging, and other uses. Following European settlement, populations of mammals declined dramatically and many were extirpated from the region, including bison (1797; *Bison bison*), elk (1855; *Cervus elephus*), mountain lion (1882; *Puma concolor*), fisher (1890; *Martes pennanti*), Eastern shore fox squirrel (1895; *Sciurus niger cinereus*), gray wolf (1910; *Canis lupus*), beaver (1911; *Castor canadensis*), and white-tailed deer (*Odocoileus virginianus*) and river otter (*Lontra canadensis*) in the early 20th century (Handley 1992).

Over the same time frame, non-native species began to invade the landscape. Invasive mammals in the region include the black rat (*Rattus rattus*) and Norway rats (*Rattus norvegicus*), the house mouse (*Mus musculus*), and nutria (*Myocastor coypus*). While many efforts to reintroduce species failed (e.g., elk, snowshoe hare (*Lepus americanus*), fisher, mountain lion), several were successful, including the restoration of white-tailed deer and beaver populations (Handley 1992). Today, Petersburg NB supports a diverse assemblage of mammals and habitats. Adequate habitat exists to sustain populations of grassland specialists such as the hispid cotton rat (*Sigmodon hispidus*). Wetland and riverine/riparian habitats support healthy populations of the American beaver and Northern river otter.

Mammals were chosen as an indicator for this assessment as they respond rapidly to change in habitat structure and plant composition (Abramsky 1978, Kaufman et al. 1983, Kincaid et al. 1983, Kaufman et al. 1998), and they occupy key positions in food webs, making them useful biological indicators of change (Dale and Beyeler 2001).

Data and methods

Mammal communities were surveyed from June 2003 - August 2004 (Pagels et al. 2005). The inventory utilized a variety of trap types, observations, and night-camera photographs to assess the presence of species. An expected species list was compiled based on literature searches, museum records, and 35 years of personal experience by John F. Pagels (Mammalogist, Virginia commonwealth University). A total of 38 mammalian species were expected to occur in Petersburg NB. The inventory included 15 sample sites at the Eastern Front unit and 17 sample sites at Five Forks unit (Figure 4.21). The sample sites for both units were located in field-forest edge, pine forest plantation, mixed pine-hardwood, hardwood, and

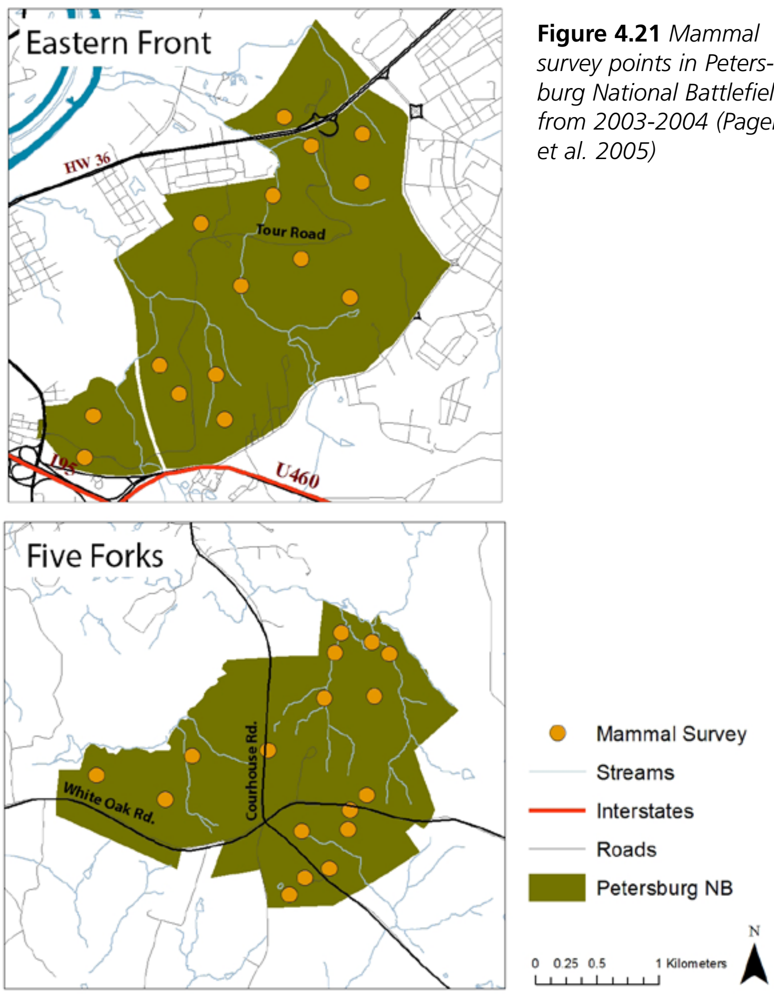


Figure 4.21 *Mammal survey points in Petersburg National Battlefield from 2003-2004 (Pagels et al. 2005)*

bottom land hardwood. Wetland habitat was also surveyed in the Five Forks unit only.

Threshold

The threshold for mammals is defined by the presence of expected species. The proportion of expected species observed established the percent attainment.

Current condition and trend

The overall condition for mammal communities in Petersburg NB was 61%. The Eastern Front unit had an attainment of 39%. The Five Forks unit achieved an attainment score of 50%. The White-footed mouse (*Peromyscus leucopus*) and short-tailed shrew (*Blarina sp.*) were the most commonly found species in both units. A total of 23 species were found (Appendix B). In the Eastern Front unit the Virginia opossum (*Didelphis virginiana*) and common raccoon (*Procyon lotor*) were found to be very abundant. Also in the Eastern Front, the common gray fox (*Urocyon cinereoargenteus*) was detected by night cameras. The Five Forks unit was found to have a greater richness and abundance than the Eastern Front unit. Coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) were both found in the Five Forks unit, although no fox and few raccoons were found. Based on the available data no trend assessment can be made.

Data gaps and level of confidence

Mammal data were limited to one survey done from 2003-2004. Confidence in the current assessment is therefore fair due to these limited data. Additional survey data would be useful in future assessments to formulate an assessment of trend for the park.

Source of expertise

John F. Pagels, Mammalogist Virginia Commonwealth University

Literature cited

Abramsky Z. 1978. Small mammal community ecology: Changes in species diversity in response to manipulated productivity. Oecologia 34: 113–123.

Bellows AS, JF Pagels, and JC Mitchell. 2001. Macrohabitat and microhabitat affinities of small mammals in a fragmented landscape on the upper Coastal Plain of Virginia. American Midland Naturalist 146(2): 345–360.

Dale VH and SC Beyeler. 2001. Challenges in the development and use of ecological indicators. Ecological Indicators 1: 3–10.

Handley Jr CO. 1992. Terrestrial mammals of Virginia: Trends in distribution and diversity. Virginia Journal of Science 43(1B): 157–170.

Kaufman DW, GA Kaufman, and EJ Finck. 1983. Effects of fire on rodents in tallgrass prairie of the flint hills region of eastern Kansas. Prairie Naturalist 15: 49–56.

Kaufman DW, GA Kaufman, PA Fay, JL Zimmerman, and EW Evans. 1998. Animal populations and communities. In AK Knapp, JM Briggs, DC Hartnett, and SL Collins (Eds.), Grassland dynamics (pp.113–139). New York: Oxford University Press.

Kincaid WB, GN Cameron, and BA Carnes. 1983. Patterns of habitat utilization in sympatric rodents on the Texas coastal prairie. Ecology 64: 1471–1480.

Pagels JF, AD Chupp, and AM Roder. 2005. Survey of mammals at Petersburg National Battlefield. Technical Report NPS/NER/NRTR—2005/027. National Park Service, Northeast Region. Philadelphia, Pennsylvania.

4.3.5 Herptile Communities

Relevance and context

Amphibian and reptile communities (i.e. herptiles) are found in a variety of habitat types (Semlitsch and Bodie 2003). Some herptile species, such as the box turtle (*Terrapene sp.*), are valuable indicators of ecological condition due to their longevity, and thus the accumulation of pollutants (Mitchell 2007). Amphibians and reptiles are also the top predators in some aquatic ecosystems (Gibbons 1988). Although they play a major role in both aquatic and terrestrial systems, herptile communities are suspected to be in decline in general (Gibbons 1988, Ryan et al. 2002). Habitat loss is one of the leading causes of population decline (Stuart et al. 2004) Other factors include habitat degradation, unsuitable habitat, invasive species, pollution, roads, disease, and climate change (Findlay and Bourdages 2000, Ryan 2001). The success of herptile communities is dependent on proper management of aquatic and terrestrial systems. Amphibians rely on aquatic habitats for parts of their life cycle and reptiles are dependent upon aquatic systems for foraging (Semlitsch and Bodie 2003).

Future management concerns for the herpetofauna of Petersburg NB are the effects of landscape management, use of pesticides on larvae, and the increase of predator populations (e.g. raccoons and domesticated cats). Additionally, the existence of roads in the park is dangerous for all species; snakes and turtles are particularly at risk and have been found dead on roadways. Roads may also prevent the migration of some species to necessary habitats (Mitchell 2007).

Data and methods

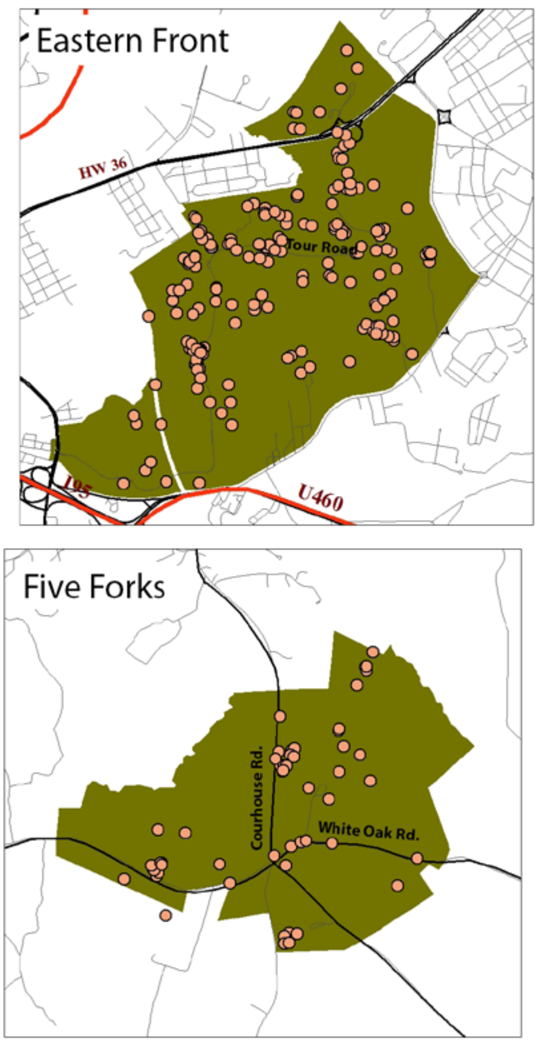
Herpetofauna were surveyed April-October 2002, February-December 2003, and June-July 2004 (Mitchell 2007). An expected species list was compiled using data from Mitchell (1994), Conant and Collines (1998), and Mitchel and Reay (1999). In total there were 24 amphibian and 32 reptile species expected to occur in Petersburg NB. Data were collected using a variety of sampling techniques dependent upon the taxonomic class; audio survey, road survey, dip net survey, minnow trap survey, turtle trap survey, and visual encounter survey were all used (Mitchell 2007).

Threshold

The threshold for herptile communities is defined by the presence of expected species. The proportion of expected species observed established the percent attainment.

Current condition and trend

The overall condition for herptile communities in the park was 86% with 48 of 56 expected species observed (Appendix C). For amphibians the current condition was 92% and the reptile condition was 81%. Comparatively, the Five Forks unit had greater species



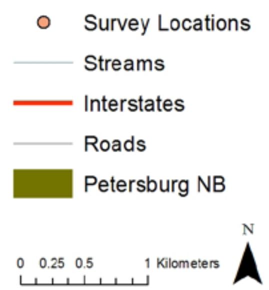


Figure 4.22 *Herpetofauna sample points from 2002-2004 inventory (Mitchell 2007).*

abundance than the Eastern Front unit. Frog, turtle, and lizard species abundance was greater in the Five Forks unit than the Eastern Front Unit. From the expected list, 90% of frogs, 100% of turtles, and 67% of lizards were detected in the Five Forks unit. The Eastern Front unit had a greater abundance of snake and salamander species with 69% and 50%, respectively, of the expected list detected.

Twelve of the 56 expected herptile species were not detected in the park. A total of 3 lizard species were not found: six-lined racerunner (*Cnemidophorus sexlineatus)*, broad-headed skink (*Eumces laticeps*), and slender glass lizard (*Ophisaurus attenuatus*). Three snake species were not observed: eastern kingsnake (*Lampropeltis getula*), northern ribbonsnake (*Thamnophis sauritus*), and rough eathsnake (*Virginia striatula*). One frog species was not found, the pickerel frog (*Rana palustris*). Five salamander species were not found at Petersburg NB: southern two-lined salamander (*Eurycea cirrigera*), four-toed salamander (*Hemidactylium scutatum*), red-backed salamander (*Plethodon cinereus*), eastern mud salamander (*Pseudotriton montanus*), northern red salamander (*Pseudotriton rubber)*. All of the expected turtle species were detected. Because of a lack of temporal data no trend can be established.

Data gaps and level of confidence

The secretive nature of some herpetofauna, specifically snakes, makes documenting their existence and abundance difficult. Additionally, appearance and abundance of herptile communities is largely dependent on temperature and moisture (Mitchell 2007). Survey techniques may have a large impact on the results of monitoring (Ryan et al. 2002). Generally, there is not a lot of long-term data on herpetofauna (Gibbons 1998), consistent with our inability to track trends. Confidence in the current condition is fair due to the age of the data used in the assessment.

Source of expertise

Joseph Mitchell, Department of Biology, University of Richmond

Literature cited

Findlay CS and J Bourdages. 2000. Response time of wetland biodiversity to road construction on adjacent lands. Conservation Biology 14: 86-94.

Gibbons JW. 1988. The management of amphibians, reptiles and small mammals in North America: The need for an environmental attitude adjustment symposium. Flagstaff, AZ July 19-21 1988.

Mitchell JC. 2007. Inventory of amphibians and reptiles of Petersburg National Battlefield. National Park Service, Northeast Region. Philadelphia, PA. Natural Resources Report NPS/NER/NRTR—2007/078. http://www.nps.gov/nero/science

Ryan TJ, T Philippi, YA Leiden, ME Dorcas, TB Wigley, and JW Gibbons. 2002. Monitoring herpetofauna in a managed forest landscape: effects of habitat types and census techniques. Forest Ecology and Management 167: 83-90.

Semlitsch R and JR Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology 17 (5): 1219-1228.

Stuart SN, JS Chanson, NA Cox, BE Young, ASL Rodrigues, DL Fischmen and RW Waller. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306: 1783-1786.

4.3.6 Fish Communities

Relevance and context

Fish are valuable indicators of biological integrity because of their broad range of distributions and their ease of detection (Harrison and Whitfield 2004, Brousseau et al. 2011). Fish communities respond to changes in both aquatic and terrestrial ecosystems (Esteves and Alexandre 2011). Specifically, fish abundance indicates water quality as well as the types and intensities of surrounding land use. By tracking changes in fish abundance, managers can become better informed about the overall health of the ecosystem (Harris and Silveria 1999).

Data and methods

Fish abundance in Poor Creek and Harrison Creek was assessed by backpack electrofishing by two crews during 2002 and 2003 (Figure 4.23). The 1.6 ha (4-ac) beaver pond on the Hatcher Run site and a small pond near the Resource Management Office also were assessed in 2003 (Atkinson 2008).

Threshold

Southerland et al. (2007) established a set of abundance thresholds with less than 0.25 fish/m^2 signifying significant concern, and greater than 1.25 fish/m^2 signifying ideal conditions. For the purpose of this assessment, an abundance of 1.25 fish/m^2 was assigned a score of 100% and 0.25 fish/m^2 was assigned an attainment score of 0%. Scores assigned to abundance levels between these thresholds were scaled linearly from 0 to 100 %.

