National Park Service
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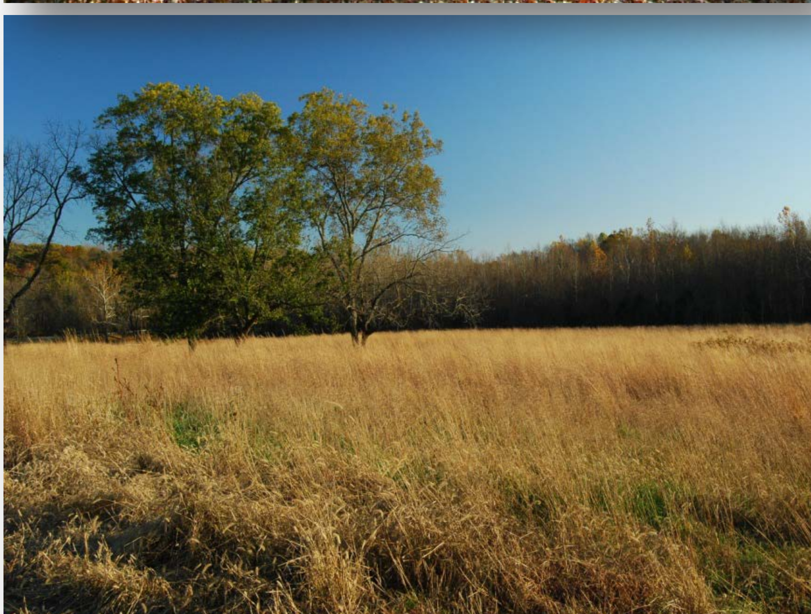
Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Appomattox Court House National Historical Park, Virginia

Natural Resource Report NPS/NER/NRR—2012/536



ON THE COVER
Appomattox Court House National Historical Park.
Photographs by: Scott Klopfer, Conservation Management Institute, Virginia Tech.

Natural Resource Condition Assessment

Appomattox Court House National Historical Park, Virginia

Natural Resource Report NPS/NER/NRR—2012/536

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Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue for more information.

Executive Summary

The goal of this assessment is to provide an overview of natural resource condition status to allow Appomattox Court House National Historical Park (NHP) to effectively manage National Park Service (NPS) trust resources through Resource Stewardship Strategies (RSS) and General Management Plans. An ancillary benefit is that it will aid the park in meeting government reporting requirements, such as the land health goals under the Government Performance Results Act (GPRA).

This assessment is based on existing data and information from natural resource managers at Appomattox Court House NHP and the Mid-Atlantic Network. A natural resource assessment should provide a concise, understandable, and accurate summary of the condition of the ecological system. Reporting on this ecological condition will provide for better decision-making at the park level; thus, collaborating with decision-makers was an important part of this project.

The natural resources evaluated in this assessment were landscape dynamics, vegetation communities, wetland and riparian resources, biological integrity, water resources, and parkwide resources such as soils, air quality, visitor use, viewscape, and soundscape. Precise measurements and objective analysis are preferred for assessing the condition of natural resources. Wherever possible, we used quantitative data and established thresholds, but in some cases only qualitative measures were available to rate important categories. Rather than remove these categories all together, we simply reported on the type of data that was available and the methods used to compare these data to a desired condition. In all cases, straightforward tables, charts, maps, and geospatial data are provided to summarize findings.

Based on available data, the majority of resources at Appomattox Court House NHP appear to be in good condition. One exception is the amount of exotic plant species detected at established forest monitoring plots. Water-quality data within the park is the most striking data gap. Data gaps also include soil chemistry and acidity, impact of visitor use on natural resources, and long-term faunal survey data.

In-park threats and stressors include habitat degradation by exotic plant species and the high number of cattle that graze on the park with access to streams and riparian areas. Outside park stressors include agricultural runoff from crop fields and cattle and concerns regarding air quality—particularly atmospheric deposition.

Acknowledgments

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Prologue

Publisher's Note: This was one of several projects used to demonstrate a variety of study approaches and reporting products for a new series of natural resource condition assessments in national park units. Projects such as this one, undertaken during initial development phases for the new series, contributed to revised project standards and guidelines issued in 2009 and 2010 (applicable to projects started in 2009 or later years). Some or all of the work done for this project preceded those revisions. Consequently, aspects of this project's study approach and some report format and/or content details may not be consistent with the revised guidance and may differ in comparison to what is found in more recently published reports from this series.

Abbreviations

APCO	Appomattox Court House National Historical Park
AQI	Air Quality Index
BBS	Breeding Bird Survey
BOD	Biological Oxygen Demand
C-CAP	Coastal Change Analysis Program
DEQ	Department of Environmental Quality
DIN	Dissolved Inorganic Nitrogen
DNH	Department of Natural Heritage
DNR	Department of Natural Resources
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
GDD	Growing Degree Days
GeoMAC	Geospatial Multi-Agency Coordination Group
GIS	Geographic Information System
GMP	General Management Plan
GPRA	Government Performance Results Act
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
I&M	Inventory and Monitoring
MIDN	Mid-Atlantic Network
NESDIS	National Environmental Satellite, Data, and Information Service
NHD	National Hydrologic Data
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
PCBs	Polychlorinated Biphenyls
PDSI	Palmer Drought Severity Index
PPM	Parts per million
RSS	Resource Stewardship Strategies
SERCC	Southeast Regional Climate Center
SGCN	Species of Greatest Conservation Need
SSURGO	Soil Survey Geographic
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VA	Virginia
VaFWIS	Virginia Fish and Wildlife Information Service
VBMP	Virginia Base Mapping Program
VDCR	Department of Conservation and Recreation
VDGIF	Virginia Department of Game and Inland Fisheries

Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010; see Prologue for more information.

NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units (hereafter "parks"). For these condition analyses, they 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.

NRCAs Strive to Provide...

Credible condition reporting for a subset of important park natural resources and indicators

Useful condition summaries by broader resource categories or topics, and by park areas

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

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[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 coverages 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 a area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested

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 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]

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 (measures ⇨ 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

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

[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 and Budget.

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.

Over the next several years, the NPS plans to fund a NRCA project for each of the ~270 parks served by the NPS Inventory and Monitoring Program. Additional NRCA Program information is posted at: http://www.nature.nps.gov/water/NRCondition_Assessment_Program/Index.cfm.

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
(longer-term strategic planning)

Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public
("resource condition status" reporting)

Resource Stewardship Planning and Science

Appomattox Court House National Historical Park (NHP) is part of the NPS Mid-Atlantic Network Inventory and Monitoring (I&M) Program. The Inventory and Monitoring program was established in 1992 to complete biological inventories for all parks with significant natural resources and establish ongoing monitoring programs in select parks. In 1998, the program grew and 32 networks were established to investigate "long-term trends in the condition of National Park System resources" (NPS 2009a). The Mid-Atlantic Network (MIDN) has completed basic inventories of all major taxa. In consultation with park staff and their Science Advisory board, the Mid-Atlantic Network chose 43 "vital signs" as indicators of overall health of park resources (Comiskey and Callahan 2008). The 43 vital signs were ranked and 20 are being implemented in a priority order, beginning with 16 that will be implemented in the next three to five years. These vital signs are:

Air and Climate

1. Ozone
2. Wet and dry deposition
3. Visibility and particulate matter
4. Air contaminants (mercury)
5. Weather and Climate

Geology and Soils

6. Stream / river channel characteristics
7. Soil structure and composition

Water

8. Stream and river water dynamics
9. Water chemistry
10. Aquatic macroinvertebrates

Biological Integrity

11. Invasive exotic plants
12. Native forest pests
13. Exotic diseases / pathogens – plants
14. Forest plant communities
15. White tailed deer (herbivory)
16. Breeding birds

Study Approach

Appomattox Court House NHP personnel, NPS Northeast Region scientists, and Mid-Atlantic Network scientists were involved at all stages of this assessment. The NRCA process began with a preliminary scoping meeting at Appomattox Court House NHP on May 28, 2009. At this meeting, we introduced the NRCA program as a whole. The main portion of the meeting was dedicated to the discussion of significant natural resources, threats and stressors to the resources, ongoing programs, issues, conflicts, concerns, and specific indicators and measures of natural resource health (i.e. I&M vital signs).

The National Park Service (NPS) monitors their natural resources using an ecological monitoring framework that has been widely used among other agencies (Fancy et al. 2009). There are six basic level 1 categories: 1) air and climate; 2) geology and soils; 3) water; 4) biological integrity; 5) human use; and 6) ecosystem patterns and processes. We found the NPS categories to be uncomplicated and intuitive. This framework is also familiar to NPS personnel and will allow the users to compare current vital sign monitoring plans to this assessment. We have organized this assessment by ecosystem resource to be most useful for park personnel.

Each section contains a brief description of the resources, past and current inventory and monitoring efforts, and threats and stressors. We identified the major threats and stressors in each section to help guide us in developing a framework and choosing appropriate indicators for the assessment. For each category assessed, we identified indicators and measures from our preliminary scoping meeting with NPS personnel and follow-up communication.

The current value of each measure was recorded and compared to documented reference values. Reference values were obtained from the NPS, federal standards (e.g. EPA, USGS), state standards (e.g. VA DEQ, DNR), primary research, or our scoping meeting (Table 1). These values were then used in determining the overall condition status for the category by assigning a midpoint to each indicator based on the condition status rating. The midpoints were then averaged to provide an overall condition status for each level 1 category. Summary tables are provided at the conclusion of each section.

In addition, we provided a data quality rating based on three categories, *thematic*, *spatial*, and *temporal*. We gave *thematic* a 1 or 0 (yes or no) based on whether these data were from the best available source. Ratings for thematic data varied by each case and are explained in the corresponding section. *Spatial* received a 1 or 0 based on the spatial proximity of these data (in-park data or out-of-park data). We also gave *temporal* a 1 or 0 based on how recently these data were acquired. *Temporal* was somewhat dependent on data type, but, generally, if the data were from the last five years, they received a 1. The data quality values were averaged, and an overall rating is given for the data quality (good = 2.67 to 3; fair = 1.34 to 2.66; and poor = 0 to 1.33). We provide access to these scores in spreadsheets to view calculations, update data, and modify importance ratings as management goals change. Data quality tables for each resource are listed in Appendix A and our land cover calculation methods are described in Appendix B.

Table 1. Data sources for indicators and measures.