Current condition and trend

Harrison Creek had an abundance of 2.24 fish/m^2 in 2002, and an abundance of 1.44 fish/m^2 in 2003 (100% attainment). Poor Creek had an abundance of 0.4 fish/m^2 in 2002 and an abundance of 0.18 individuals/m^2 in 2003, showing a decline in fish abundance and a current attainment score of 0%. In 2003 the Resource Managers Pond was first surveyed and scored 0% attainment with an abundance of 0.03 fish/m^2. Hatcher Run in the Five Forks Unit was also surveyed in 2003 receiving a threshold attainment of 100% with 1.3 fish/m^2. The entire park re-

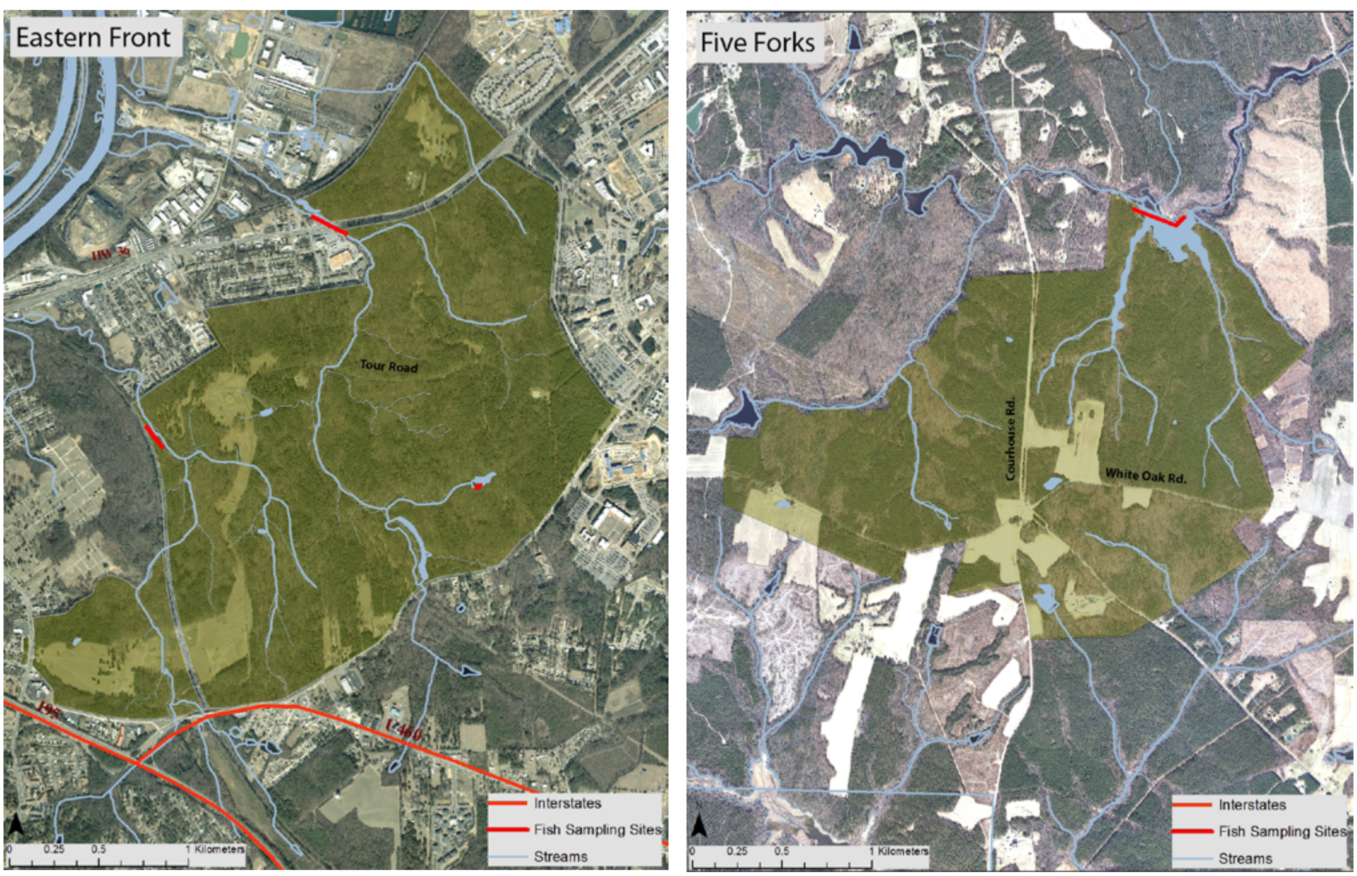


Figure 4.23 *Fish surveying points located in the Five Forks and Eastern Front units (Atkinson 2008).*

ceived an attainment score of 50% with two out of the four survey locations above the 1.25 fish/m^2 reference point and two locations below the 0.25 fish/m^2 reference point signifying significant concern. No trend currently exists for the Resource Managers Pond and Hatcher Run. Harrison Creek and Poor Creek are declining with abundances decreasing from 2002-2003.

Data gaps and level of confidence

Confidence in this assessment is low. An increase in surveying sites would further improve the confidence in the score. Future surveying would be necessary to assess a trend for the Resource Managers Pond and Hatcher Run. More recent data would also be useful to better assess current condition and trend for Harrison Creek and Poor Creek. Only one point (the beaver pond on Hatcher Run) was assessed in the Five Forks unit.

Source of expertise

James B. Atkinson, Natural Resources Branch Shenandoah National Park

Literature cited

Atkinson JB. 2008. Fish Inventories of Mid-Atlantic and Northeast Coastal Barrier Network Parks within Virginia, Maryland and Pennsylvania. Technical Report NPS/NER/NRTR—2008/113. National Park Service, Philadelphia, Pennsylvania.

Brousseau CM, RG Randall, JA Hoyle, and CK Minns. 2011. Fish community indices of ecosystem health: How does the Bay of Quinte compare to other coastal sites in Lake Ontario? Aquatic Ecosystem Health and Management 14(1):75-84.

Esteves KE and CV Alexandre. 2011. Development of an index of biotic integrity based on fish communities to assess the effects of rural and urban land use on a stream in Southeastern Brazil. International Review of Hydrobiology 96(3): 296-317.

Harris JH and R Silveira. 1999. Large-scale assessments of river health using an index of biotic integrity with low-diversity fish communities. Freshwater Biology 41: 235-252.

Harrison TD and AK Whitfield. 2004. A multi-metric fish index to assess the environmental condition of estuaries. Journal of Fish Biology 65: 683-710.

Southerland MT, GM Rogers, MJ Kline, RP Morgan, DM Boward, PF Kazyak, RJ Klauda, and SA Stranko. 2007. Improving biological indicators to better assess the condition of streams. Ecological Indicators 7: 751-767.

4.3.7 White-Tailed Deer

Relevance and context

White-tailed deer (*Odocoileus virginianus*) are the smallest members of the North American deer family, Cervidae, and are the most abundant species of ungulate on the North American continent (Russell et al. 2001). This species commonly occurs throughout the eastern United States at densities ranging between 5–20 deer/km^2 (Bowers 1997). Due to their generalized diet, broad habitat ranges, and high densities, white-tailed deer can drastically affect the forest ecosystems in which they live (Bowers 1997). Deer directly affect the growth, reproduction, and survival of plant species by browsing, often with preferences, on the leaves, stems, flowers, and seeds of specific plant species (Côté et al. 2004). Browsing contributes to shifts in the understory composition of forest ecosystems with the potential to change the succession patterns of these forests, especially to non-native species (Knight et al. 2009). Deer are known to disturb populations of threatened or endangered plants (Miller et al. 1992). In addition, changes in undergrowth due to deer herbivory can account for a decrease in the sensitive species of birds that depend on those areas for nesting, foraging, and protection (McShea and Rappole 1997).

Estimates of pre-colonial deer populations in Virginia range from 313,000-433,000 (3.1 to 4.2 deer/km^2), with populations highest for the Tidewater region of the state (Knox 1997). Subsequently, a decline in deer during colonial times is widely attributed to overharvesting for food and hides by settlers (Knox 1997). The early 1900s marked the low point for white-tailed deer densities; the deer in the Piedmont and highland physiographic provinces of Virginia were almost completely extirpated (Knox 1997, Horsley et al. 2003, Côté et al. 2004).

Management strategies in the early and mid-1900s encouraged the growth of white-tailed deer populations throughout Virginia and the southeastern United States. Strict hunting regulations and changes in land use contributed to the rise of deer populations (Russell et al. 2001). A deer restoration program initiated by the Virginia Department of Game and Inland Fisheries (VDGIF) in 1926 focused on repopulating Virginia's deer by importing and stocking forests with deer (VDGIF 2007). These management techniques proved effective as Virginia's population of deer grew from approximately 25,000 in 1931 to approximately 215,000 in 1970 according to VDGIF estimates (VDGIF 2007).

The most significant contributing factor to the expansion of deer populations was increased resource and habitat availability in the state as land use changed from dense forest to agricultural areas and fragmented forests (Côté et al. 2004). White-tailed deer thrive in transitional habitats like wooded areas with openings for foraging. Forests transitioning to developed areas and agricultural areas provide deer their preferred habitat. In addition, natural predators are no longer available for deer population control (Côté et al. 2004). Parks and other privately owned areas that prohibit hunting also contribute to high densities of deer populations throughout the southeastern United States (Porter and Underwood 1999). Deer in parks have exhibited explosive population growth due to a lack of natural predators and protection from recreational hunting (McCullough 1997). In 1970, populations of deer exhibiting high densities corresponded directly to federal and state properties (Knox 1997).

Whitetailed deer in Petersburg National Battlefield

Photo Courtesy of Petersburg National Battlefield, NPS

Data and methods

Annual deer surveys have been conducted in Petersburg NB since 2000 (Blumenschine 2012). Crews of 3-4 people follow a set route in a pick-up truck for 30 minutes after sunset to survey the deer populations in the Eastern Front unit of the park (Figure 4.24). Following guidelines set out by Rogers (1996), the crew uses two spotlights to estimate deer populations with recordings every one-tenth of a mile.

Threshold

According to Knox (1997), the environmental carrying capacity for deer in Virginia is 1.9–9.7 deer/km². Any densities exceeding this threshold are considered an overly abundant population and can significantly affect the structure and composition of forest ecosystems (Rossell et al. 2005). As densities approach 8.0 deer/km², plant species are continuously reduced and songbird populations may be affected (DeCalesta 1997). Experimental studies in northwestern Pennsylvania indicate a threshold for white-tailed deer of 8.0 deer/ km². Past this threshold forest ecosystems begin to exhibit negative effects due to over-browsing (Horsley et al. 2003). An ecosystem manipulation study in central Massachusetts found that deer densities of 10–17 deer/km² inhibited the regeneration of understory species, and densities of 3–6 deer/km² were optimal for supporting a diverse and abundant forest understory (Healy 1997). For this assessment, an ecological and management threshold of 8.0 deer/ km² was used for the forest habitat.

Current condition and trend

As of 2012, the deer density for Petersburg NB was 80 deer/km², well above the forest ecosystem threshold of 8.0 deer/km² (attainment score of 0%).

Over the past decade, deer densities in the Eastern Front unit have been significantly over the threshold level of 8.0 deer/ km², peaking at 159 deer/ km² in 2004. Deer densities were at a minimum in 2010 at 48.6 deer/km², which is still six times the recommended density. Deer densities do not seem to be increasing and may be declining (Figure 4.25).

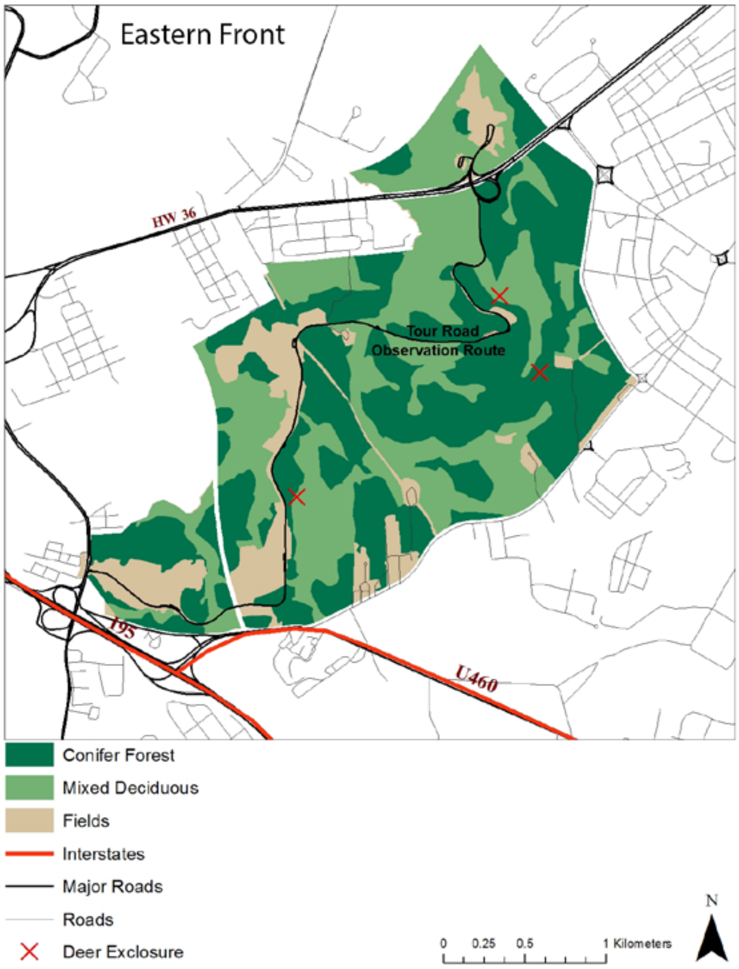


Figure 4.24 *White-Tailed Deer route from 2000-2012 (Blumenschine 2012).*

Data gaps and level of confidence

Using a fixed transect along a road or trail presents a possible source of error for calculating deer densities for an entire park. Using a road limits the survey to the habitat surrounding the road, which may not represent all of the habitat types available (Bates 2006). For example, extrapolating counts taken along this edge environment may overestimate populations for

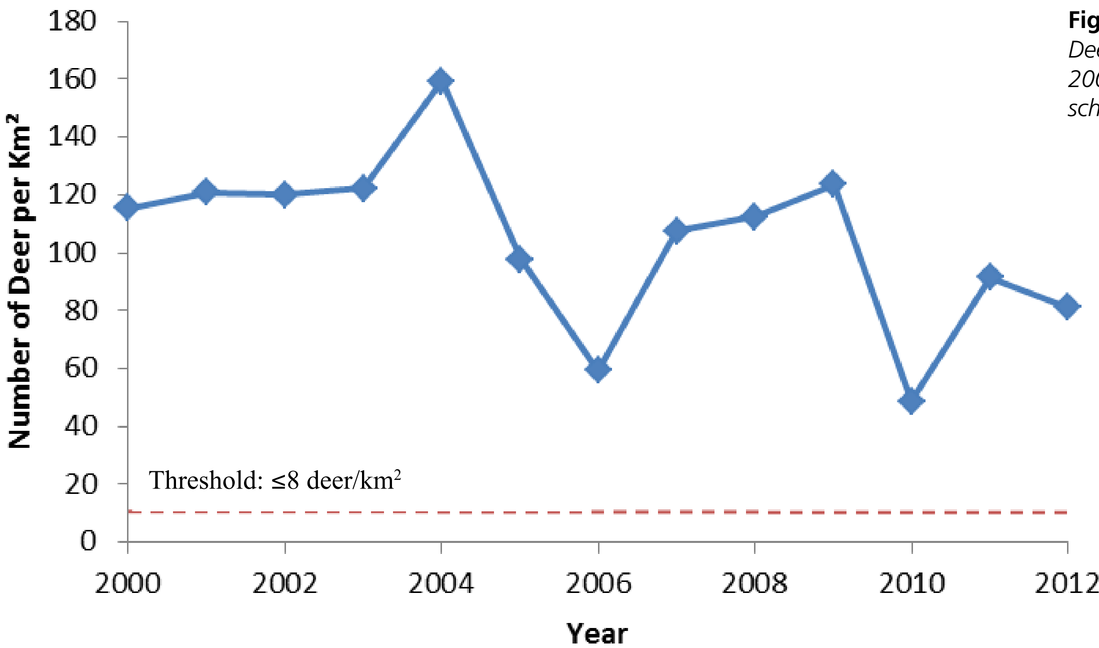


Figure 4.25 *White-Tailed Deer densities from 2000-2012 (Blumenschine 2012).*

the entire park because of deer preference for edge habitats. Measuring the distance from the observer to each deer may help to improve the accuracy of deer density inventories. However, given how far the observed densities are above threshold, the confidence in the assessment score of 0% attainment is high. Nevertheless, the trend data provided are a more reliable estimate than absolute densities. These data combined with other information (e.g., deer exclosure data, I&M monitoring data of deer browse) provide a more complete picture of deer effects on the ecosystem.

Data are only available for the Eastern Front unit of the park. It is believed that Five Forks unit has lower densities due to higher hunting pressures surrounding the unit and less favorable habitat due to pine plantations. Browse lines are less evident in Five Forks unit, but quantitative estimates of the deer population are not available. The unit also had the third lowest percent cover of deer-preferred herbaceous species out of all Mid-Atlantic Parks (Comiskey and Wakamiya 2011).

Sources of expertise

William McShea, Research Biologist, Smithsonian Institution

Literature cited

Bates S. 2006. National Capital region network inventory and monitoring program White-Tailed deer density monitoring protocol version 1.1: Distance and pellet-group surveys. National Park Service.

Blumenschine T. 2012. Deer trends in Petersburg National Battlefield Park. Unpublished NPS report.

Bowers M. 1997. Influence of deer and other factors on an old-field plant community: An eight-year exclosure study. Pp. 310-326 in the science of overabundance: Deer ecology and population management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, DC.

Comiskey JA and SM Wakamiya. 2011. Mid-Atlantic Network Forest Vegetation Monitoring 2007-2010. National Park Service. Natural Resource Technical Report NPS/MIDN/NRTR—2011/471.

Côté SD, TP Rooney, JP Tremblay, C Dussault, and DM Waller. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology, Evolution, and Systematics 35: 113-147.

DeCalesta DS. 1997. Deer and ecosystem management. Pp. 267-279 in The science of overabundance: Deer ecology and population management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, D.C.

Healy WH. 1997 Influence of deer on the structure and composition of oak forests in central Massachusetts. Pp. 249-266 in The science of overabundance: Deer ecology and population management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, D.C.

Horsley SB, SL Stout, and DS DeCalesta. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. Ecological Applications 13: 98-118.

Knight TM, JL Dunn, LA Smith, J Davis, and S Kalisz. 2009. Deer facilitate invasive plant success in a Pennsylvania forest understory. Natural Areas Journal 29(2): 110-116.

Knox WM. 1997. Historical changes in the abun- dance and distribution of deer in Virginia. Pp. 27-36 in The science of overabundance: Deer ecology and population management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, D.C.

McCullough DR. 1997. Irruptive behavior in ungulates. Pp 69-98 in The science of overabundance: Deer ecology and population management. Eds WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington DC.

McShea WJ, and JH Rappole. 1997. Herbivores and the ecology of forest understory birds. Pp. 298-309 in The science of overabundance: Deer ecology and population management. Eds. WJ McShea, HB Underwood, and JH Rappole. Smithsonian Institution Press, Washington, DC.

Miller SG, SP Bratton, and J Hadidian. 1992. Impacts of white-tailed deer on endangered plants and threatened vascular plants. Natural Areas Journal 12: 67-74.

Porter WF and HB Underwood. 1999. Of elephants and blind men: Deer management in the U.S. national parks. Ecological Applications 9: 3-9.

Rogers L. 1996. Procedures for establishing deer-spotlight transects and conducting deer-spotlight surveys. South Carolina Wildlife and Marine Resources Department.

Rossell Jr CR, B Gorsira, and S Patch. 2005. Effects of white-tailed deer on vegetation structure and woody seedling composition in three forest types on the Piedmont Plateau. Forest Ecology and Management 210: 415-424.