Level 1 Category	Attribute	Vital Sign/Indicator	Data Source
Landscape Dynamics	Land Cover	Natural vegetation within park	2001 NLCD (U.S. Geological Survey 2001)
	Land Use	Impervious surface within park	2001 NLCD
		Converted land cover	NPScape
		Population density	NPScape
Soundscape		Frequency and magnitude of anthropogenic sound (especially air and road traffic)	APCO data
Vegetation Communities	Forest Health	Species Composition	I&M data
		Land cover	2002 NPS vegetation map; 2001 NLCD (U.S. Geological Survey 2001)
		Key forest bird species	Kearney (2003)
		Native forest pests	I&M data
		Invasive exotic plants	I&M data, Forder (2010)
		Soil structure and composition	Ecological Integrity Reporting SOP NETN (Version 3.09)
		White-tailed deer density	Horsley et al. (2003); APCO data
	Grassland Integrity	Species composition	Forder (2010)
		Proportion of nonnative plot cover	Forder (2010)
		Species count	Forder (2010)
		Key grassland bird species	Kearney (2003)
		Soil structure and composition	Ecological Integrity Reporting SOP NETN (Version 3.09)
Wetland/Riparian Resources		Extent of wetlands	2002 NPS vegetation map; Environmental Concern Inc. 2002
		Surrounding land use index	2002 NPS vegetation map; 2001 NLCD (U.S. Geological Survey 2001); NPScape
		Landscape connectivity	2002 NPS vegetation map; Environmental Concern 2002
		Buffer index	2002 NPS vegetation map; 2001 NLCD (U.S. Geological Survey 2001)
Air and Climate: Air Quality	Ozone	8-hour average O_3 concentration	Clean Air Status and Trends Network (CASTNet) and Gaseous Pollutant Monitoring (GPMN) (NPS 2009d)
	Atmospheric Deposition	Sulfur deposition	National Atmospheric Deposition Program (NADP)
		Nitrogen deposition	NADP (University of Illinois at Urbana-Champaign 2009)
	Visibility	Haze index (deciviews)	Interagency Monitoring of Protected Visual Environments (IMPROVE) (CSU 2009)
	Mercury	Total mercury in precipitation	Mercury Deposition Network (MDN), a NADP Network (NADP 2009)
Water Resources: Hydrology	Hydrology	Flow	USGS (2009c)

Level 1 Category	Attribute	Vital Sign/Indicator	Data Source
Water Resources: Water Quality	Stream Condition	Dissolved oxygen	VA DEQ (2009)
		pH	VA DEQ (2009)
		Temperature	VA DEQ (2009)
		Bacterial (fecal coliform)	VA DEQ (2009)
		Bacterial (*E. coli*)	VA DEQ (2009)
		Conductivity	VA DEQ (2009)
		Turbidity	VA DEQ (2009)
	Macroinvertebrates	VA SOS multi-metric score	VA SOS (2009), Gannicott and Shahady (2004)
Biological Integrity: Focal Taxa	Fish	Jaccard's Index of Similarity	APCO species list (Certified Organisms: NPSpecies 2009), NatureServe watershed reference list, VDGIF (2009b) VaFWIS species list, Atkinson (2005, 2008)
	Amphibians	Jaccard's Index of Similarity	APCO species list, reference list from Mitchell (2006), VDGIF VaFWIS species list
	Reptiles	Jaccard's Index of Similarity	APCO species list, reference list from Mitchell (2006), VDGIF VaFWIS species list
	Birds	Jaccard's Index of Similarity	APCO species list, BBS data for Southern Piedmont (U.S. Geological Survey 2009b), VDGIF VaFWIS species list
		Community trends	BBS data for Southern Piedmont
	Mammals	Jaccard's Index of Similarity	APCO species list, reference list from Pagels et al. (2005), VDGIF VaFWIS species

Park Resource Setting

Appomattox Court House National Historical Park (NHP) is located in south central Virginia, roughly 75 miles west-southwest of Richmond, 21 miles east of Lynchburg, and two miles northeast of the town of Appomattox in the heart of Appomattox County. An aerial view (Figure 1) using 2007 Virginia Base Mapping Program (VBMP) imagery shows the forests, meadows, and pastures that comprise the landscape of the park. The park is bisected by State Route (SR) 24, placing the majority of the park property on the western side of SR 24. The Appomattox River also bisects the park, placing the majority of the park property to the south of the river. The park’s federally owned authorized boundary contains 1,709 ac, with an additional 76 ac of non-federally owned authorized land. Slightly more than 758 ac of the Appomattox Court House NHP property lies to the east of SR 24.

Appomattox Court House NHP (Figure 1) was originally commissioned by President Hoover on June 18, 1930 as a memorial site to be run by the War Department. Appomattox Court House was transferred to the National Park Service in 1933 and became Appomattox Court House National Monument in 1935 after President Roosevelt signed an amendment authorizing funds for land procurement and changing the park’s name. Appomattox Court House National Monument was renamed April 6, 1954, and officially became Appomattox Court House National Historical Park (Gurney 1955).

The purpose of Appomattox Court House NHP is to commemorate the effective termination of the Civil War brought about by the surrender of the Confederate Army of Northern Virginia under General Robert E. Lee to the Union Army under Lieutenant General Ulysses S. Grant on April 9, 1865, and for the further purpose of honoring those who engaged in this tremendous conflict. As such, the mission of Appomattox Court House NHP is to preserve in perpetuity the village where General Lee surrendered to Lt. General Grant and make this valuable part of American heritage available for visitors to experience, enjoy, understand, and appreciate (NPS 2007b).

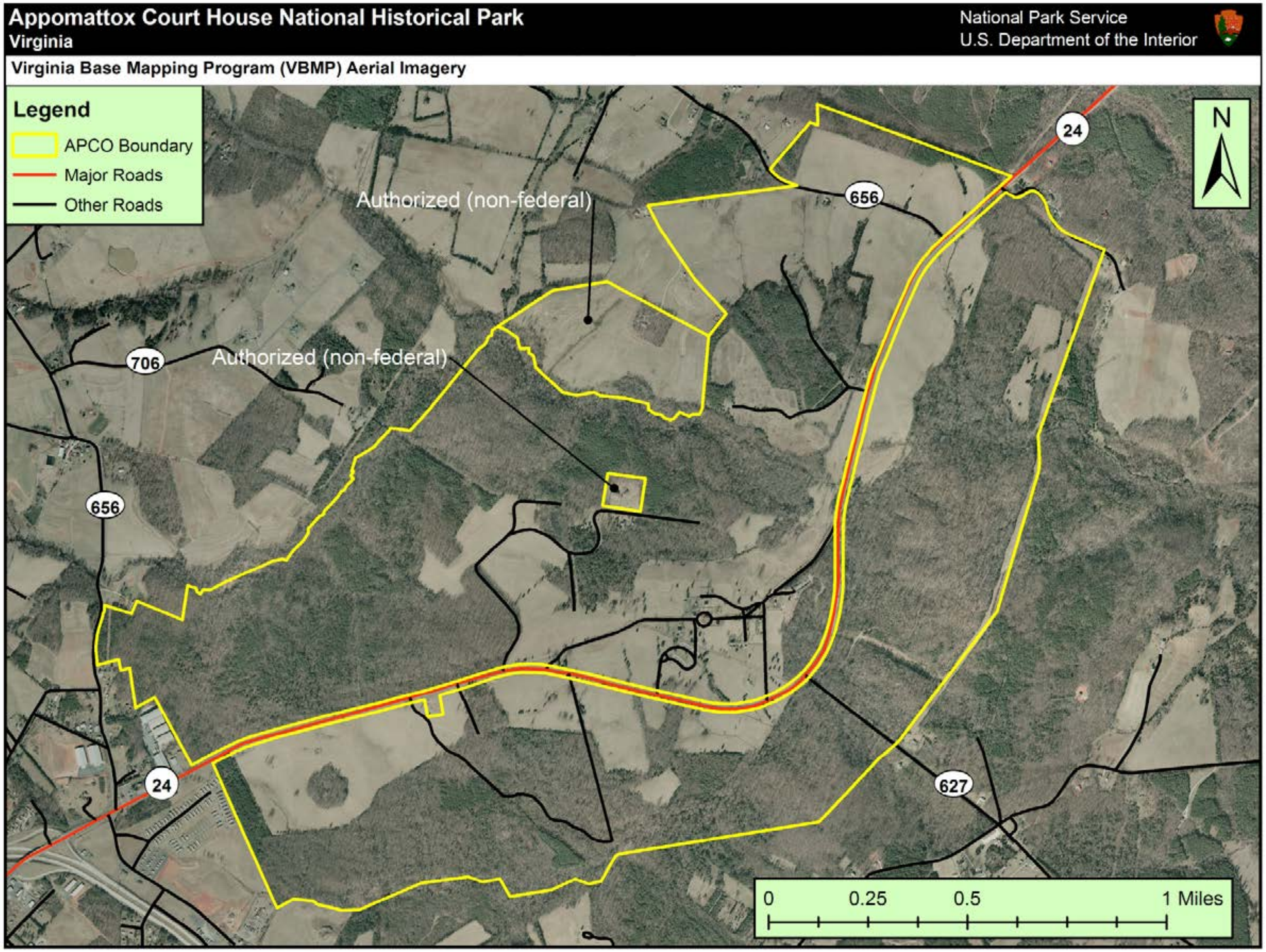

Figure 1. View of Appomattox Court House National Historical Park (APCO) with 2007 Virginia Base Mapping Program (VBMP) aerial imagery.

The entire park is classified as a cultural landscape (Eick 2010). Managers at Appomattox Court House must protect both the natural and cultural resources within the park. To help natural resource managers balance the sometimes conflicting cultural and natural resource priorities at a park like APCO, the NPS system must follow a General Management Plan (GMP). The GMP defines the central management philosophy of the park and outlines future management objectives and aids in decision-making for the next 15–20 years. The goals listed in the Appomattox Court House NHP GMP (NPS 2008a) are:

- *Resource Protection*:
  Cultural and natural resources and values are managed to maintain and restore their integrity within the park.
- *Visitor Experience and Use*:
  Provide a safe, high-quality, educational experience for visitors
- *Partnerships and Cooperative Actions*:
  Increase operational capacity through cooperative efforts with public and private organizations.
- *Operational Efficiency*:
  Park facilities, infrastructure, and services are coordinated to efficiently support operational needs, including interpretation and resource management. Staffing is adequate to maintain the park and serve visitor needs.