Russell FL, DB Zippin, and NL Fowler. 2001. Effects of white-tailed deer (Odocoileus virginianus) on plants, plant populations, and communities: A review. The American Midland Naturalist 146: 1-26.

Virginia Department of Game and Inland Fisheries. 2007. Virginia Deer Management Plan 2006-2015. Wildlife Information Publication No. 07-01.

4.3.8 Forest Regeneration

Relevance and context

Forest regeneration is vital to maintaining forest cover and biodiversity (Aronson and Handel 2011). A lack of forest regeneration could lead to drastic changes in ecosystem processes such as increased erosion and decreased evapotranspiration (Boring and Monk 1981). Major threats to forest regeneration include over-browsing by deer and invasions of non-native plant species. Deer over browsing may lead to an abundance of non-palatable plant species (Knight et al. 2004). Non-native plant invasions may change the normal functions of a forest ecosystem (Mack et al. 2000). Both stressors may lead to decreased diversity and possible extinction of native plant species (Aronson and Handel 2011).

Data and methods

Plots were randomly selected using a generalized random-tessellation stratified (GRTS) approach and assessed by Inventory and Monitoring (I&M) field crews from 2007 to 2010. A resampling of plots was begun in 2011. The GRTS approach involves laying a 250 m grid across the entire region to establish plots. The plots are spatially balanced and maintain their balance through additions and deletions of other plots (Tierney et al. 2009). A total of fifty-two, 20-by-20 m plots were assessed; 28 in the Eastern Front unit and 24 in the Five Forks unit (Figure 4.26). Number, height and cover of all seedlings were recorded for 12 quadrats within each plot (Comiskey and Wakamiya 2011).

Threshold

The NPS I&M monitoring protocol designates each plot within the park with a rating of good, caution, or of significant concern (Comiskey and Wakamiya 2011). Good signifies seedling abundance at or above 8 seedlings/m^2, caution is 2 to 8 seedlings/m^2, and significant concern is less than 2 seedlings/m^2. Plots deemed good or caution are considered to have adequate regeneration (Comiskey and Wakamiya 2011); therefore, 2 seedlings/m^2 was used as the threshold for this assessment. This threshold is supported by studies of forest regeneration in Pennsylvania and Southcentral Virginia(McWilliams et al. 1995; Carter and Frederickson 2007)

Current condition and trend

A total of 19 of the 52 plots in Petersburg NB had adequate regeneration (37% attainment). The Eastern Front and Five Forks units also were assessed separately. The Eastern Front was found to have 36% of plots with adequate regeneration and the Five Forks unit had 38% adequate regeneration. Resampling of these plots has just begun, so there is not currently enough data to assess trend for the park.

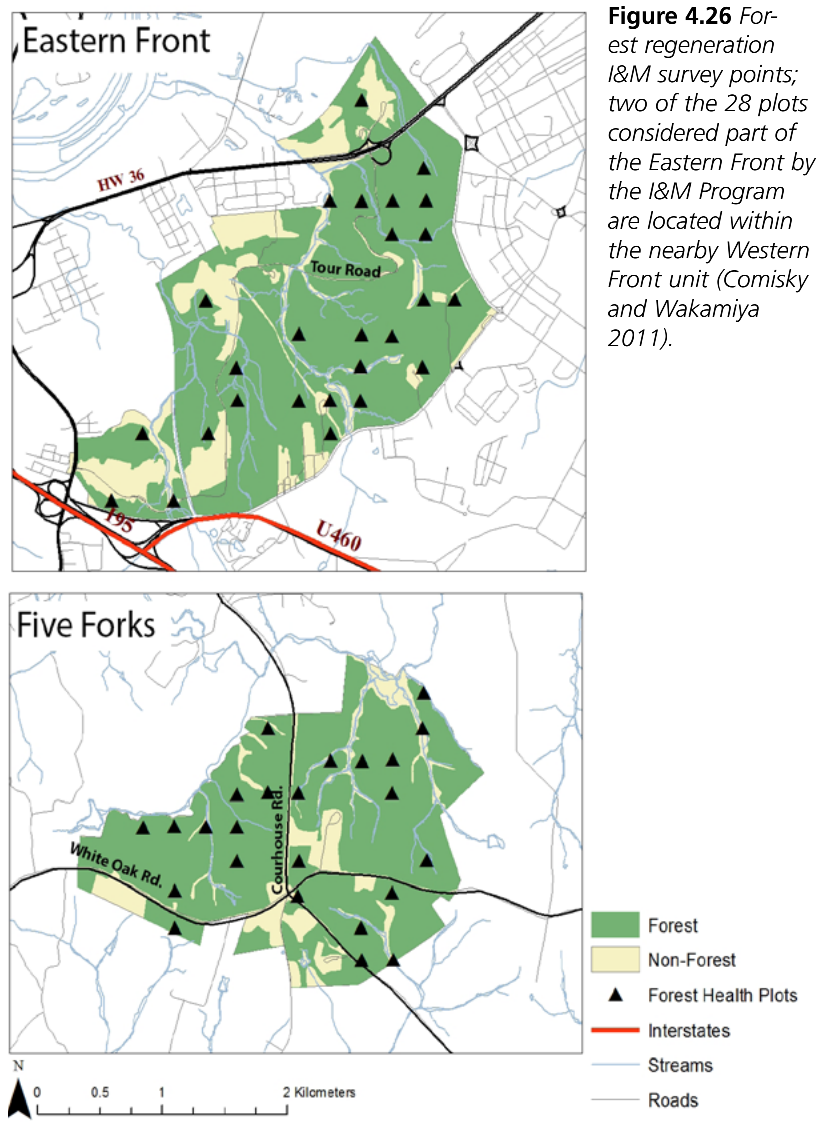


Figure 4.26 *Forest regeneration I&M survey points; two of the 28 plots considered part of the Eastern Front by the I&M Program are located within the nearby Western Front unit (Comisky and Wakamiya 2011).*

Photo Courtesy of Petersburg National Battlefield, NPS

Fire being managed by park staff in Petersburg National Battlefield.

Data gaps and level of confidence

The level of confidence in this metric is high based on the careful attention to sample design and quality control of the vegetation monitoring effort. According to Comiskey and Wakamiya (2011), greater than 70% of all plots should have seedling densities greater than 2 seedlings/m^2. The park clearly falls below this standard at the current time.

Sources of expertise

James A. Comiskey, Program Manager/ Ecologist Mid-Atlantic Network, National Park Service

Literature cited

Aronson MFJ and SN Handel. 2011. Deer and invasive plant species forest herbaceous communities and canopy tree regeneration. Natural Areas Journal 31(4):400-407.

Boring LR and CD Monk. 1981. Early regeneration of a clear-cut southern Appalachian Forest. Ecology 62:1244-1253.

Carter WK and TS Frederickson. 2007. Tree seedling and sappling density and deer browsing incidents on recently logged and mature nonindustrial private forestlands in Virginia, USA. Forest Ecology and Management 242:671-677.

Comiskey JA and SM Wakamiya. 2011.

Knight TM, JL Dunn, LA Smith, J Davis, and S Kalisz. 2009. Deer facilitate invasive plant success in a Pennsylvania forest understory. Natural Areas Journal 29(2): 110-116.

Mack RN, D Simberloff, WM Lonsdale, H Evan, M Clout, and FA Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences and control. Ecological Applications 10:699-710.

McWilliams WH, SC Stout, TW Bowersox, and LH McCormick. 1995. Adequacy of Advance Tree-Seedling Regeneration in Pennsylvania's Forests. Northern Journal of Applied Forestry 12:187-191.

Mid-Atlantic Network Forest Vegetation Monitoring 2007-2010. National Park Service. Natural Resource Technical Report NPS/MIDN/NRTR—2011/471.

Tierney GL, Faber-Langendoen D, Mitchell BR, Shriver WG, and Gibbs JP. 2009. Monitoring and evaluating the ecological integrity of forest ecosystems. Frontiers in Ecology and the Environment 7:308-316.

Wilcove DS, D Rothstein, J Dubow, A Phillips, and E Losos. 1998. Quantifying threats to imperiled species in the States. BioScience 48:607-615.

4.3.9 Invasive Plant Species

Relevance and context

Non-native invasive plants are one of the largest threats to the natural heritage of the National Park system (Allen et al. 2009). Plant invasions of non-native species lead to the establishment of non-native plant populations (Fox et al. 2000). Second only to habitat loss, invasive species are a major threat to native habitats and species (Wilcove et al. 1998). In fragmented forest landscapes, invasive plants can exacerbate the effects of habitat destruction by displacing native species through their overwhelming production of new propagules and direct competition for resources (Rouget and Richardson 2003, Levine et al. 2003). Non-native species affect ecosystem productivity, diversity, and health (Miller 2003). In 2008 more than 1 million ha (5% of park lands) were estimated to be dominated by non-native, invasive plant species in National Parks across the country (NPS 2008). Twenty-four plant species are cataloged within the U.S Invasive Plant Atlas as occuring in Petersburg NB (Swearingen 2007).

Data and methods

Invasive plants were assessed in Petersburg NB as part of the Mid-Atlantic I&M vegetation monitoring protocol (Comiskey and Wakamiya 2011). Plots were randomly selected using a generalized random-tessellation stratified (GRTS) approach and assessed by field crews from 2007 to 2011. A total of fifty-two, 20-by-20 m plots were assessed; 28 in the Eastern Front unit and 24 in the Five Forks unit (Figure 4.26). The presence or absence of a list of 29 invasive indicator plants and vines was recorded for 12 quadrats within each plot (Comiskey and Wakamiya 2011).

Threshold

The threshold used to assess condition was that the invasive non-native plants should be detected on less than 25% of the quadrats for a plot. Because 100% eradication is not a realistic goal (at least in the short term), this threshold was determined to be a reasonable management goal. The threshold also serves as a guide to evaluate the effectiveness of active plant controls implemented within a treatment area (i.e., treatment actions are deemed successful by the park if no more than 25% of a treatment area is infested with invasive plants). The park monitoring data were assessed against the threshold of 25% and designated pass/fail based on whether they were below or above threshold. The Five Forks unit, the Eastern Front unit, and the whole park were then assigned scores based on the percentage of plots below the 25% threshold value.

Photo Courtesy of Petersburg National Battlefield, NPS

Stiltgrass in the woods in Petersburg National Battlefield

Current condition and trend

The Five Forks unit achieved a 100% score with 0 plots having invasive plants on more than 25% of their sample quadrats (mean percent of quadrats with invasives = 1.7%). Chinese lespedeza (*Lespedeza cuneata*) was the most common invasive plant species found at the Five Forks unit. The Eastern Front unit was assigned a score of 79% with 6 plots found to have invasive plants covering ≥ 25% of their quadrats (mean percent of quadrats with invasives = 32.4%). In the Eastern Front unit, Japanese stiltgrass (*Microstegium vimineum*) was the most commonly detected invasive species (Comiskey and Wakamiya 2011). The park achieved an overall attainment score of 88% with only 6 plots out of the 52 plots failing the 25% threshold (Table 4.4). Data were not available to assess trend for invasive plants. A total of 7 invasive species were found (Appendix D).

Data gaps and level of confidence

Invasive species coverage has a high spatial variability and is temporally very dynamic. Therefore confidence in the assessment of current condition is low. Sensitive plant areas in Petersburg NB have been delineated by the park in consultation with Patterson (2008) as areas that are most sensitive to Japanese stiltgrass invasion. These areas have been designated as future priorities for treatment to protect the native species (Figure 4.27). The Exotic Plant Management Team (EPMT) has also treated areas within Petersburg NB that were infested with invasive plant species. As of 2009, 347 acres of Petersburg NB were identified as infested by invasive plants (Akerson 2009). Areas identified by Patterson overlap considerably with the treated areas by the EPMT (Figure 4.27). However, a comprehensive assessment of invasive plant densities for these areas has not occurred.

Sources of expertise

Karen D. Patterson, Virginia Department of Conservation and Recreation, Division of Natural Heritage

Literature cited

Allen J, C Brown, and T Stohlgren. 2009. Non-native plant invasions of United States National Parks. Biological Invasions 11:2195-2207.

Akerson, J. 2009. The Mid-Atlantic Invasive Plant Management Cooperative of National Parks: Work Plant 2010-2014. Luray, VA

Comiskey JA andSM Wakamiya. 2011. Mid-Atlantic Network Forest Vegetation Monitoring 2007-2010. National Park Service. Natural Resource Technical Report NPS/MIDN/NRTR—2011/471.

Fox AM, DR Gordon, JA Dusky, LL Tyson and RK Stocker. 2000. The story behind the IFAS assessment of non-native plants in Florida's natural areas. UF/IFAS Invasive Plants Work Group, University of Florida

Guo Q, H Qian, RE Richlefs, and W Xi. 2006. Distributions of exotic plants in eastern Asia and North America.

Levine JM, M Vila, CM D'Antonio, JS Dukes, K Grigulis and S Lavorel. 2003. Mechanisms underlying the impacts of exotic plant invasions. Proceedings of the Royal Society of London Series B 270: 775-781.

Table 4.4 *Percent of vegetation monitoring plots with less than 25% of sample quadrats containing invasive species for the two largest units of Petersburg National Battlefield (Comiskey and Wakamiya 2011)*

Number of Plots Sampled		% Plots Fail	% Plots Pass	Condition Score
Eastern Front	28	21%	79%	79%
Five Forks	24	0%	100%	100%
Whole Park	52	12%	88%	88%

Miller JH. 2003. Nonnative invasive plants of Southern forests: A field guide for identification and control. Forest Service Southern Research Station.

National Park Service. 2008. Exotic plant management team 2008 Annual Report. Natural Resource Program Center, Biological Resources Management Division.

Patterson KD. 2008. Vegetation classification and mapping at Petersburg National Battlefield, Virginia. Technical Report NPS/NER/NRTR- 2008/127. National Park Service, Philadelphia, PA.

Rouget M and DM Richardson. 2003. Inferring process from pattern in plant invasions: a semi-mechanistic model incorporating propagule pressure and environmental factors. American Naturalist 162: 713-724.

Swearingen JM. 2007. Highlights: Invasive plant species listed in comprehensive database. Park Science 24(2):10.

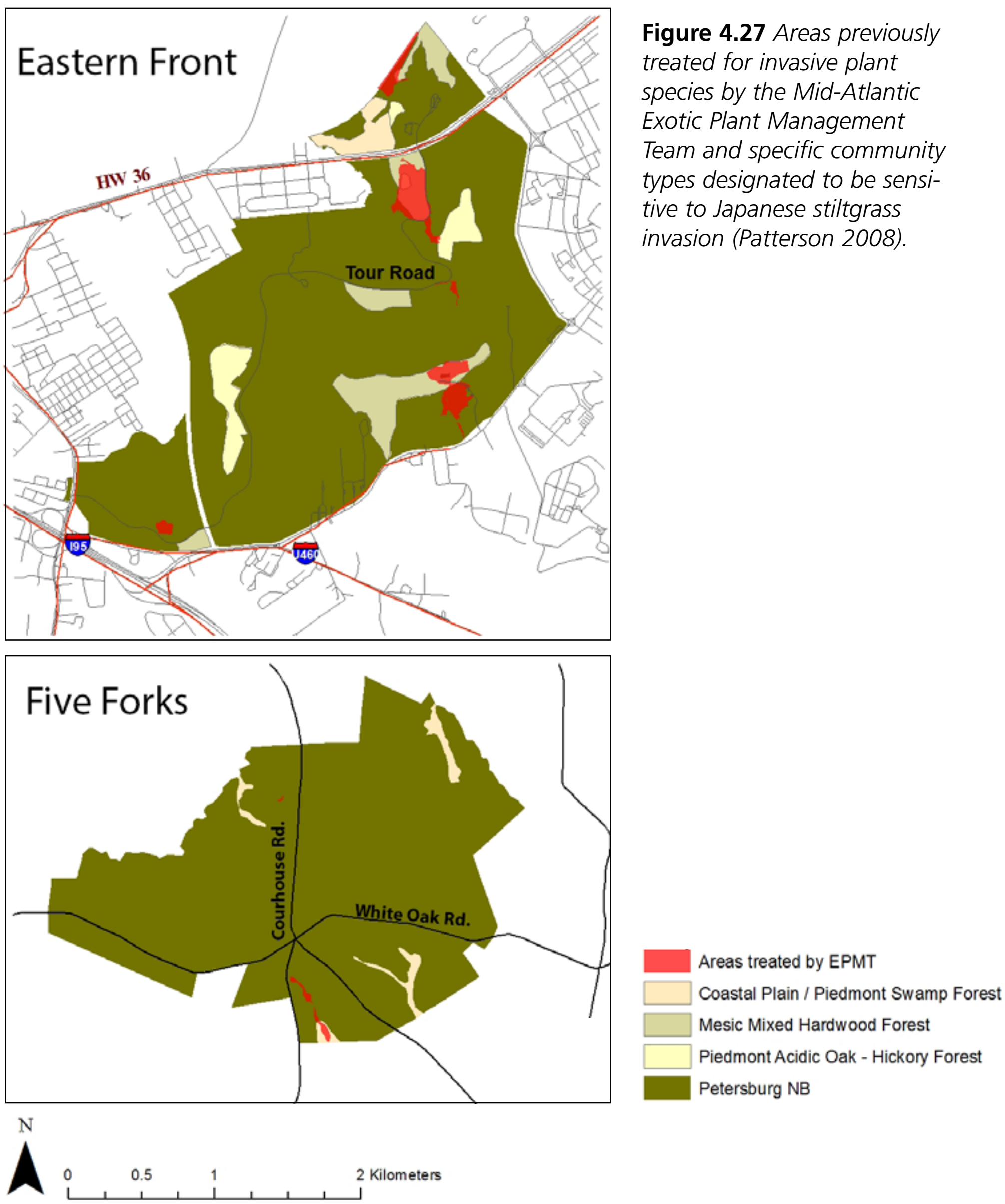


Figure 4.27 *Areas previously treated for invasive plant species by the Mid-Atlantic Exotic Plant Management Team and specific community types designated to be sensitive to Japanese stiltgrass invasion (Patterson 2008).*

4.4 LANDSCAPE DYNAMICS

4.4.1 Percent Forest

Relevance and context

Habitat loss is the primary cause of species extinctions in the Unites States (Czech et al. 2000). Although part of the enabling legislation for Petersburg NB is to maintain open battlefield conditions, forest is the dominant land cover in the park. Land conversion from forest can occur for a variety of purposes including agriculture, timber harvesting, and mining (Dale et al. 2000). In the region surrounding the park, this conversion is primarily from forest to urban lands. From 1973 to 2000 total forest area has decreased by 4.3% nationally (Sleeter et al. 2013) and 4.0% in the eastern U.S. (Drummond and Loveland 2010) due to increasing urban, suburban and exurban development. In addition to its effects on species extinctions, loss of forest cover can lead to an increase in exotic species invasions (Vitousek et al. 1997), degraded and diminished water flows (Meyer and Turner 1992), and the spread of new diseases (Langlois et al. 2001). A variety of studies have also documented the ecological impacts that changes in land cover on adjacent lands can have on parks (Pringle 2000, Defries et al. 2007, Hansen and Defries 2007).