The previous GMP for Appomattox Court House NHP was completed in 1977; an update is currently in draft form. To comply with the National Environmental Policy Act (NEPA), the GMP also assesses the probable impacts of a no-action alternative and proposed alternatives to the GMP. There are currently three alternatives being considered in addition to the no-action alternative.

Under Alternative 1, there is no change in management direction and plans already in place are implemented. Maintenance of the park's existing conditions will continue and the visitor experience continues to be primarily oriented to the village. The trail system continues in its current form and is not expanded to the new land area. The park boundary continues to be unchanged except for minor adjustments through donations or by willing sellers. The following three alternatives include upholding the core management philosophy of the park.

Alternative 2 is the NPS and environmentally preferred alternative. In this alternative, a boundary adjustment (common to all alternatives) and other actions will make the park more accessible to visitors. The primary and secondary visitor use zones would be expanded. In addition, a new maintenance facility would be constructed. The current facility location is near an observation point and is easily viewed by visitors. Alternative 2 best reflects the park's purpose and significance and provides for a high level of resource protection. This alternative promotes adaptive reuses of historic structures with minimal new construction. Visitors will be concentrated within the core area of the park. Visitor impacts on lands outside of the historic core will be minimized.

With Alternative 3, some aspects of the natural environment would be affected as visitor use expands in the park. As in Alternative 2, the re-use of an existing 1970's building for consolidating administrative offices would maximize recycling of resources. This alternative achieves a balance between visitor activity and resource use.

Alternative 4 includes expansion of the trail system park-wide. This alternative achieves a range of beneficial uses of the environment including a park-wide trail. However, opportunities for visitor use will be limited to the trail system. The natural environment would see less extensive change and assumes the number of visitors will not grow as much as expected in alternatives 2 and 3.

Climate

The climate in the Appomattox County region of the Virginia Piedmont is moderated by the mountains to the west and the Chesapeake Bay to the east, resulting in warm, humid summers and mild winters (Hamilton et al. 1986). The average annual temperature of the area is 55 degrees Fahrenheit (°F). The coldest month on average is January, with an average high temperature of 44.9°F and a low of 24.4°F. The warmest month on average is July, with average high temperatures of 86.5°F and lows of 64.5°F (Franklin County 2009). The lowest and highest recorded temperatures were -14°F in 1994 and 103°F recorded in both 1965 and 1982. The growing season lasts approximately 186 days, from late April to mid-October (Hamilton et al. 1986).

Precipitation is fairly evenly distributed through most of the year but the wettest month is May, with an average rainfall of 4.51 inches (TWC 2009). Annual rainfall in Appomattox County averages 43 inches, while annual snowfall averages 18 inches (Franklin County 2009). Major storms do not seem to be of great concern for this area of Virginia, but thunderstorms producing high winds and flashfloods are not uncommon. Between 1950 and 2007, Appomattox County experienced only one tornado (VA DEM 2009). See Appendix C for a more detailed climate discussion of the landscape around Appomattox Court House NHP.

Geology, Landforms, and Soils

Appomattox Court House NHP lies within the Outer Piedmont sub-region of Virginia's Piedmont Province, between the Coastal Plain and Blue Ridge provinces (Bailey 1999). The largest physiographic province in Virginia, the Piedmont features a gently rolling topography with deeply weathered igneous and metamorphic bedrock whose ages range from Proterozoic to Paleozoic. The humid climate present in the Piedmont results in strongly weathered rocks, leaving the bedrock buried under a thick blanket of saprolite between two and 20 m thick. Consequently, the Piedmont region generally lacks solid outcrops in areas not subject to significant erosion (WM 2009).

Topography in the vicinity of Appomattox Court House NHP features gently rolling hills and a variable landscape, ranging from stream floodplains and shallow ravines at an elevation of roughly 600 ft to terraces at roughly 830 ft (Mitchell 2006). At the park, elevations range from 600 ft at the Appomattox River to about 830 ft along the western park boundary (Patterson 2008).

According to Soil Survey Geographic (SSURGO) data from the USDA Natural Resources Conservation Service (2009a), there are 15 different soil types present within the Appomattox Court House NHP boundaries; the soils with the greatest extent at the park are Mecklenburg-Poindexter complex, covering 445.4 ac (25%), and Cullen clay loam, covering 438.9 ac (24.7%). See Parkwide Resources for more information concerning soils.

Vegetation Communities

Appomattox Court House NHP is comprised of forests, woody wetlands, pastures and hayfields, crop fields, and developed open spaces. The majority of the park is covered with mixed pine and hardwood forests, with the predominant coniferous species being native Virginia pine (*Pinus virginiana*) and planted loblolly (*Pinus taeda*) pine. Hardwood species, including oak (*Quercus spp.*), tulip poplar (*Liriodendron tulipifera*), hickory (*Carya spp.*), and others are found in terrestrial areas. Species such as red maple (*Acer rubrum*) and black willow (*Salix nigra*) are found in some of the wetter areas of the park (Mitchell 2006). Major vegetation groups identified at the park during the vegetation mapping effort by Patterson (2008) include:
oak / heath forests, mesic acidic forests, oak - hickory forests, basic mesic and calcareous forests, seepage wetlands, alluvial forests, and nonriverine forests. See Vegetation Communities for more information including communities of interest found at the park.

Surface Water

Appomattox Court House NHP sits in the upper half of the James River drainage basin near the lower boundary between the James River Basin and the Roanoke River Basin (Figure 2). The James River Basin begins in the Allegheny Mountains along the border of Virginia and West Virginia and drains southeasterly across four of Virginia's five physiographic provinces: the Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain provinces (WM 2009). The James River Basin, Virginia's largest river basin, covers about 6.5 million ac (10,206 sq mi) and drains into the Chesapeake Bay. It spans all or portions of 38 counties and 15 cities. Over 65% of the basin is forested, 19% is in cropland and pasture, and roughly 12% is urban (VA DEQ 2008).

The James River Basin is divided into eight subbasins, one of which is the Appomattox River subbasin, hydrologic unit code (HUC) 02080207 (VA DCR 2009). The subbasin covers an area of nearly 1,032,000 ac (1,612 sq mi) and includes all or portions of 13 counties and three cities. The Appomattox River subbasin is further divided into 10 watersheds and 45 sub-watersheds. Appomattox Court House NHP is situated just downstream from the headwaters of the Appomattox River, in the 19,840-ac (31 sq mi) Appomattox River-Wolf Creek sub-watershed (HUC 020802070201). The Appomattox River-Wolf Creek sub-watershed is part of the larger, 125,440-acre (196 sq mi) Appomattox River-Vaughans Creek watershed (HUC 0208020702) (Figure 2). The Appomattox River, which drains 1,023,851 ac of agricultural, rural residential, and urban land to the James River, bisects Appomattox Court House NHP in the northern portion of the park's boundary (Longwood University 2009). In addition to the Appomattox River, there are several smaller streams and waterways, including North Branch, Plain Run Branch, and Rocky Run. Flooding and channel erosion are naturally occurring phenomena and a possible point of concern for Appomattox Court House NHP (Thornberry-Ehrlich 2005). In all, there are approximately 8.2 mi of streams within the park boundaries (NPS 2007b).

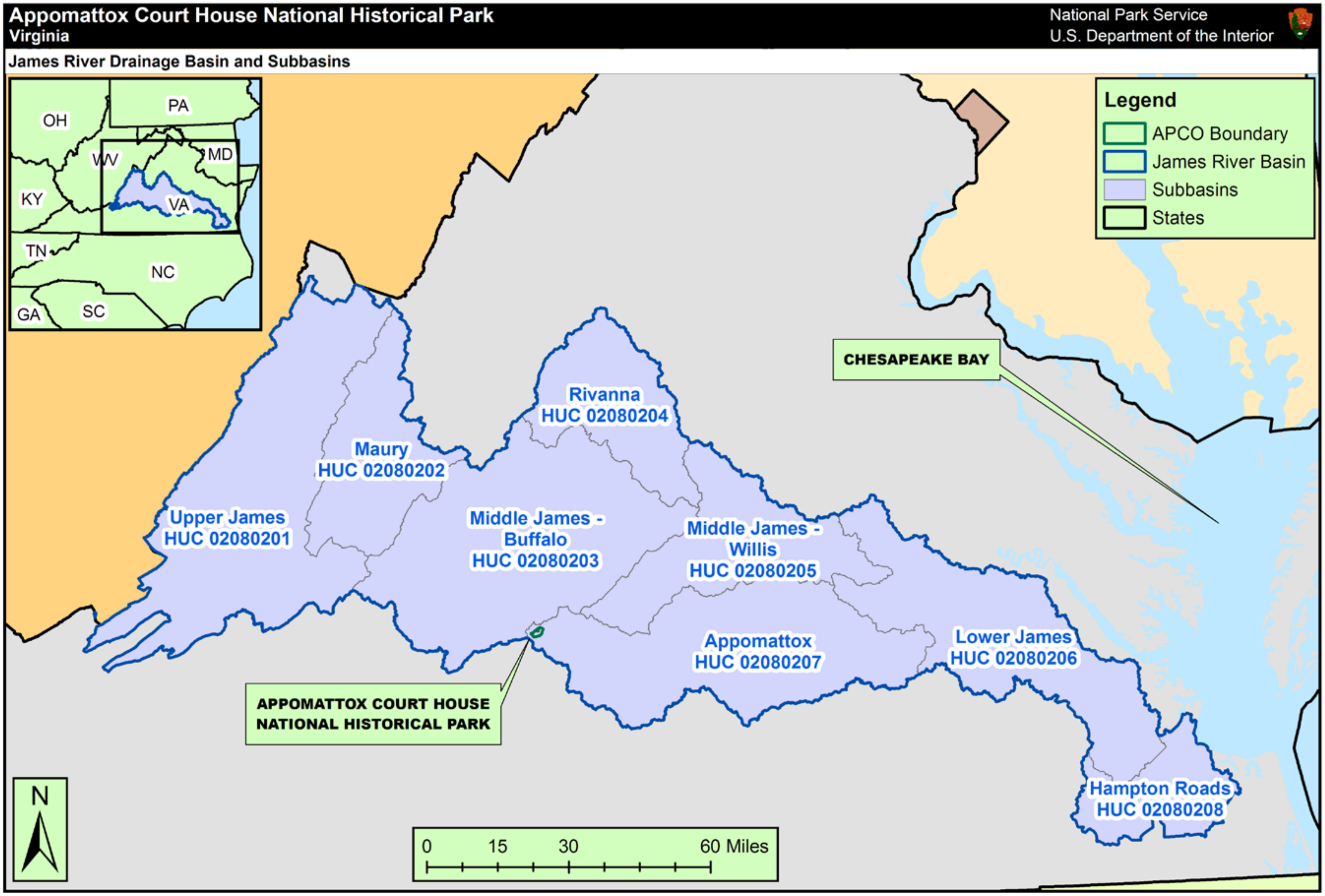

Figure 2. The location of the James River drainage basin (HUC 020802) and its subbasins in Virginia.