Data and methods

Data from the Virginia Natural Heritage Program's vegetation mapping (Patterson 2008) were used as the basis for a forest/non-forest binary land cover map of Petersburg NB. Natural Heritage field sampling was conducted from 2002-2006 and combined with aerial photography from February 2002 to create the Natural Heritage map (Patterson 2008). This 20-category land cover classification was simplified in consultation with park staff to create the final map of forest cover used for this assessment (see Table 3-1 in Chapter 3). No other comparably detailed map of land cover in the park was available; therefore, trend could not be directly assessed. However, maps of forest land cover for 1992 and 2001 were extracted from the National Land Cover Dataset (NLCD) for a 30-km (19-mi) buffer surrounding the park to provide broader context of the landscape change (Budde et al. 2009).

Threshold

Simulation studies of forest loss suggest a critical threshold value of at least 59% of the total landscape area be maintained in forest to maintain many ecological functions and services (Gardner et al. 1987; Turner et al. 2001). Landscapes with lower forest amount tend to lose the characteristic qualities of intact forest required of organisms such as forest interior birds and forest dwelling mammals. Small loses in forest within landscapes near this critical threshold result in large changes in average patch size, the amount of interior forest, the amount of edge habitat, and related metrics of fragmentation (Fahrig 2003). These same studies identified a second potential threshold value of 30% (Turner et al. 2001, Fahrig 2003). Landscapes with less than 30% forest suffer from more serious concerns related to overall habitat loss rather than issues of forest fragmentation per se (i.e., the breaking apart of intact habitat into a larger number of smaller pieces). For this assessment, forest land cover percentages above 59% were assigned an attainment score of 100%; forest percentages below 30% were assigned an attainment score of 0%; and forest percentages between 30–59% were scaled linearly from 0–100% attainment.

Current condition and trend

Using the modified Natural Heritage land cover map, the park had a total forest cover of 77.3%, which represents 100% attainment. The Eastern Front unit (77%) had less forest than the Five Forks unit (83%), but both were above the thresholds of concern (Table 4.5). Forest in the landscape surrounding the park decreased from 66% in 1992 to 59% in 2001 (Figure 4.28) .

Data gaps and level of confidence

This assessment of forest cover treats all types of forest as equivalent. Differences

Table 4.5 *Percent of park land covered by forest (modified from Patterson 2008).*

Park Unit	Forested Land Cover (%)	Condition Score
Eastern Front	77%	100%
Five Forks	83%	100%
Whole Park	77%	100%

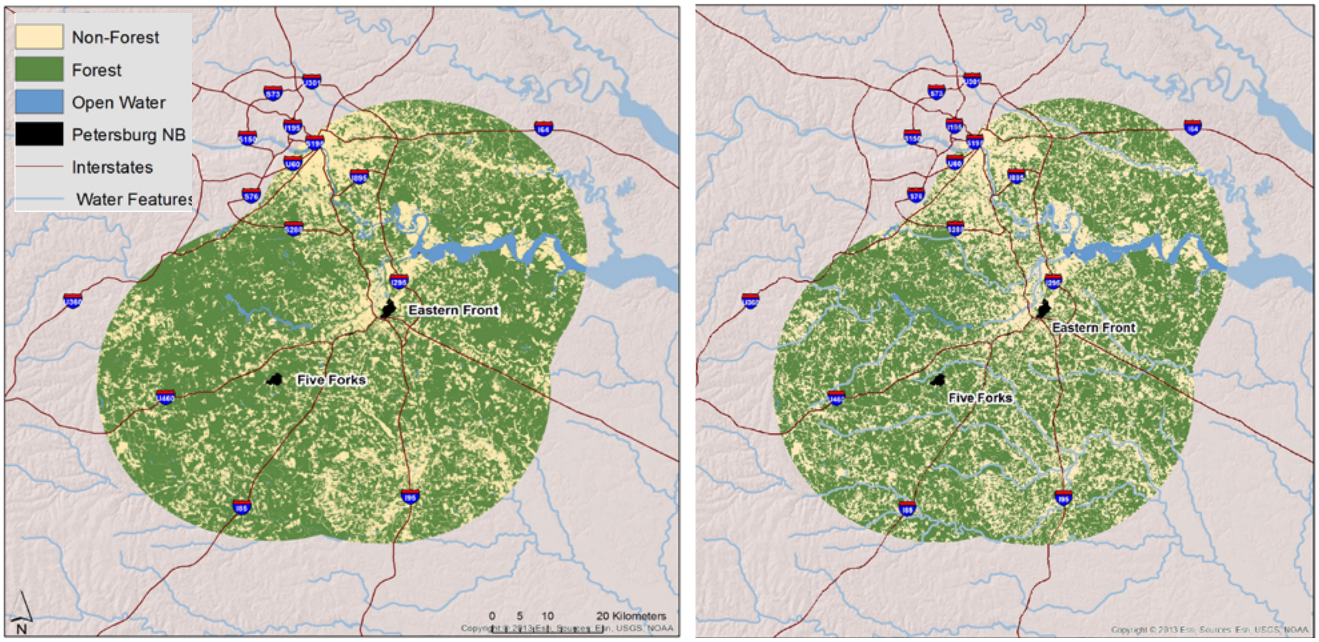


Figure 4.28 *Percent forest in 30 km (19-mi) buffer surrounding Petersburg National Battlefield in 1992 (left) and 2001 (right) (Budde et al. 2009).*

in forest composition and quality are not considered. Similarly, the assessment treats all non-forest cover types equivalently. However, different types of non-forest land could have drastically different effects on forest fragmentation. Trend was not formally assessed due to the lack of a second vegetation map of comparable detail to the Natural Heritage classification. The decline in regional forest cover from 1992 to 2001 is concerning. The overall level of confidence in this metric is fair.

Sources of expertise

Chris Ludwig, Chief Biologist, Virginia Department of Conservation and Recreation

Literature cited

Budde PJ, BJ Frakes, L Nelson, and U Glick. 2009. NPScape Data and Processing. Inventory and Monitoring Division, National Park Service, Fort Collins, CO.

Czech CB, PR Krausman, and PK Devers. 2000. Economic associations among causes of species endangerment in the United States. BioScience 50: 593-601.

Dale VH, S Brown, RA Haeuber, NT Hobbs, NHuntly, RJ Naiman, WE Riebsame, MG Turner, and TJ Valone. 2000. Ecological principles and guidelines for managing the use of land: A report from the Ecological Society of America. Ecological Applications 10: 639-670.

DeFries R, A Hansen, BL Turner, R Reid, and JLiu. 2007. Land use change around protected areas: Management to balance human needs and ecological function. Ecological Applications 17(4): 1031-1038.

Drummond MA and TR Loveland. 2010. Land-use pressure and a transition to forest-cover loss in the eastern United States. BioScience 60(4): 286-988.

Fahrig L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology and Systematics 34: 487-515.

Gardner RH, BT Milne, MG Turner, and RV O'Neill. 1987. Neutral models for the analysis of broad-scale landscape pattern. Landscape Ecology 1(1): 19-28.

Hansen AJ and R Defries. 2007. Ecological mechanisms linking nature reserves to surrounding lands: A conceptual framework for assessing implications of land use change. Ecological Applications 17: 974-988.

Langlois JP, L Fahrig, G Merriam, and H Arstsob. 2001. Landscape structure influences continental distribution of hantavirus in deer mice. Landscape Ecology 16:255-266.

Meyer WB and BL Turner. 1992. Human-population growth and global land cover change. Annual Review of Ecology and Systematics 23: 39-61.

Patterson KD. 2008. Vegetation classification and mapping at Petersburg National Battlefield, Virginia. Technical Report NPS/NER/NRTR- 2008/127. NPS, Philadelphia, PA.

Pringle CM. 2000. Threats to U.S. public lands from cumulative hydrologic alterations outside of their boundaries. Ecological Applications10(4): 971-989.

Sleeter BM, TL Sohl, TR Loveland, RF Auch, W Acevedo, MA Drummond, KL Sayler, and SV Stehman. 2013. Land-cover change in the conterminous United States from 1973 to 2000. Global Environmental Change 23: 733–748

Turner MG, RH Gardner, and RV O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York.

Vitousek PM, CM Dantonio, LL Loope, M Rejmanek, and R Westbrooks. 1997. Introduced species: A significant component of human caused global change. New Zealand Journal of Ecology 21: 111-121.

Loblolly pine-hardwood forest in Petersburg National Battlefield

Photo Courtesy of Petersburg National Battlefield, NPS

4.4.2 Forest Connectivity

Relevance and context

Landscape connectivity is the degree to which the landscape facilitates or impedes movement between resource patches (Taylor et al. 1993). The connectivity of habitat heavily influences the survival and prolonged existence of native organisms within a landscape, affecting ecosystem dynamics (Bolger et al. 2008) and increasing susceptibility to biological invasions (Minor et al. 2009). Fragmented ecosystems have been shown to experience negative effects independent of habitat loss due to decreases in connectivity (Mortelliti et al. 2010).

Data and methods

Forest connectivity was assessed using Conefor Sensinode 2.6 software (Saura & Torné 2009). Forest was classified using data from Patterson (2008) as described in the Percent Forest section above (Section 4.4.1; see also Table 3-1 in Chapter 3). Forest was then mapped into discrete forest patches and the distance between all patch pairs was measured from closest edge to closet edge. The Landscape Coincidence Probability (LCP) was used as the primary index of connectivity (Pascual-Hortal and Saura 2006, Saura and Pascual-Hortal 2007, Saura et al. 2011a, Saura et al. 2011b). LCP is defined as the probability that two randomly located points within the landscape are: (1) both in forest, and (2) either directly connected or connected through a path of connected patches. A distance of 360 m (1,181 ft) was used as a threshold distance to assign patch pairs as either connected or not connected in the analysis. This distance represents the scale of seed dispersal for many tree species and represents a reasonable distance across which small mammals can travel between forest patches (He and Mladendoff 1999, Bowman et al. 2002).

Thresholds

LCP values range from 0 to 1, increasing with increased connectivity. A completely intact and connected habitat within a particular landscape would receive an LCP score of 1, and total absence of forested habitat within a particular landscape would receive a score of 0. A threshold value of 0.75 was set for the assessment, above which the park was assigned a score of 100% and below which the park was assigned an attainment score of 0% (Townsend et al. 2009).

Current condition and trend

The Eastern Front unit obtained an LCP value of 0.73 (Figure 4.29). This value is slightly under the established threshold value of 0.75. Forest connectivity has been compromised by: development within the park, purposeful preservation of non-forest landscapes (preservation of battlefield meadows, etc.), and road construction. The Five Forks unit received an LCP value of 0.77.

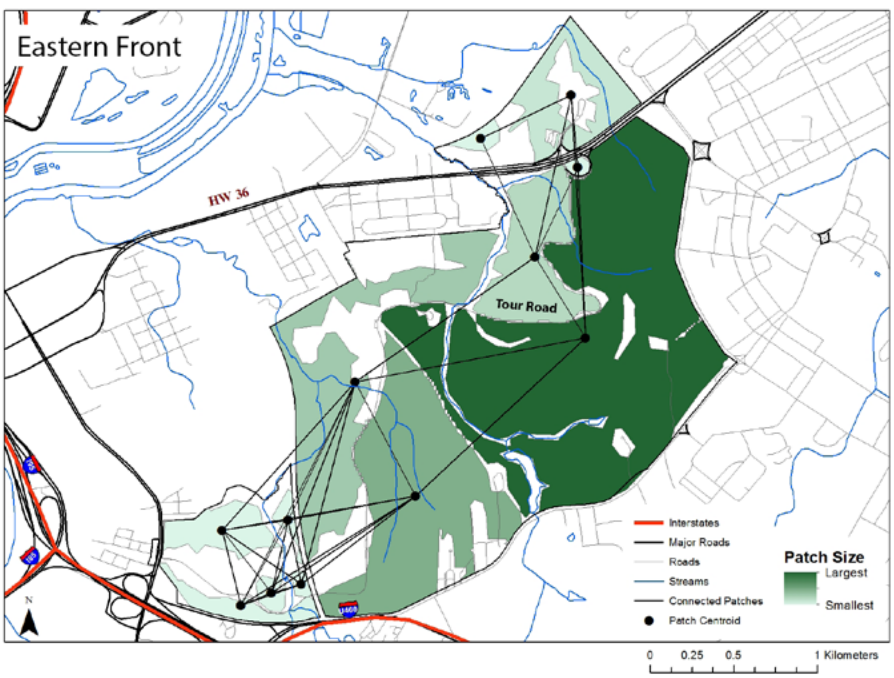


Figure 4.29 *Connectivity of forest patches in the Eastern Front. Lines are drawn between potentially connected patches (landcover data modified from Patterson 2008).*

This value is slightly above the threshold value of 0.75. However, it warrants continued monitoring. Due to the dispersed nature of the different park units, Petersburg NB as a whole is highly disconnected (0% attainment).

Data Gaps and level of confidence

Confidence in the findings is fair. At the park-scale, barriers among the different units are plentiful. For the individual units, the closeness of the metric score to threshold for both the Eastern Front unit and the Five Forks unit warrants additional investigation. The assessment treated all non-forest cover the same, and this assumption decreases the confidence in the results. For example, roads are a less crossable boundary than fields for many species, but they were treated as equivalent in the analysis.

Sources of expertise

Karen D. Patterson, Virginia Department of Conservation and Recreation, Division of Natural Heritage

Literature cited

Bolger DT, KH Beard, AV Suarez, and TJ Case. 2008. Increased abundance of native and non-native spiders with habitat fragmentation. Diversity and Distributions 14: 655-65.

Bowman J, JAG Jaeger, and L Fahrig. 2002. Dispersal distance of mammals is proportional to home range size. Ecology 83: 2049-2055

Calabrese JM and WF Fagan. 2004. A comparison-shopper's guide to connectivity metrics. Frontiers in Ecology and the Environment 2: 529-536.

He HS and DJ Mladenoff. 1999. The effects of seed dispersal on the simulation of long-term forest landscape change. Ecosystems 2: 308-319.

Minor ES, SM Tessel, KAM Engelhardt, and TR Lookingbill. 2009.The role of landscape connectivity in assembling exotic plant communities: A network analysis. Ecology 90: 1802-809.

Mortelliti A, S Fagiani, C Battisti, D Capizzi, and L Boitani. 2010. Independent effects of habitat loss, habitat fragmentation and structural connectivity on forest-dependent birds. Diversity and Distributions 16: 941-51.

Pascual-Hortal L and S Saura. 2006. Comparison and development of new graph-based landscape connectivity indices: towards the priorization of habitat patches and corridors for conservation. Landscape Ecology 21: 959-967

Saura S and L Pascual-Hortal. 2007. A new habitat availability index to integrate connectivity in landscape conservation planning: comparison with existing indices and application to a case study. Landscape and Urban Planning 83: 91-103.

Saura S, C Estreguil, C Mouton, and M Rodríguez-Freire. 2011a. Network analysis to assess landscape connectivity trends: application to European forests (1990-2000). Ecological Indicators 11: 407-416.

Saura S, S González-Ávila, and R Elena-Rosselló. 2011b. Evaluación de los cambios en la conectividad de los bosques: el índice del área conexa equivalente y su aplicación a los bosques de Castilla y León. Montes, Revista de Ámbito Forestal 106: 15-21.

Saura S and J Torné. 2009. Conefor Sensinode 2.2: a software package for quantifying the importance of habitat patches for landscape connectivity. Environmental Modelling & Software 24: 135-139.

Taylor PD, L Fahrig, K Henein, and G Merriam. 1993. Connectivity is a vital element of landscape structure. Oikos 68:571-573.

Townsend PA, TR Lookingbill, CC Kingdon, and RH Gardner. 2009. Spatial pattern analysis for monitoring protected areas. Remote Sensing Environment 113:1410-1420.

4.4.3 Riparian Buffer Width

Relevance and context

Forested riparian buffers enhance biodiversity and improve water quality. They enhance terrestrial biodiversity by providing foraging, nesting, breeding, and escape cover; protecting sensitive habitats; and maintaining landscape connectivity (Hodges and Krementz 1996, Wanger 1999, Bentrup 2008). They also provide valuable buffer benefits to aquatic habitat, for example, by shading streams to maintain favorable temperature (Moore et al. 2005). Forested riparian buffers protect water quality by reducing the amount of sediment, nutrients, and other pollutants that enter streams, lakes, and other surface waters (Phillips 1989).They attenuate nutrients such as nitrogen and through plant uptake, microbial immobilization and denitrification, soil storage, and groundwater mixing (Lowrance et al. 1997).

Despite strong evidence that forested riparian buffers are an important best management practice (BMP), many factors affect the ability of the riparian forest to function effectively including pollutant load, field slope, type and density of vegetation, soil structure, subsurface drainage patterns, and the frequency and force of storm events (Osborne and Kovacic 1993). The scientific basis for determining a specific width for the BMP depends on the overall rational for the buffer, with 100 m recommended as an appropriate corridor width for terrestrial species that use forested riparian areas as movement corridors and amphibians, turtles and other aquatic species that use the land for at least part of their life cycles (Bentrup 2008).