Flora and Fauna

One of the first goals of the I&M Program has been to establish baseline biological inventories for vascular plants and vertebrates in order to provide a reliable account of species at each park, with inventory and monitoring results to be used as a fundamental tool for future park management.

Preliminary inventories for mammals, birds, reptiles, amphibians, and fish have been completed for Appomattox Court House NHP (Pagels et al. 2005, Mitchell 2006, Bradshaw 2007, Atkinson 2008). Documented at Appomattox Court House NHP are 99 species of birds, 19 amphibian, 14 reptile, 21 mammal, and 30 fish species. Additionally, 344 species of trees, shrubs, and herbaceous plants occur in the park. Several Virginia Species of Greatest Conservation Need have been documented, including 23 bird, one amphibian, two reptile, one fish, and one Virginia (DCR, DNH) rare plant species (Table 2). One of the highlights from the fish inventories in 2002 and 2004 was the diversity of darters (fantail, longfin, johnny, and stripeback) encountered within the Appomattox River.

Table 2. Virginia Species of Greatest Conservation Need found in Appomattox Court House National Historical Park.

Common Name		Scientific Name	VA SGCN
Birds	American woodcock	*Scolopax minor*	Tier IV
	bald eagle	*Haliaeetus leucocephalus*	Tier II
	black-and-white warbler	*Mniotilta varia*	Tier IV
	brown creeper	*Certhia americana*	Tier IV
	brown thrasher	*Toxostoma rufum*	Tier IV
	chimney swift	*Chaetura pelagica*	Tier IV
	eastern kingbird	*Tyrannus tyrannus*	Tier IV
	eastern meadowlark	*Sturnella magna*	Tier IV
	eastern towhee	*Pipilo erythrophthalmus*	Tier IV
	eastern wood-pewee	*Contopus virens*	Tier IV
	field sparrow	*Spizella pusilla*	Tier IV
	grasshopper sparrow	*Ammodramus savannarum*	Tier IV
	green heron	*Butorides virescens*	Tier IV
	Louisiana waterthrush	*Seiurus motacilla*	Tier IV
	northern bobwhite	*Colinus virginianus*	Tier IV
	northern parula	*Parula americana*	Tier IV
	northern rough-winged swallow	*Stelgidopteryx serripennis*	Tier IV
	ovenbird	*Seiurus aurocapillus*	Tier IV
	scarlet tanager	*Piranga olivacea*	Tier IV
	wood thrush	*Hylocichla mustelina*	Tier IV
	yellow-billed cuckoo	*Coccyzus americanus*	Tier IV
	yellow-breasted chat	*Icteria virens*	Tier IV
	yellow-throated vireo	*Vireo flavifrons*	Tier IV
Amphibians	mole salamander	*Ambystoma talpoideum*	Tier II
Reptiles	eastern box turtle	*Terrapene carolina carolina*	Tier III
	queen snake	*Regina septemvittata*	Tier IV
Fish	American eel	*Anguilla rostrata*	Tier IV

Landscape Dynamics

The Mid-Atlantic region of the eastern United States is developing rapidly and many parks in the Mid-Atlantic Network (MIDN) are now facing pressure from adjacent suburban development. The resulting effects of population growth include land use change, increased pollution, increased resource extraction, habitat fragmentation, and increased distribution of exotic and invasive species (Wagner et al. 2006). The primary stressors listed in the MIDN vital signs report that have the greatest effect on terrestrial ecosystems are climate change, atmospheric pollution, biotic change, and land use change (Comiskey and Callahan 2008). Such changes can result in numerous negative impacts on our federal and state protected lands.

We reclassified and examined the C-CAP and NPS vegetation map to quantify natural, semi-natural, and unnatural vegetation within the park; these classifications are described in greater detail in Appendix B. Appomattox Court House NHP is composed of 64.0% natural, 30.6% semi-natural, and 5.4% unnatural vegetation (Table 3; Figure 3). For reference purposes, there are other protected conservation areas near Appomattox Court House NHP that can be included in future evaluations (Appendix D).

Table 3. Comparison of reclassified land cover (from 2002 NPS vegetation map and 2005 C-CAP) within the Appomattox Court House National Historical Park boundary.

Vegetation Reclass	APCO Acres (NPS Veg)	APCO % (NPS Veg)	APCO Acres (C-CAP)	APCO % (C-CAP)
Natural Vegetation	1113.1	64.0	1122.8	64.5
Semi-natural Vegetation	532.5	30.6	602.5	34.6
Unnatural Vegetation	93.8	5.4	16.5	0.9

Land Cover Change

Land cover change is an on-going issue across the country and often serves as a primary threat to other natural resources. Increased vehicular traffic, noise, and emissions could degrade the overall visitor experience of the park. Increasing the amount of impervious surfaces in and around the park also has direct consequences to the park's water quality, fisheries, and wildlife.