Data and methods

Land cover data from the Virginia Natural Heritage Program (Patterson 2008) were used to generate a map of forest and wetland for the park (see Chapter 3). The percentage of land cover in forest or wetland was then calculated for all 100-m buffer strips around the park's streams.

Threshold

The Chesapeake Bay Program has set a long-term goal of 70% forest coverage in riparian areas of the Bay watershed (Sprague et al. 2006). Using this threshold value, forest/wetland cover of less than 70% in the riparian zone was deemed as 0% attainment for the purpose of this assessment.

Current condition and trend

Using the modification of the Natural Heritage land cover map, 94% of the riparian area of Petersburg NB was forested or wetland, which represents a 100% attainment relative to the minimum threshold of 70%. The riparian buffer in the Eastern Front unit was 91% forested or wetland. In the Five Forks unit, riparian buffer was 97% forested or wetland. Both of these units, therefore, were assessed as exceeding the 70% threshold (Figure 4.30).

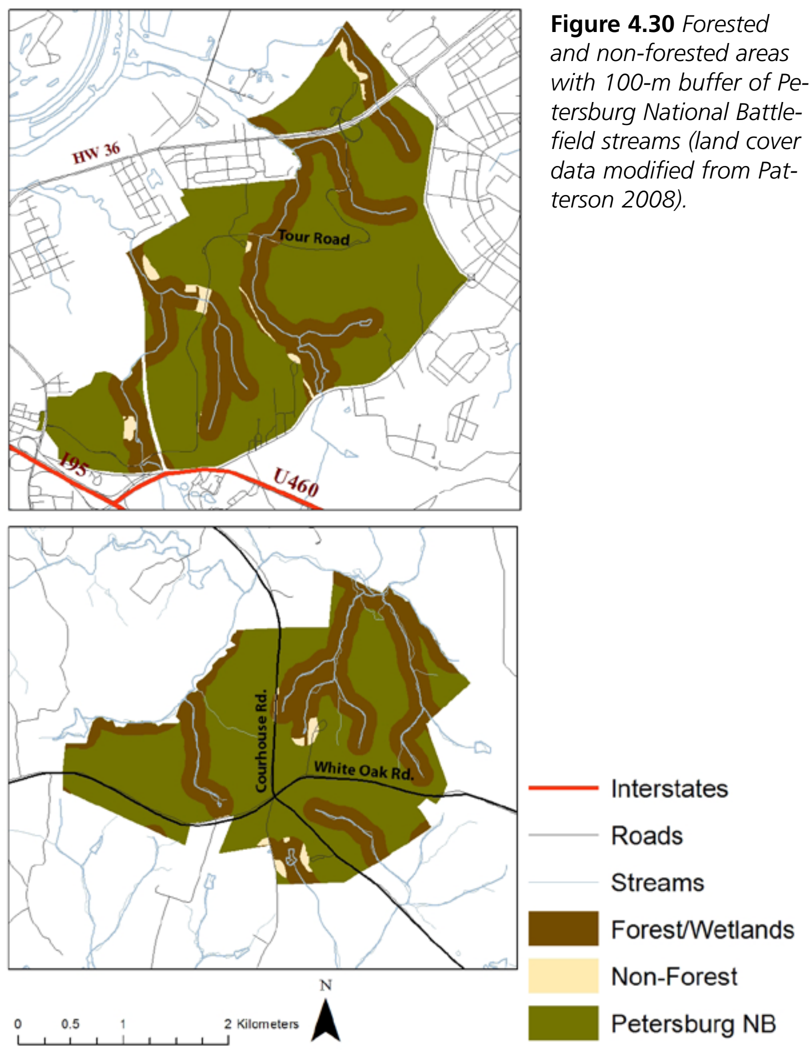


Figure 4.30 *Forested and non-forested areas with 100-m buffer of Petersburg National Battlefield streams (land cover data modified from Patterson 2008).*

Data were not available to assess temporal trend in forest cover within the park.

Data gaps and level of confidence

This metric treats different non-forest cover the same (i.e., roads, fields, and buildings were all considered simply non-forest). However, grasslands and roads, for example, would have very different habitat potentials and buffering capacities. The health of the forest within the buffer zone is also not quantified. More research could be done to investigate forest quality, age, composition, etc. within each of the buffer zones. The land cover data are several years old and no equivalent, detailed vegetation survey of the park has been conducted to allow assessment of temporal trend. Although the National Land Cover Dataset (NLCD) is available for multiple years for the park, NLCD data were not used for this assessment because of documented inconsistencies in mapping wetland areas at high resolution using these data (Hollister et al. 2004, Thogmartin 2004). The overall level of confidence in this metric is therefore fair.

Sources of expertise

Albert Todd, Watershed Program Leader, USDA Forest Service, Annapolis, MD.

Literature cited

Bentrup G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Hodges MF, Jr., and D. G. Krementz. 1996. Neotropical migratory breeding bird communities in riparian forests of different widths along the Altamaha River, Georgia. The Wilson Bulletin 108:496-506.

Hollister JW, ML Gonzalez, JF Paul, PV August, and JL Copeland. 2004. Assessing the accuracy of National Land Cover dataset area estimates at multiple spatial extents. Photogrammetric Engineering And Remote Sensing 70:405-414.

Lowrance R. 1992. Groundwater nitrate and denitrification in a coastal plain riparian forest. Journal of Environmental Quality 21:401-405.

Moore RD, DL Spittlehouse, and A Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: A review. Journal of the American Water Resources Association 41:813-834.

Osborne LL, and DA Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. Freshwater Biology 29:243-258.

Patterson KD. 2008. Vegetation classification and mapping at Petersburg National Battlefield, Virginia. Technical Report NPS/NER/NRTR- 2008/127. National Park Service, Philadelphia, PA.

Phillips JD. 1989. An evaluation of the factors determining the effectiveness of water quality buffer zones. Journal of Hydrology 107:133-145.

Sprague E, D Burke, S Claggett, and A Todd (eds). 2006. The State of Chesapeake Forests. The Conservation Fund.

Thogmartin WE, AL Gallant, MG Knutson, TJ Fox, and MJ Suarez. 2004. Commentary: A cautionary tale regarding use of the National Land Cover Dataset 1992. Wildlife Society Bulletin 32:970-978.

Wanger S. 1999. A review of the scientific literature on riparian buffer width, extent and vegetation. Office of Public Service & Outreach Institute of Ecology, University of Georgia.

4.4.4 Impervious Surface

Relevance and context

Impervious surface is a quantifiable indicator of human activity on the landscape that directly correlates to environmental condition (Arnold and Gibbons 1996). It includes rooftops, roads, and parking lots that decrease infiltration and groundwater storage while increasing runoff and water pollution (Center for Watershed Protection 2003). Some studies have indicated that the total percent impervious surface in a watershed has a stronger effect on stream ecosystem integrity than the amount of riparian deforestation, though the two factors certainly interact to degrade stream condition (Walsh et al. 2007). Percent impervious surface can provide a good approximation of watershed and aquatic habitat degradation, even within areas of little development (Gergel et al. 2002). For context, approximately 20% of a 30 km (19 mi) buffer around the park was impervious surface cover in 2001 (Budde et al. 2009)(Figure 4.31). However, most of this development occurs in parts of the watershed that do not directly flow into the park.

Data and methods

Impervious surface data were taken from the 2006 National Land Cover Data set (NLCD) in which all 30 m pixels were classified into 101 possible values (0–100%) (Homer et al. 2007). The mean impervious surface value was calculated for the park and separately for the Five Forks unit and the Eastern Front unit. The mean impervious surface value also was calculated for the 12-digit Hydrologic Unit Code (HUC) watersheds surrounding the park (Faber-Langendoen 2009). Finally, Arc Hydro Tools were used to delineate the smaller watersheds surrounding streams that flow directly into the Eastern Front and Five Forks units. This last measure was deemed the most ecologically relevant to park condition, and it was used for the final assessment of the impervious surface indicator.

Threshold

Multiple studies have illustrated significant ecosystem impacts in watersheds with less than 10% impervious cover. For example, a study in coastal New Jersey revealed that impervious surface cover as low as 2% may have effects on pH and specific conductance (Conway 2007). In a Maryland study, impervious surface cover from 0.5–2% resulted in the decline of the majority (80%) of the stream taxa, while 2–25% impervious cover showed a decline in 100% of the taxa (King et al. 2011). Coastal Plain watersheds

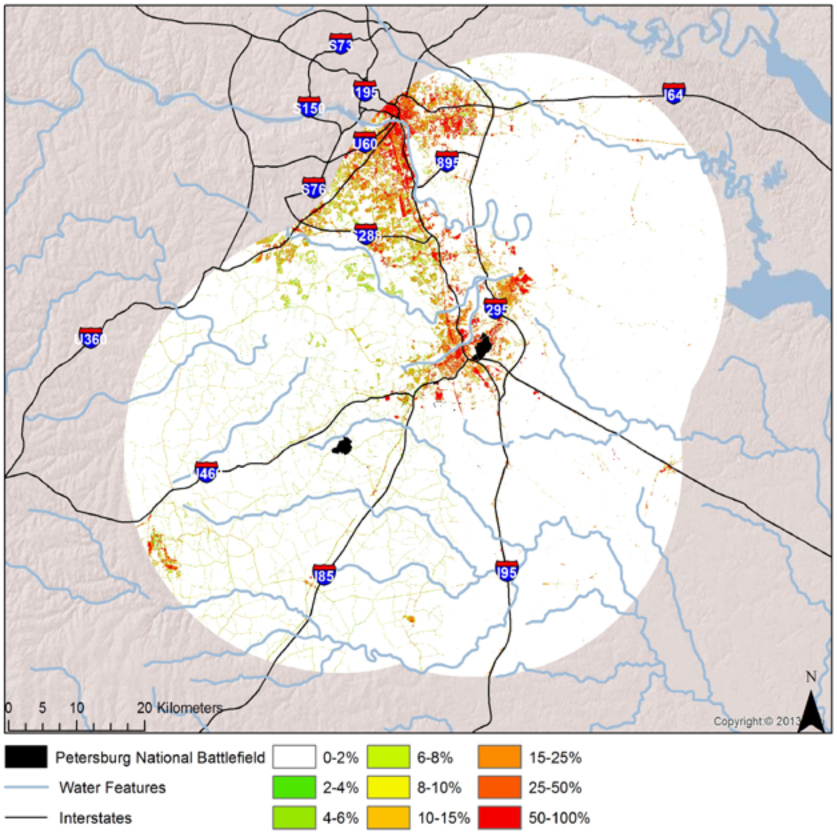


Figure 4.31 *Impervious surface cover from NLCD 2001, showing a 30 km (19 mi) buffer around Petersburg NB. Adapted from NPScape products (Budde et al. 2009).*

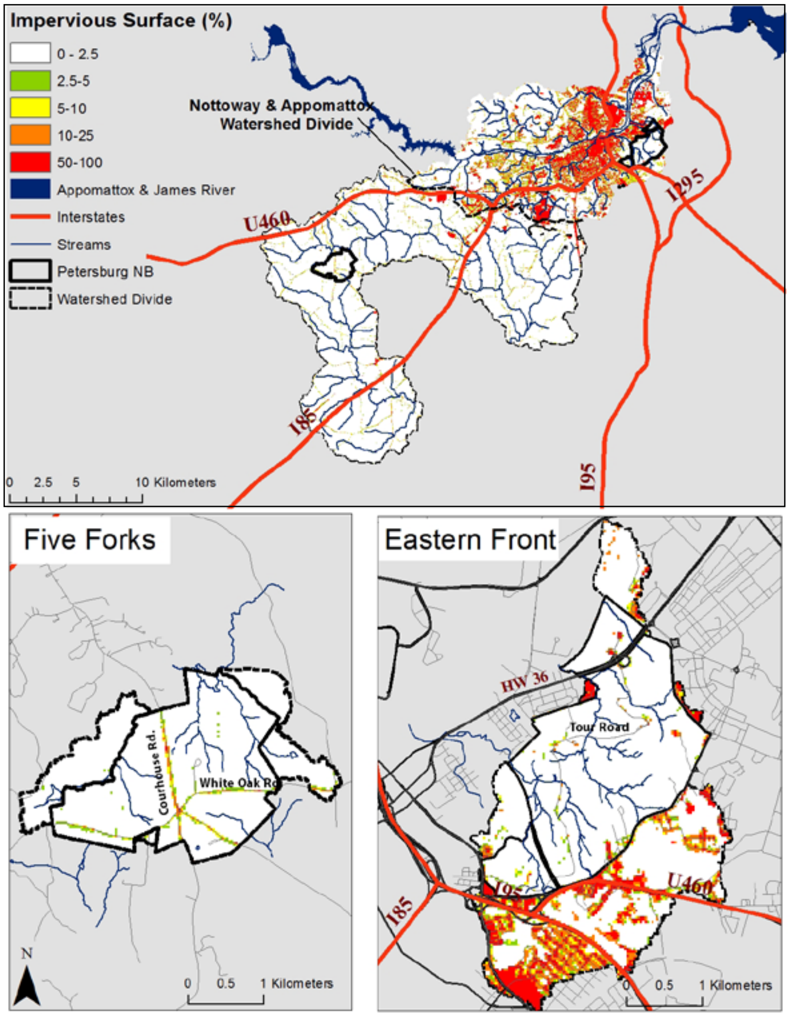


Figure 4.32 *Impervious surface located in watersheds draining into Petersburg National Battlefield (landcover data from 2006 NLCD).*

with 4–23% impervious cover have shown a loss of sensitive aquatic invertebrate taxa (Utz et al. 2009), and watersheds with 3–5% cover have shown significant changes in stream flow (Yang et al. 2010). This assessment used a threshold value of less than 10% impervious surface cover for achieving 100% attainment, based on the historical adoption of this threshold value within the freshwater conservation community (Arnold and Gibbons 1996, Booth and Jackson 1997, Lussier et al. 2008).

Current condition and trend

Using the impervious surface estimate from the 2006 NLCD, the park was assessed on three different scales (listed in order of increasing size): the impervious surface cover within the park, the impervious surface cover within the small watersheds feeding the Eastern Front and Five Forks units, and the impervious surface cover within the two HUC 12 watersheds containing the park (Figure 4.32). The park units themselves and the HUC 12 watershed containing the Five Forks unit had impervious surface covers less than the 10% threshold value. The HUC 12 watershed containing the Eastern Front unit (i.e., the Appomattox River watershed) failed to meet the attainment threshold, with a mean value of 11.5%. However little of this development was upstream of the park. The watersheds containing streams that flow into the park (i.e., the scale selected for this assessment) contained less than 10% impervious surface for both the Eastern Front and Five Forks units (Figure 4.33). The park is therefore given a 100% attainment score for this metric. No data are available to assess trend directly for this metric.

Data gaps and level of confidence

This park is located within a highly dynamic urban and suburban setting. New roads and developments along the park boundary are being created and/or widened every year. However, no data are currently available for an assessment of temporal trend in impervious surface cover. The 2006 NLCD data are already somewhat dated for an assessment of current condition. A localized data source rather than the NLCD also would allow for improved classification accuracy of impervious surfaces. As discussed in the threshold section, a strong argument could be made for using a lower threshold than the rule-of-thumb 10% value. Confidence in the assessment of this metric is fair.

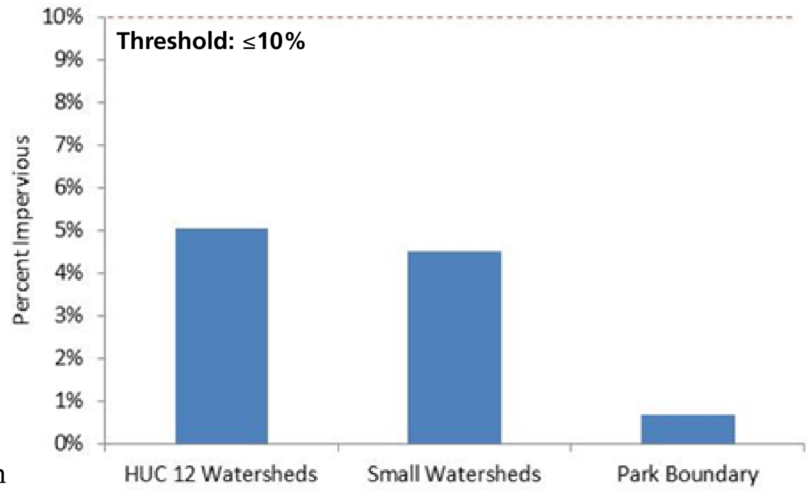


Figure 4.33 *Percent impervious surface located in watersheds draining into Petersburg National Battlefield (derived from 2006 NLCD data).*

Sources of expertise

Matt Baker, Associate Professor of Geography, University of Maryland Baltimore County

Literature cited

Arnold Jr CL and CJ Gibbons. 1996. Impervious surface coverage. Journal of the American Planning Association 62(2): 243-269.

Booth DB and LE Reinelt. 1993. Consequences of urbanization on aquatic systems: Measured effects, degradation thresholds, and corrective strategies. Watersheds '93, Conference sponsored by the U.S. Environmental Protection Agency, Alexandria, VA, March 21-24, pp. 545-550.

Budde PJ, BJ Frakes, L Nelson, and U Glick. 2009. NPScape Data and Processing. Inventory and Monitoring Division, National Park Service, Fort Collins, CO.

Center for Watershed Protection. 2003. Impacts of impervious cover on aquatic systems. Center for Watershed Protection, Ellicott City, MD.

Conway TM. 2007. Impervious surface as an indicator of pH and specific conductance in the urbanizing coastal zone of New Jersey, USA. Journal of Environmental Management 85: 308-316.

Faber-Langendoen D. 2009. Freshwater Wetlands Monitoring and Assessment Framework for the Northewast Temperate Network. Rep. no. 143. Syracuse: National Park Service.

Gergel SE, MG Turner, JR Miller, JM Melack, and EH Stanley. 2002. Landscape indicators of human impacts to riverine systems. Aquatic Sciences 64:118-128.

Homer C, J Dewitz, J Fry, M Coan, N Hossain, C Larson, N Herold, A McKerrow, JN VanDriel and J Wickham. 2007. Completion of the 2001 National Land Cover Database for the Conterminous United States, Photogrammetric Engineering and Remote Sensing 73: 337-341.

King RS, ME Baker, PF Kazyak, and DE Weller. 2011. How novel is too novel? Stream community threshold at exceptionally low levels of catchment urbanization. Ecological Application 21: 1659-1678.

Lussier SM, SN da Silva, M Charpentier, JF Heltshe, SM Cormier, DJ Klemm, M Chintala, and S Jayaraman. 2008. The influence of suburban land use on habitat and biotic integrity of coastal Rhode Island streams. Environmental Monitoring and Assessment 139: 119-136.

Utz RM, RH Hilderbrand, and DM Boward. 2009. Identifying regional differences in threshold responses of aquatic invertebrate to land cover gradients. Ecological Indicators 9: 556-567.

Walsh CJ, KA Waller, J Gehling, and R MacNally. 2007. Riverine invertebrate assemblages are degraded more by catchment urbanisation than by riparian deforestation. Freshwater Biology 52: 574-587.

Yang G, LC Bowling, KA Cherkauer, BC Pijanowski, and D Niyogi. 2010. Hydroclimatic response of watersheds to urban intensity: An observational and modeling-based analysis for the White River Basin, Indiana. Journal of Hydrometeorology 11: 122-138.

4.4.5 Contiguous Grassland Area

Relevance and context

The decline of grassland birds in the Mid-Atlantic is attributed to a combination of factors. One of the most important causes is the fragmentation of open space in the region (Watts 2000, Peterjohn et al. 2007). The combination of increasing urban development and forest secondly succession on abandoned agricultural land has generally resulted in fewer and smaller grassland patches. In Virginia, the amount of open grassland has been reduced by 55% since 1945 and currently comprises less than 2% of the landscape (Watts 2000). Up to 95% of these grassland patches are < 10 ha (25 ac) in size (Watts 2000). Most grassland bird species are highly sensitive to patch size. Grassland birds are experiencing one of the highest rates of decline of any group of birds in North America (Peterjohn and Sauer 1999). Historical and cultural parks may be critical refuges for grassland birds in the Northeast. In a recent inventory of four battlefield parks (Antietam, Monocacy, Manassas, and Gettysburg), compositions of grassland bird communities were highly variable among sites. However, there was a consistent finding that breeding grassland birds avoided fields < 10 ha (25 ac) in size (Peterjohn et al. 2007).

Data and methods

Data from the Virginia Natural Heritage Program (Patterson 2008) were reclassified into grassland and non-grassland categories (see Chapter 3). All fields were then characterized by size. The largest single contiguous patch of grassland was compared to a minimum threshold for the entire park and for each of the two main units of the park.

Threshold

Watts (2000) provides a minimum patch size requirement of 10 ha (25 ac) for park fields. In his assessment of grassland bird area requirements, Peterjohn (2006) used similar reference values. According to his recommendations contiguous grassland areas <4.9 ha (12 ac) in size are generally avoided by grassland birds. Areas need to be greater than 10 ha (25 ac) to be consistently occupied. Even 10-ha patches are not large enough to serve as high-quality habitat for many grassland birds. Peterjohn (2006) recommends contiguous grassland area ≥40 ha (100 ac) to support entire grassland bird communities in the region. We therefore use a graduated set of thresholds for the assessment: all patches <5 ha = 0% attainment; at least one patch ≥5 ha = 30% attainment; at least one patch ≥ 10 ha = 70% attainment; at least one patch ≥ 40 ha = 100% attainment.

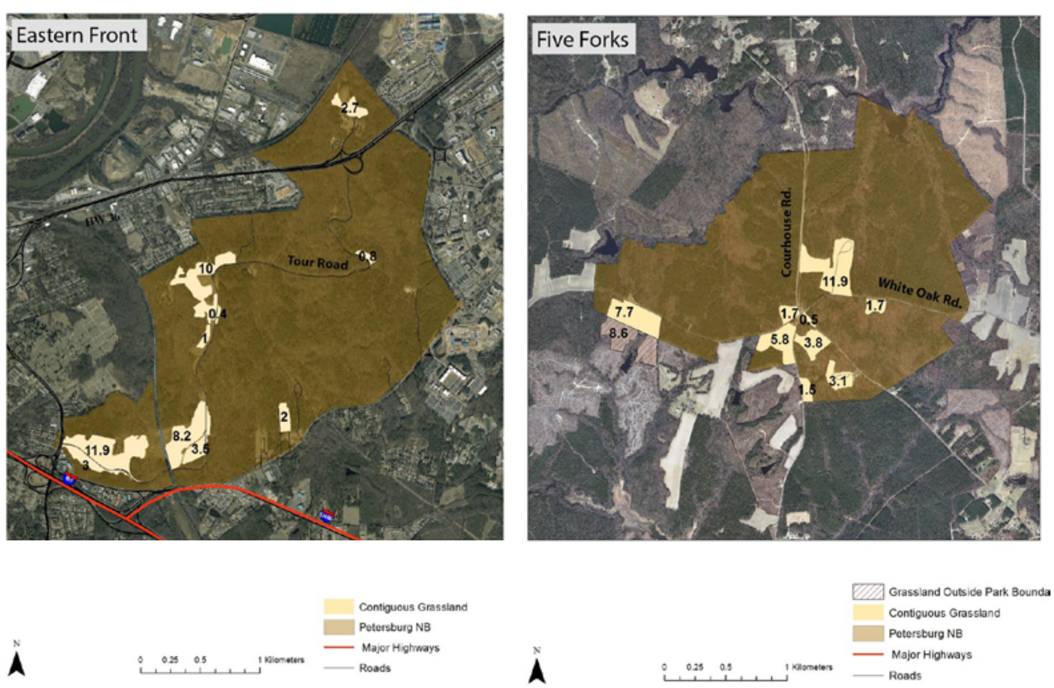


Figure 4.34 *Large patches of grassland located in Petersburg National Battlefield. Area of patch provided in hectares. Figures use Orthophoto basemap provided by NPS (2012). Landcover data for grassland patches modified from Patterson (2008).*

Current condition and trend

The park met the ecological threshold of having at least one patch ≥ 10 ha in size for an attainment score of 70%. All individual park units also met the threshold (Figure 4.34). There were two 10 ha patches over the 10 ha threshold in the Eastern Front unit. In the Five Forks unit, there was only one patch over 10 ha in area but two over 5 ha. No metrics in the park met the 40-ha threshold. Data were not available for an assessment of trend.

Data gaps and level of confidence

Confidence in this metric is assessed as fair. The size of grassland patches can be quantified with a high level of accuracy using relatively simple mapping techniques. The level of confidence would be increased by additional research to refine the threshold, e.g., the influence of patch quality on minimum patch size, species specific minimum area requirements, etc. Thresholds applicable to species other than grassland birds would also be relevant. Finally, a better measure of patch size would incorporate adjacent property along the park boundary. For example, the field in the southwest corner of the Five Forks unit would more than double in size if contiguous neighboring fields were also considered in the assessment (Figure 4.34).

Sources of expertise

Brian Watts, Director, Center for Conservation Biology, The College of William & Mary

Literature cited

Patterson KD. 2008. Vegetation classification and mapping at Petersburg National Battlefield, Virginia. Technical Report NPS/NER/NRTR- 2008/127. National Park Service, Philadelphia, PA.

Peterjohn B. 2006. Conceptual ecological model for management of breeding grassland birds in the Mid-Atlantic region. Natural Resources Report NPS/NER/NRR—2006/005. National Park Service, Philadelphia, PA.

Peterjohn B, B Eick, and B Blumberg. 2007. Native grasses: Contributors to historical landscapes and grassland-bird habitat in the Northeast. ParkScience 24.

Peterjohn BG and JR Sauer. 1999. Population status of North American grassland birds from the North American Breeding Bird Survey, 1966–1996. Studies in Avian Biology 19: 27-44.

Watts BD. 2000. Management of park fields to enhance the natural resource value and biodiversity of Colonial National Historical Park.

4.4.6 Natural Lightscapes and Night Sky

Relevance and context

The lower 48 states of the U.S. have some of the highest levels of artificial light in the world, with 60% of the population having insufficient night time darkness to fully transition over from cone to rod vision (Longcore and Rich 2004). By one estimate, 99% of the world's skies are considered light-polluted (Cinzano 2001). Natural lightscapes, including dark night skies, are an important component of visitors' park experiences and are an area of focus for NPS management (Smith and Hallo 2013). Two recognized consequences of light pollution are astronomical (the ability of stargazers to view stars and other celestial bodies) and ecological (the effects on wildlife and wildlife behavior) (Longcore and Rich 2004). Ecological impacts on wildlife can include changes to biodiversity, migration patterns, and habitat quality for birds, trees, and fish (Rich and Longcore 2006). Light pollution can also change animal interactions; for example, prey species losing the protective cover of darkness can effect predator-prey interactions (Rich and Longcore 2006). Even remote locations can be affected by distance light sources depending on the intensity and wavelength (i.e., color) of the emitted light (Salmon 2003).

Data and methods

Night sky brightness can be measured in units of 'V magnitudes' per arcsecond^2 using charged coupled device (CCD) digital cameras with a 'V' (green) filter. These measurements can then be compared to a reference value representing natural sky conditions. At present, no measurements of night sky brightness have been collected in Petersburg NB.

Threshold

A reference condition of >21.5 magnitudes per arcsecond^2 represents a value slightly brighter than the observed and modeled value for sky brightness at a site completely free of any human light sources and has been recommended by the NPS Night Sky Team as a threshold value (Garstang 1989a; Skiff 2001). During a full moon in the suburbs of a large city, V magnitudes of approximately 18.0 magnitudes per arcsecond^2 have been previously measured (Skiff 2001). One study recorded a value of 18.7 magnitudes per arcsecond^2 for urban centers from Rhode Island down to Connecticut, representing approximately 21 times natural background (Garstang 1989a).

Current condition and trend

The condition of natural lightscapes in Petersburg NB is unknown. No data are available to assess current condition or trend directly for this metric. Despite improvements in lighting technology, a strong positive correlation between human population increase and light pollution suggests that night sky brightness is at risk of increasing with continued development in the region (Garstung 1989b). The urban setting of the Eastern Front unit suggests that this unit may be especially threatened by bright night skies.

Poplar grove National Cemetary Luminary Event in Petersburg National Battlefield
Photo Courtesy of Petersburg National Battlefield, NPS

Data gaps and level of confidence

Data are not currently available for an assessment of this metric. Night sky resource inventories are needed in the park area and will contribute to Air Quality Related Value Assessments being completed nationally. Petersburg NB should be considered for inclusion in the national assessment of night sky brightness by the Natural Sounds and Night Sky Division to fill this important data gap.

Sources of expertise

National Park Service Natural Sounds and Night Sky Division, Night Sky Team http://www.nature.nps.gov/night/light.cfm

Literature cited

Cinzano P. 2001. The first world atlas of the artificial night sky brightness. Monthly Notices of the Royal Astronomical Society 328: 689–707.

Garstang RH. 1989a. Night-sky brightness at observatories and sites. Publications of the Astronomical Society of the Pacific 101: 306-329.

Garstang RH. 1989b. The status and prospects for ground-based observatory sites. Annual Review of Astronomy and Astrophysics 27: 19-40.

Longcore T and C Rich. 2004. Ecological light pollution. Frontiers in Ecology and the Environment 2(4): 191-198.

Rich C and T Longcore. (eds). 2006. Ecological consequences of artificial night lighting. Island Press, Washington, DC.

Salmon M. 2003. Artificial night lighting and sea turtles. Biologist 50(4): 163-168.

Skiff B. 2001. How dark can the night sky get? 23 May 2013 http://www.astropix.com/hmtl/L_story/skybrite.ht

Smith BL and JC Hallo. 2013. A system-wide assessment of night resources and night recreation in the U.S. national parks: A case for expanded definitions. Park Science 29(2): 54–59.

4.4.7 Soundscapes

Relevance and context

A soundscape is defined by the total ambient acoustic environment of a given area (Wrightson 2000). Evaluation of soundscapes has become an increasingly important component of landscape ecology (Truax and Barrett 2011). Natural soundscapes provide valuable resources that are integral to park ecological communities (Miller 2008). Examples of acoustic resources derive from biological sources, such as wildlife, and from geophysical sources, such as wind and rain (Pijanowski et al. 2011). Properly functioning soundscapes are important for intra-species communication, territory establishment, courting and mating, nurturing and protecting young, predation and predator avoidance, and effective use of habitat (Pijanowski et al. 2011, Truax and Barrett 2011). Specific species may be sensitive to sound; thus changes in sound regime can displace animals or make them accustomed to noise and unaffected by noise-based behavioral cues (Barber et al. 2009). Visitors also appreciate natural sounds throughout the park, which offer a source of relaxation and pleasant experiences. One system-wide survey of park visitors revealed that nearly as many visitors come to national parks to enjoy the natural soundscape (91%) as come to view the scenery (93%; NPS 1995). Recent studies have demonstrated that noise pollution is not restricted to only developed areas; instead, many protected areas also experience significant noise loads even in "natural" settings (Miller 2008, Barber et al. 2011).

Photo Courtesy of Petersburg National Battlefield, NPS

Living history cannon crew in Petersburg National Battlefield

Data and methods

Methods for quantifying the types of sounds, sound levels, and periods of audibility are under constant revision (Miller 2008). Presently, no measurements have been collected in Petersburg NB. At a typical monitoring station, digital acoustic recorders would take sound pressure level and frequency readings which can be visually represented in a spectogram (Pijanowski et al. 2011). The sound pressure level (loudness) is recorded in decibels (dB) and the frequency (pitch) of a sound is recorded in hertz (Hz). Sound equipment used in other parks can record sounds from 12.5 to 40,000 Hz, which exceeds the human hearing range. High frequency sounds (a cricket chirping) and low frequency sounds (water flowing in a river) often occur simultaneously. The frequency spectrum is split into 33 smaller ranges that each encompass one-third of an octave. For each one-third octave band, dB level is recorded once per second for the duration of the monitoring period. Recording the sound intensity of each one-third octave band allows acoustic technicians to determine what types of sounds are contributing to the overall sound pressure level of a site. Additional metrics commonly used to describe audibility include percent of time audible (the amount of time a sound is heard) and average noise free interval (the length of continuous periods without noise) (Miller 2008).

Threshold

Both what are considered appropriate sound sources and thresholds for sound pressure level vary depending on the time of day and the character of the site. Zion National Park has established recommended threshold values of ≤3 dB for more than 75% of the day and ≤3 dB for more than 90% of the night for wilderness areas in the park (NPS 2011). These levels are likely overprotective for Petersburg NB. In the more developed frontcountry zone of Zion National Park, they recommend threshold levels of ≤6 dB for more than 40% of the day and ≤4 dB more than 70% of the night. Additional recommendations include not allowing any human noises > 60 dB during the day or > 45 dB during the night (NPS 2011).

Current condition and trend

The current condition of the Petersburg NB soundscape is unknown. The urban location of the park suggests that noise levels are likely high, especially for the Eastern Front Unit which abuts large developments and major roads. In terms of trend, there is growing concern about the amount of noise coming from the Fort Lee army base adjacent to the Eastern Front Unit.

Data gaps and level of confidence

Currently no data are available to assess this metric. However, unwanted noise is a growing concern within all park units of Petersburg NB because it can interfere with communications and the visitor experience, bother surrounding neighborhoods, and potentially disrupt wildlife activities. Additional data on the types and magnitude of sounds within the park are need to fill this important data gap and to maintain compliance with Director's Order 47 regarding sound preservation and management (NPS 2000).

Research is needed to identify the types of sounds within Petersburg NB and to establish baseline sound levels. A comprehensive soundscape management plan (SMP) is recommended for the park. The Natural Sounds Program was established in 2000 to help parks manage their acoustic environments to ensure educational and inspirational visitor experiences. The program aims to discern the difference between the physical sound sources and human perceptions of those sounds. The program also works closely with the Federal Aviation Administration (FAA) to develop Air Tour Management Plans (ATMP) in national parks to address noise effects from over flights and commercial air tours.

Sources of expertise

National Park Service, Natural Sounds Program, www.nature.nps.gov/ naturalsounds

Literature cited

Barber JR, F Turina, and KM Fristrup. 2009. Tolerating noise and the ecological costs of "habituation". ParkScience. 26(3): 24-25.

Barber JR, CL Burdett, SE Reed, KA Warner, C Formichella, KR Crooks, DM Theobald, and KM Fristrup. 2011. Anthropogenic noise exposure in protected natural areas: estimating the scale of ecological consequences. Landscape Ecology 26(9): 1281-1295.

Krause B, SH Gage, and W Joo. 2011. Measuring and interpreting the temporal variability in the soundscape at four places in Sequoia National Park. Landscape Ecology 26(9): 1247-1256.

Miller NP. 2008. U.S. national parks and management of park soundscapes: A review. Applied Acoustics 69: 77-92.

National Park Service. 1995. Report on the effects of aircraft over flights on the National Park System.

Natural Park Service. 2000. Directors Order #47: Soundscape preservation and noise management.

Natural Park Service. 2011. Zion National Park soundscape management plan and environmental assessment.

Pijanowski BC, LJ Villanueva-Rivera, S Dumyahn, A Farina, BL Krause, BM Napoletano, SH Gage, and H Pieretti. 2011. Soundscape ecology: The science of sound in the landscape. BioScience 61(3): 203-216.

Truax B and GW Barret. 2011. Soundscape in a context of acoustic and landscape ecology. Landscape Ecology 26(9): 1201-1207.

Wrightson K. 2000. An introduction to acoustic ecology. Soundscape: The Journal of Acoustic Ecology 1(1): 10-13.

Photo Courtesy of Petersburg National Battlefield, NPS

Chapter 5: Discussion

5.1 PETERSBURG NATIONAL BATTLEFIELD CONTEXT FOR ASSESSMENT

The resources of Petersburg National Battlefield (Petersburg NB) possess historic, esthetic, cultural, economic, and scientific values. The condition of natural resources in the park must be considered in the context of its geography, legislative mission, and history. The park's founding documents require park management to protect certain historical conditions, including the preservation of historical landmarks.

The natural condition of these resources has been assessed systematically through: describing the park resource setting, consulting with relevant stakeholders on the assessment approach, compiling available data for resources and stressors, identifying suitable metric indicators of resource condition, using available literature and expert opinion to develop thresholds for these metrics, and deriving a percentage score for the two largest units and the park as a whole. Based on this information, this final chapter summarizes the key conditions, stressors, and threats to resources within the park. It furthermore provides recommendations for better understanding these resources and maintaining or improving their future condition.

> *"With so many irreplaceable cultural resources, the park has the important, and often difficult, task of achieving a balance between the cultural and natural aspects of preservation."*
>
> *- Petersburg National Battlefield (http://www.nps.gov/pete/naturescience/index.htm)*

5.2 PARK NATURAL RESOURCE CONDITION

Different park objectives and management practices are required for each of the four vital sign categories within Petersburg NB: Air Quality, Water Quality, Biological Integrity, and Landscape Dynamics. The natural condition of the park has been assessed based on 25 metrics representing these categories as outlined in Chapter 3. The detailed methods and final assessment of condition and trend were provided for each metric in Chapter 4. In this chapter, we present the key findings and recommendations for each metric based on a direct consideration of the assessment findings. Recommendations were compiled in collaboration with park natural resource personnel.

Photo Courtesy of Petersburg National Battlefield, NPS

Beaver pond in the Five Forks unit in Petersburg National Battlefield

5.2.1 Air Quality

The condition of air quality in Petersburg NB was assessed as being ***"very degraded,"*** based on attaining 0% of desired threshold scores (Table 5.1). Confidence in this assessment is *high* based on the data available. The length and temporal resolution of the air quality data sets allow clear assessment of trends. However the spatial resolution of the data are poor. Data were attained from regional monitoring stations and were not park specific. Air quality measurements within the park, though not a priority, would be beneficial to future assessments of air quality. Although air quality at Petersburg NB is "very degraded," trends for the past decade indicate that many of the indicators are improving.

Unfortunately, air quality degradation is a regional issue. Park management efforts to directly improve regional air quality are likely to have minimal impact for contaminants other than ozone. However, the park can play a leading role in regional education of the causes and effects of air pollution. These include human health issues, plant defoliation, water acidification and eutrophication, and altered nutrient cycling (Table 5.2).

Table 5.1 *Summary of air quality indicators including threshold attainment for Petersburg National Battlefield*

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Ozone	0%	Very degraded	Improving
Total Wet Nitrogen Deposition	0%	Very degraded	Improving
Total Wet Sulfur Deposition	0%	Very degraded	Improving
Visibility	0%	Very degraded	Improving
Mercury Deposition	0%	Very degraded	No Trend Available
Air Quality	**0%**		

Table 5.2 *Key findings and recommendations for air quality in Petersburg National Battlefield.*

Key Findings	Recommendations
•Regional degradation of air quality	•Spread awareness throughout the region
•Improving conditions for many indicators	•Educate the public on the causes and effects of air pollution
•Local impacts experienced from ozone pollution	•Provide signage and brochures about not letting buses idol when visiting the park
	•Analyze relationships between air and water quality in more depth

5.2.2 Water Quality

The condition of water quality in Petersburg NB was assessed as being ***"very good,"*** with threshold attainment at 83% (Table 5.3). Based on the available data, confidence in the assessment of condition is *fair*. The temporal resolution of water quality measurements is generally very good. However, trend is difficult to assess due to the limited sample frame (22 months in most cases). One approach to potentially increase the spatial resolution of the data sets would be to initiate a new sampling framework. For example, existing samples could be used as core sites with a rotating panel of additional sample locations (Table 5.4).

Water temperature and chemistry is in good condition, especially given the urban context of the park. A concern is the low summertime DO levels for small streams in the park that dry out or become stagnant in the summer months. Indicators such as fish communities, impervious surface cover, and riparian buffer width included in other vital sign categories are also informative of water conditions.

Table 5.3 *Summary of water quality indicators including threshold attainment for Petersburg National Battlefield.*

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Dissolved Oxygen	81%	Very Good	Stable
Water Temperature	100%	Very Good	Stable
Water pH	83%	Very Good	Stable
Benthic Macroinvertebrates	67%	Good	No Trend Available
Water Quality	**83%**		

Table 5.4 *Key findings and recommendations for water quality in Petersburg National Battlefield*

Key Findings	Recommendations
•High temperature months result in low dissolved oxygen retention especially in the Five Forks unit	•Continue sampling of water quality parameters to determine trend
•Only two sample locations for benthic macroinvertebrates	•Increase spatial sampling of benthic macroinvertabrates and possibly other metrics
•Water temperature and pH are generally in good condition	•Focus on Hatchers Run as a priority aquatic resource

5.2.3 Biological Integrity

The condition of biological integrity was assessed as being ***"good,"*** based on attaining 66% of desired threshold scores (Table 5.5). Confidence in the assessment for this vital sign is *low*. Assessment of current condition for many of the indicators was based on a single inventory data set. In many cases, these inventories were nearly a decade old. Over half of the metrics had no data to assess temporal trends. Many of the same pollutants and stressors degrade the condition of several metrics; thus many of the metrics are interconnected. For example, fish communities and herptile communities are both influenced by water quality. Similarly, the degraded condition of some metrics is the result of another metric. For example, the overpopulation of white-tailed deer may be at least partially responsible for the decline in forest regeneration. The lack of forest regeneration, in turn, may be affecting bird species that rely on this resource. More research on these interconnections of resources is warranted (Table 5.6).

More basic data collection is needed on biotic resources such as mammals and terrestrial invertebrates. Additional data on invasive plant species distributions would also be useful to management.The assessment is slightly weighted towards bird indicators due to the availability of data for this resource. Although no trend is reported for grasssland birds, the lack of young grassland species in the 2011 monitoring data is worth noting. In general, this functional group is highly dependent on disturbances that may be becoming less common on the landscape. The absence of birds that prefer mature grassland habitat from both the initial inventory and follow-up monitoring is also notable.

Table 5.5 *Summary of biological integrity indicators including threshold attainment for Petersburg National Battlefield.*

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Bald Eagles	100%	Very Good	Stable
Forest Interior Dwelling Species	100%	Very Good	Stable
Grassland Bird Species	71.5%	Good	No Trend Available
Mammal Richness	61%	Good	No Trend Available
Herptile Communities	86%	Very Good	No Trend Available
Fish Communities	50%	Fair	Degrading
White-Tailed Deer	0%	Very Degraded	Stable
Forest Regeneration	37%	Degraded	No Trend Available
Invasive Plant Species	88%	Very Good	No Trend Available
Biological Integrity	**66%**		

Table 5.6 *Key findings and recommendations for biological integrity indicators in Petersburg National Battlefield.*

Key Findings	Recommendations
•High white-tailed deer populations threaten endemic plants and forest regeneration	•Conduct more comprehensive and accurate deer monitoring by measuring distance to each deer; investigate deer effects on vegetation
•Assessment slightly weighted towards bird as indicators	•Increase research on feedbacks among biotic resources
•Invasive plant species concerns vary spatially	•Prioritize invasive plant treatments by species and spatially

5.2.4 Landscape Dynamics

The condition of landscape dynamics were assessed as being ***"very good,"*** based on an average attainment of 74% for all metrics (Table 5.7). The assessment suffers from a lack of data for both natural lightscapes and soundscapes, and by the limited temporal resolution of many of the metrics (most rely on a single dataset); thus confidence in this assessment score is *fair*. Forest connectivity was the only metric to receive a score of 0% attainment. Forest connectivity is compromised by internal park development, management of historical battlefields as grasslands, and most importantly, the division of the park into discrete units within the urban matrix of the City of Petersburg. Stressors to forest connectivity are likely to continue as forest land cover is removed from areas surrounding the park and park management focuses on battlefield conversion and acquisition (Table 5.8).

Table 5.7 *Summary of landscape dynamic indicators including threshold attainment for Petersburg National Battlefield.*

Indicators	Reference Condition Attainment	Current Condition	Trend in Condition
Percent Forest	100%	Very Good	No Trend Available
Forest Connectivity	0%	Very Degraded	No Trend Available
Riparian Buffer Width	100%	Very Good	No Trend Available
Impervious Surface	100%	Very Good	No Trend Available
Contiguous Grassland Area	70%	Good	No Trend Available
Natural Lightscapes and Night Sky	N/A	N/A	N/A
Soundscapes	N/A	N/A	N/A
Landscape Dynamics	**74%**		

Table 5.8 *Key findings and recommendations for landscape dynamics in Petersburg National Battlefield.*

Key Findings	Recommendations
•Forest connectivity near threshold for both major units and very low among units •Grassland patches are not large enough to act as reliable source habitat for all species of grassland birds •Park likely suffers from light and sound pollution but currently no data are available to assess	•Preserve additional forest lands surrounding park •Consider spatial context when converting forest to fields to maximize grassland patch size and reduce effects on forest connectivity •Consider spatial context and land cover when acquiring new sites to be added to the park •Gather data on night skies and soundscapes

The urban context of the park also provides a challenge for light and noise management. In 2010, the NPS established a Soundscape Management Plan for Zion National Park which outlines an approach to manage and protect the acoustic environment for visitor enjoyment and for wildlife needs (NPS 2011). Other acoustic work in Sequoia National Park was used to identify 25 vegetation regimes in the park with unique management goals (Krause et al. 2011). These plans could be used as a model for Petersburg NB. Fort Lee stated they would install noise control devices on outdoor equipment where practicable. The base has also expressed a willingness to adjust the locations or scheduling of training activities to lower off-post noise levels. Additional management efforts in the preservation of natural soundscapes are warranted in the park to maintain compliance with Director's Order 47: Sound Preservation and Noise Management (NPS 2000). Direct monitoring and data collection of the park's lightscapes and soundscapes would be beneficial to future condition assessments. Increasing attention to changes in lands surrounding the park would also be useful.

5.3 PARK COMPARISON: EASTERN FRONT AND FIVE FORKS

For a subset of the metrics, data were available to assess the two major units of the park separately (Table 5.9). Air quality was measured at the regional scale and could not be evaluated for the different park units. Water chemistry conditions were more degraded for acidic streams in the Five Forks unit, which suffered from depleted DO levels in the summer months. However, the more integrative biotic measure of stream quality (fish communities) was much higher for the Five Forks unit than the Eastern Front unit. The overall score of biological integrity was also lower for the Eastern Front unit. The lower score reflects higher abundances of non-native plants and a problem with deer overabundance. Both units had low scores for forest regeneration, potentially caused by high deer densities; however, deer density data are not available for the Five Forks unit. It is expected that deer populations in the Five Forks unit are not as high as in the Eastern Front unit. The Eastern Front unit contains the park's only pair of breeding bald eagles. Landscape conditions within each of the units were high. Though, again, outside pressures were higher for the Eastern Front unit as quantified by the high impervious surface cover (11.5%) in the HUC 12 watershed surrounding that unit. Forest connectivity within the Eastern Front unit also was slightly below the designated threshold (connectivity index of 0.73 compared to a threshold of 0.75).

5.4 OVERALL PARK CONDITION

The overall natural resources of Petersburg NB were assessed to be in ***"fair"*** condition, attaining 56% of desired threshold scores (Table 5.10). However, the confidence in the assessment is *fair* due to the minimal data available for some key indicators. Future priorities include the implementation of a noise and light pollution monitoring protocol. It is important to point to the improving trends in regional air quality (ozone, wet nitrogen deposition, wet sulfur deposition, and visibility), which was the primary resource of concern in this assessment. Biological integrity was the next most degraded resource. Issues of concern were associated with the white-tailed deer and forest regeneration metrics. Fish communities, benthic macroinvertebrates, and invasive plants were also a concern for the Eastern Front unit. Additional data would be useful to further identify the potential scope of these problems and to help resolve these biotic challenges. More recent data on mammals and herptiles are needed to assess trend. Some plants and animals (e.g., herbaceous grasses, terrestrial invertebrates) cannot be assessed at all because of lack of data. Also, the assessment of fish and benthic macroinvertabrates would benefit from a greater spatial coverage of monitoring points for these resources. Petersburg NB has a dense network of sampling across multiple indicators, unfortunately there is little co-location of sampling between indicators. Overlapping sample locations would be useful in future assessments to study the interactions between indicators (Figure 5.1 and Figure 5.2).

The confidence in the assessment for each vital sign is based on the temporal and spatial accuracy of the data. Air quality data has sufficient temporal resolution but poor spatial resolution. Landscape dynamics data has decent spatial resolution but poor temporal resolution with only one detailed inventory for the park(Patterson 2008), making it difficult to assess a trend. Much of the concern with landscape dynamics is the changes occurring outside the park boundaries, which are more difficult to quantify. Water quality data have sparse spatial coverage and monitoring began only recently; however the data have good temporal resolution. Biotic integrity has poor temporal resolution generally with only one inventory conducted for many of the indicators.

5.5 LITERATURE CITED

Krause B, SH Gage, and W Joo. 2011. Measuring and interpreting the temporal variability in the soundscape at four places in Sequoia National Park. Landscape Ecology 26(9): 1247-1256.

Natural Park Service. 2000. Directors Order #47: Soundscape preservation and noise management.

Natural Park Service. 2011. Zion National Park soundscape management plan and environmental assessment.

Patterson KD. 2008. Vegetation classification and mapping at Petersburg National Battlefield, Virginia. Technical Report NPS/NER/NRTR- 2008/127. National Park Service, Philadelphia, PA.

Photo Courtesy of Todd Lookingbill

Scenic Magnolia tree at Grant's Headquarters at City Point in Petersburg National Battlefield

Table 5.9 *Indicator attainment values compared between the Eastern Front and Five Forks units of Petersburg National Battlefield.*

	Eastern Front			Five Forks		
Indicator	Reference Condition Attainment	Current Condition	Trend	Reference Condition Attainment	Current Condition	Trend
Dissolved Oxygen	98%	Very Good	Stable	48%	Fair	Stable
Water Temperature	100%	Very Good	Stable	100%	Very Good	Stable
Water pH	98%	Very Good	Stable	54%	Fair	Stable
Benthic Macroinvertebrates	67%	Good	No Trend Available	67%	Good	No Trend Available
Water Quality	91%			67%		
Bald Eagle	100%	Very Good	Stable	N/A	N/A	N/A
Mammal Richness	39%	Degraded	No Trend Available	50%	Fair	No Trend Available
Herptile Communities	61%	Good	No Trend Available	59%	Fair	No Trend Available
Fish Communities	33%	Degraded	Declining	100%	Very Good	No Trend Available
Forest Regeneration	36%	Degraded	No Trend Available	38%	Degraded	No Trend Available
Invasive Plant Species	79%	Good	No Trend Available	100%	Very Good	No Trend Available
White-Tailed Deer	0%	Very Degraded	Stable	N/A	N/A	N/A
Biological Integrity	50%			58%		

Percent Forest	100%	Very Good	No Trend Available	100%	Very Good	No Trend Available
Forest Connectivity	0%	Very Degraded	No Trend Available	100%	Very Good	No Trend Available
Riparian Buffer Width	100%	Very Good	No Trend Available	100%	Very Good	No Trend Available
Impervious Surface	100%	Very Good	No Trend Available	100%	Very Good	No Trend Available
Contiguous Grassland Area	70%	Good	No Trend Available	70%	Good	No Trend Available
Landscape Dynamics	**74%**			**94%**		

Table 5.10 *Summary of park vital signs including attainment average of indicators for Petersburg National Battlefield.*

Vital Sign	Reference Condition Attainment	Current Condition	Confidence in Assessment
Air Quality	0%	Very Degraded	High
Water Quality	83%	Very Good	Fair
Biologic Integrity	66%	Good	Low
Landscape Dynamics	74%	Good	Fair
Petersburg National Battlefield	56%	Fair	Fair

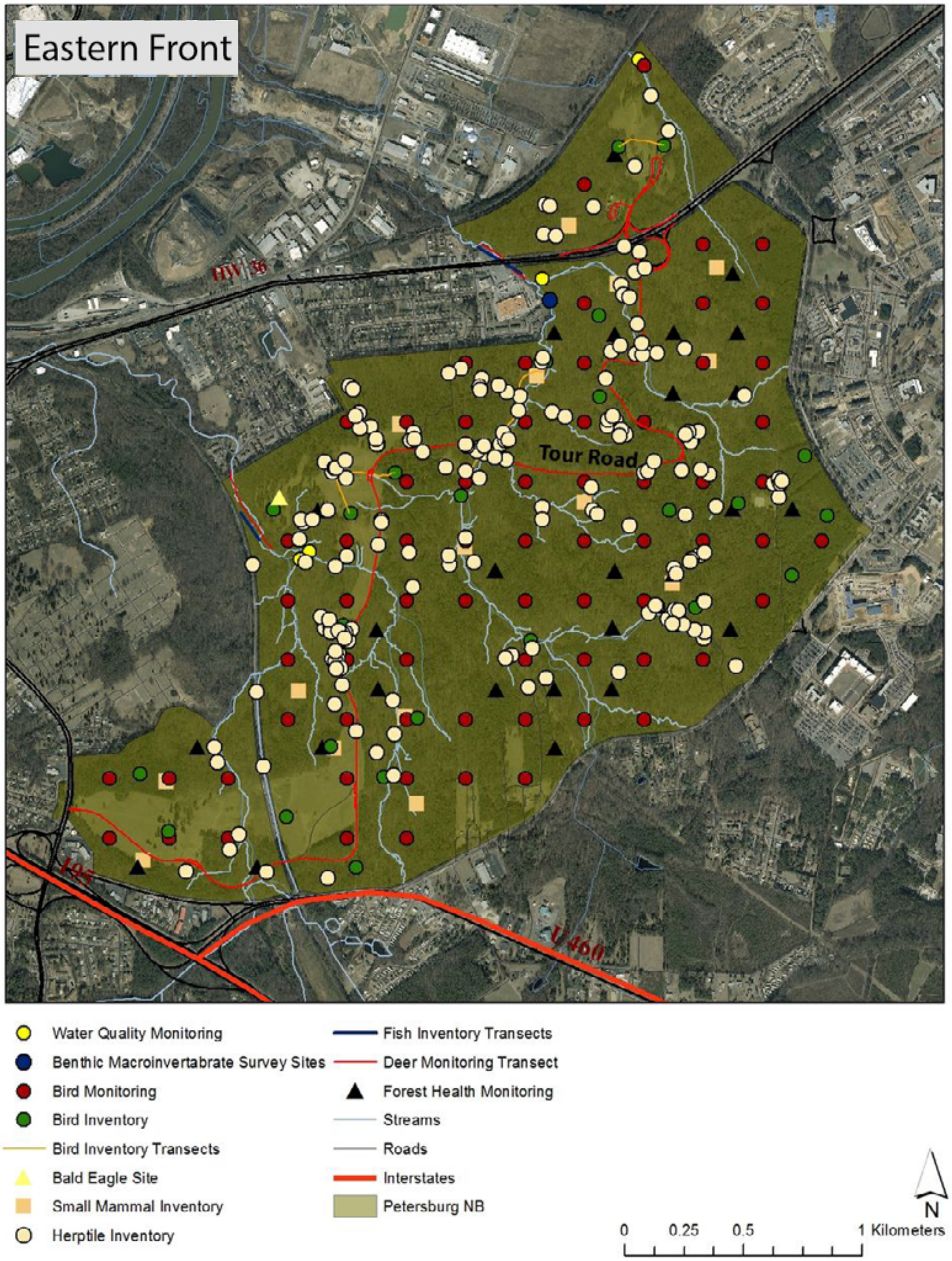


Figure 5.1 *All survey points for all indicators at the Eastern Front unit (see sources from previous figures in Chapter 4).*

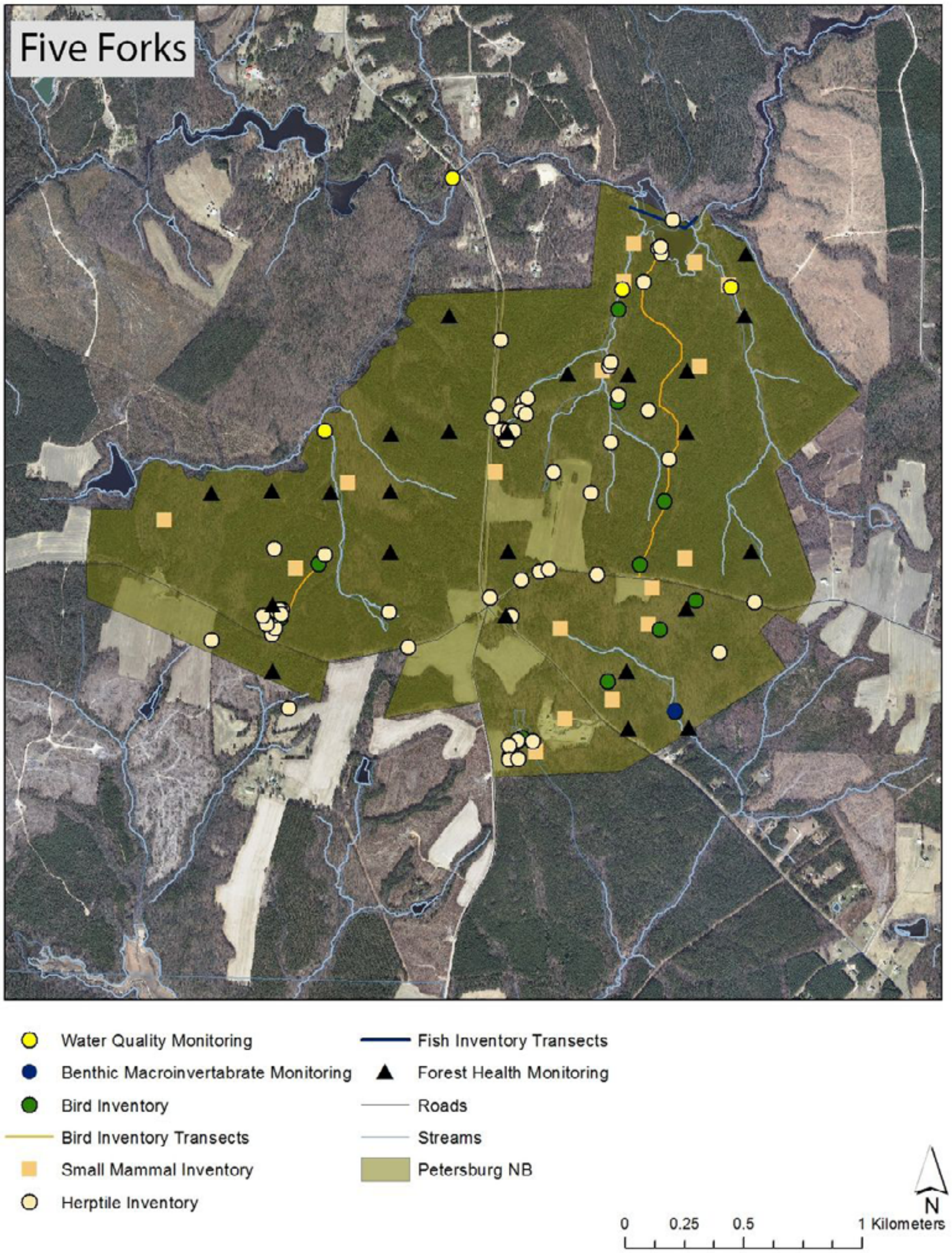


Figure 5.2 *All survey point locations for all indicators in the Five Forks unit. (see sources from previous figures in Chapter 4).*

Appendix A: List of Forest Interior Dwelling Species (FIDS) found at Petersburg National Battlefield (Bradshaw 2008).

Species	Taxonomic Name	Species	Taxonomic Name
Acadian flycatcher	*Empidonax virescens*	Acadian flycatcher	*Empidonax virescens*
American crow	*Corvus brachyrhynchos*	American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*	American goldfinch	*Carduelis tristis*
American redstart	*Setophaga ruticilla*	American redstart	*Setophaga ruticilla*
American robin	*Turdus migratorius*	American robin	*Turdus migratorius*
barred owl	*Strix varia*	barred owl	*Strix varia*
bay-breasted warbler	*Dendroica castanea*	bay-breasted warbler	*Dendroica castanea*
belted kingfisher	*Ceryle alcyon*	belted kingfisher	*Ceryle alcyon*
black vulture	*Coragyps atratus*	black vulture	*Coragyps atratus*
black-and-white warbler	*Mniotilta varia*	black-and-white warbler	*Mniotilta varia*
black-throated green warbler	*Dendroica virens*	black-throated green warbler	*Dendroica virens*
blue jay	*Cyanocitta cristata*	blue jay	*Cyanocitta cristata*
blue-gray gnatcatcher	*Polioptila Polioptila*	blue-gray gnatcatcher	*Polioptila Polioptila*
blue-headed vireo	*Vireo solitarius*	blue-headed vireo	*Vireo solitarius*
broad-winged hawk	*Buteo platypterus*	broad-winged hawk	*Buteo platypterus*
brown creeper	*Certhia americana*	brown creeper	*Certhia americana*
brown thrasher	*Toxostoma rufum*	brown thrasher	*Toxostoma rufum*
brown-headed cowbird	*Molothrus ater*	brown-headed cowbird	*Molothrus ater*
brown-headed nuthatch	*Sitta pusilla*	brown-headed nuthatch	*Sitta pusilla*
Canada goose	*Branta canadensis*	Canada goose	*Branta canadensis*
Carolina chickadee	*Poecile carolinensis*	Carolina chickadee	*Poecile carolinensis*
Carolina wren	*Thryothorus ludovicianus*	Carolina wren	*Thryothorus ludovicianus*
cedar waxwing	*Bombycilla cedrorum*	cedar waxwing	*Bombycilla cedrorum*
chestnut-sided warbler	*Dendroica pensylvanica*	chestnut-sided warbler	*Dendroica pensylvanica*
chimney swift	*Chaetura pelagica*	chimney swift	*Chaetura pelagica*
chipping sparrow	*Spizella passerina*	chipping sparrow	*Spizella passerina*
common grackle	*Quiscalus quiscula*	common grackle	*Quiscalus quiscula*
common yellowthroat	*Geothlypis trichas*	common yellowthroat	*Geothlypis trichas*
dark-eyed junco	*Junco hyemalis*	dark-eyed junco	*Junco hyemalis*
downy woodpecker	*Picoides pubescens*	downy woodpecker	*Picoides pubescens*
eastern bluebird	*Sialia sialia*	eastern bluebird	*Sialia sialia*
eastern kingbird	*Tyrannus tyrannus*	eastern kingbird	*Tyrannus tyrannus*
eastern meadowlark	*Sturnella magna*	eastern meadowlark	*Sturnella magna*
eastern phoebe	*Sayornis phoebe*	eastern phoebe	*Sayornis phoebe*
eastern towhee	*Pipilo erythrophthalmus*	eastern towhee	*Pipilo erythrophthalmus*
eastern wood-pewee	*Contopus virens*	eastern wood-pewee	*Contopus virens*
fish crow	*Corvus ossifragus*	fish crow	*Corvus ossifragus*
fox sparrow	*Passerella iliaca*	fox sparrow	*Passerella iliaca*
golden-crowned kinglet	*Regulus satrapa*	golden-crowned kinglet	*Regulus satrapa*
gray catbird	*Dumetella carolinensis*	gray catbird	*Dumetella carolinensis*
great blue heron	*Ardea herodias*	great blue heron	*Ardea herodias*
great crested flycatcher	*Myiarchus crinitus*	great crested flycatcher	*Myiarchus crinitus*

Species	Taxonomic Name	Species	Taxonomic Name
green heron	*Butorides virescens*	yellow-bellied flycatcher	*Empidonax flaviventris*
hairy woodpecker	*Picoides villosus*	yellow-billed cuckoo	*Coccyzus americanus*
hermit thrush	*Catharus guttatus*	yellow-breasted chat	*Icteria virens*
hooded warbler	*Wilsonia citrina*	yellow-rumped warbler	*Dendroica coronata*
house finch	*Carpodacus mexicanus*	yellow-throated vireo	*Vireo flavifrons*
indigo bunting	*Passerina cyanea*	yellow-throated warbler	*Dendroica dominica*
killdeer	*Charadrius vociferus*	barn swallow	*Hirundo rustica*
Louisiana waterthrush	*Seiurus motacilla*	blackpoll warbler	*Dendroica striata*
magnolia warbler	*Dendroica magnolia*	black-throated blue warbler	*Dendroica caerulescens*
mallard	*Anas platyrhynchos*	Cape May warbler	*Dendroica tigrina*
mourning dove	*Zenaida macroura*	great horned owl	*Bubo virginianus*
northern bobwhite	*Colinus virginianus*	Kentucky warbler	*Oporornis formosus*
northern flicker	*Colaptes auratus*	northern cardinal	*Cardinalis cardinalis*
northern mockingbird	*Mimus polyglottos*	northern rough-winged swallow	*Stelgidopteryx serripennis*
northern parula	*Parula americana*		
northern waterthrush	*Seiurus noveboracensis*		
ovenbird	*Seiurus aurocapillus*		
palm warbler	*Dendroica palmarum*		
pileated woodpecker	*Dryocopus pileatus*		
pine warbler	*Dendroica pinus*		
prairie warbler	*Dendroica discolor*		
prothonotary warbler	*Protonotaria citrea*		
purple martin	*Progne subis*		
red-bellied woodpecker	*Melanerpes carolinus*		
red-eyed vireo	*Vireo olivaceus*		
red-shouldered hawk	*Buteo lineatus*		
red-tailed hawk	*Buteo jamaicensis*		
red-winged blackbird	*Agelaius phoeniceus*		
ring-billed gull	*Larus Delawarensis*		
ruby-crowned kinglet	*Regulus calendula*		
scarlet tanager	*Piranga olivacea*		
sharp-shinned hawk	*Accipiter striatus*		
song sparrow	*Melospiza melodia*		
spotted sandpiper	*Actitis macularia*		
summer tanager	*Piranga ruba*		
Swainson's thrush	*Catharus ustulatus*		
swamp sparrow	*Melospiza georgiana*		
tufted titmouse	*Baeolophus bicolor*		
turkey vulture	*Cathartes aura*		
white-breasted nuthatch	*Sitta carolinensis*		
white-eyed vireo	*Vireo griseus*		
white-throated sparrow	*Zonotrichia albicollis*		
wild turkey	*Meleagris gallopavo*		
winter wren	*Troglodytes troglodytes*		
wood duck	*Aix sponsa*		
wood thrush	*Hylocichla mustelina*		

Appendix B: Mammal species found at Petersburg National Battlefield from 2003-2004 (Pagels et al. 2005)

Taxonomic Name	Species
Blarina carolinensis	southern short-tailed shrew
Canis latrans	coyote
Castor canadensis	American beaver
Didelphis virginiana	Virginia opossum
Glaucomys volans	southern flying squirrel
Lynx rufus	bobcat
Marmota monax	woodchuck
Mephitis mephitis	striped skunk
Microtus pinetorum	woodland vole
Mus musculus	house mouse
Ochrotomys nuttalli	golden mouse
Odocoileus virginianus	white-tailed deer
Oryzomys palustris	marsh rice rat
Peromyscus leucopus	white-footed mouse
Procyon lotor	common raccoon
Sciurus carolinensis	eastern gray squirrel
Sigmodon hispidus	hispid cotton rat
Sorex hoyi	pygmy shrew
Sorex longirostris	southeastern shrew
Sylvilagus floridanus	eastern cottontail
Tamias striatus	eastern chipmunk
Urocyon cinereoargenteus	common gray fox
Vulpes vulpes	red fox

Appendix C: Herptile Species found at Petersburg National Battlefield from 2002-2004 (Mitchell 2007).

	Taxonomic Name	Species
Lizards	*Eumeces fasciatus*	five-lined skink
	Eumeces inexpectatus	southastern five-link skink
	Sceloporus undulatus	eastern fence lizard
	Scincella lateralis	ground skink
Snakes	*Agkistrodon contortrix*	northern copperhead
	Carphophis amoenus	eastern worm snake
	Coluber constrictor	northern black racer
	Diadophis punctatus	northern ring-necked snake
	Elaphe alleghaniensis	eastern ratsnake
	Heterodon platirhinos	eastern hog-nosed snake
	Lampropeltis calligaster	mole kingsnake
	Nerodia sipedon	northern watersnake
	Opheodrys aestivus	rough greensnake
	Storeria dekayi	northern brownsnake
	Storeria occipitomaculata	red-bellied snake
	Thamnophis sirtalis	eastern gartersnake
	Virginia valeriae	smooth earth snake
Frogs	*Acris crepitans*	northern cricket frog
	Bufo americanus	American toad
	Bufo fowleri	Fowler's toad
	Gastrophryne carolinensis	eastern narrow-mouthed toad
	Hyla chrysoscelis	Cope's gray treefrog
	Hyla femoralis	pine woods treefrog
	Pseudacris brimleyi	Brimley's chorus frog
	Pseudacris crucifer	northern spring peeper
	Pseudacris feriarum	upland chorus frog
	Scaphiopus holbrookii	eastern spadefoot
	Rana catesbeiana	American bullfrog
	Rana clamitans	northern green frog
	Rana sphenocephala	southern leopard frog
Salamanders	*Ambystoma maculatum*	spotted slamander
	Ambystoma opacum	marbled salamander
	Amphiuma means	two-toed amphiuma
	Desmognathus fuscus	dusky salamander
	Eurycea guttolineata	three-lined salamander
	Notophthalmus viridescens	red-spotted newt
	Plethodon chlorobryonis	Atlantic Coast slimy salamander
	Plethodon cylindraceus	white-spotted slimy salamander
	Siren intermedia	lesser siren

	Taxonomic Name	Species
Turtle	*Chelydra serpentina*	common snapping turtle
	Chrysemys picta	eastern painted turtle
	Clemmys guttata	spotted turtle
	Kinosternon subrubrum	eastern mud turtle
	Pseudemys concinna	river cooter
	Pseudemys rubriventris	red-bellied cooter
	Sternotherus odoratus	stinkpot
	Terrapene carolina Trachemys	eastern box turtle
	Trachemys scripta	yellow-bellied slider

Appendix D: Invasive Species found at Petersburg National Battlefield from 2007-2011 (Comiskey and Wakamiya 2011)

Species	Taxonomic Name
climbing euonymus, winter creeper	*Euonymus fortunei*
English ivy	*Hedera helix*
Chinese lespedeza, sericea lespedeza	*Lespedeza cuneata*
honeysuckle - exotic	*Lonicera spp.*
Japanese honeysuckle	*Lonicera japonica*
Japanese stiltgrass	*Microstegium vimineum*
Oriental lady's thumb	*Polygonum caespitosum*

Invasive Species recorded in Invasive Plant Atlas as occuring in Petersburg National Battlefield (Swearingen 2007)

Species	Taxonomic Name
autumn-olive	*Elaeagnus umbellata*
big periwinkle	*Vinca major*
Chinese wisteria	*Wisteria sinensis*
common mullein	*Verbascum thapsus*
crownvetch	*Securigera varia*
English ivy	*Hedera helix*
European privet	*Ligustrum vulgare*
Japanese honeysuckle	*Lonicera japonica*
Japanese stiltgrass	*Microstegium vimineum*
johnsongrass	*Sorghum halepense*
leatherleaf mahonia	*Mahonia bealei*
mimosa	*Albizia julibrissin*
multiflora rose	*Rosa multiflora*
orchardgrass	*Dactylis glomerata*
oriental bittersweet	*Celastrus orbiculatus*
paper-mulberry	*Broussonetia papyrifera*
princesstree	*Paulownia tomentosa*
sacred bamboo	*Nandina domestica*
sericea lespedeza	*Lespedeza cuneata*
thorny olive	*Elaeagnus pungens*
tree-of-heaven	*Ailanthus altissima*
white poplar	*Populus alba*
wine raspberry	*Rubus phoenicolasius*
winter creeper	*Euonymus fortunei*

NPS 325/122163, August 2013

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™