Some of the most immediate and potentially severe threats to biotic diversity are related to changes in land cover and wildlife habitat. The Virginia Comprehensive Wildlife Conservation Strategy External Steering Committee identified the following critical issues regarding land use changes for the next ten years (VA DGIF 2005):

- Habitat loss, fragmentation, and isolation
- Poor land use decision-making
- Integration of economic development and sound conservation
- Sprawl
- Decline of agriculture
- Riparian development
- Lack of land conservation
- Inadequate land use planning, and
- Predation, due to high mesocarnivore populations.

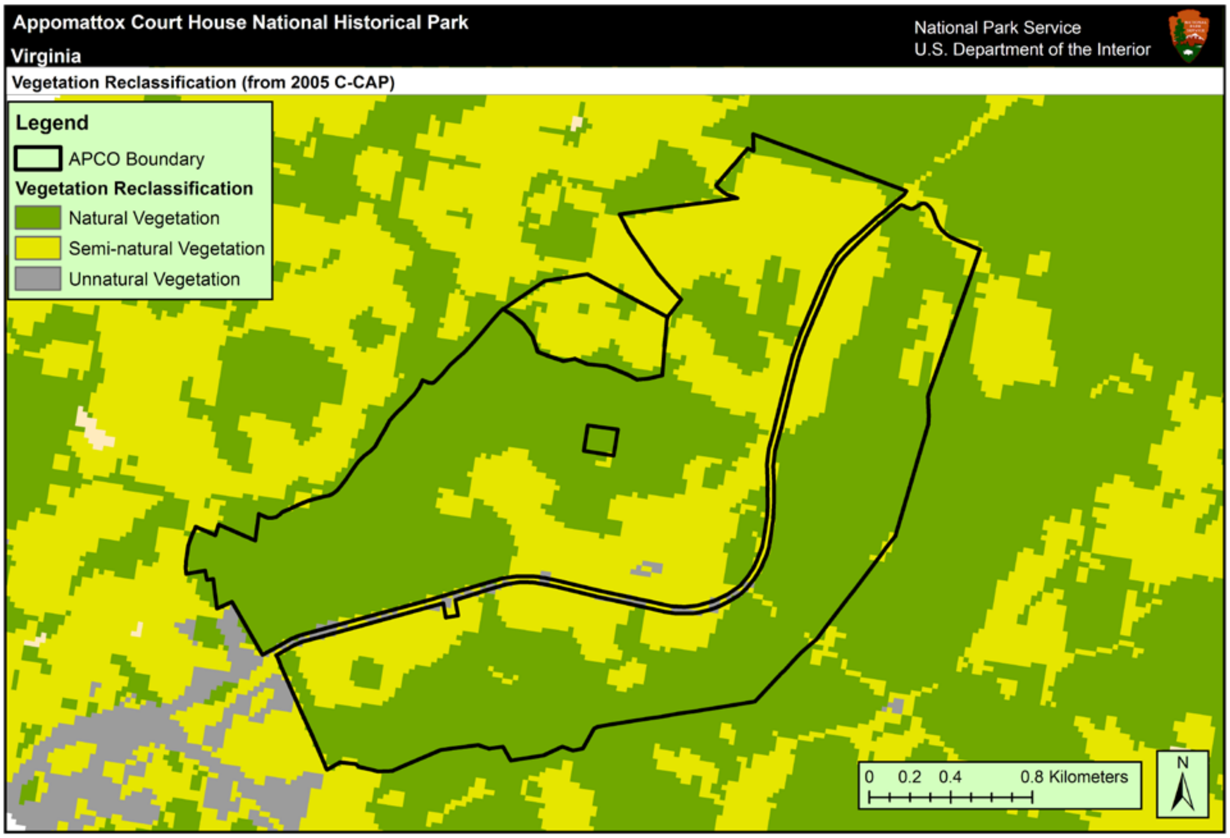

Figure 3. Vegetation reclassification (from 2005 C-CAP) for Appomattox Court House National Historical Park (APCO).

Figure 4 illustrates the land cover change from 1992–2001 (NPScape) for a 30-km buffer surrounding Appomattox Court House NHP. We also examined the change in land cover within a 1-km buffer surrounding Appomattox Court House NHP. We chose the most recent, complete, and detailed classification from the National Oceanic and Atmospheric Administration (NOAA 2006) Coastal Change Assessment Program (C-CAP). Figure 5 depicts the land cover for 1996, 2001, and 2005, respectively. Land class definitions for C-CAP classifications can be found in Appendix B. We simplified the classifications by combining classes to better compare these classes; this allowed us to examine percent change of total acreage within each simplified class (Table 4). It is evident that mapping technologies were different, since there was a slight acreage change in the water class among the three years. The grassland/herbaceous class also increased significantly as imagery and mapping technologies improved. Despite mapping discrepancies, this comparison can be used to reinforce and further illustrate a slight increase in urban lands and a decrease in forested lands in the watershed containing Appomattox Court House NHP. These changes will remain important as protected natural areas continue to fall under increased pressure to accommodate more of their region's natural processes and biodiversity.

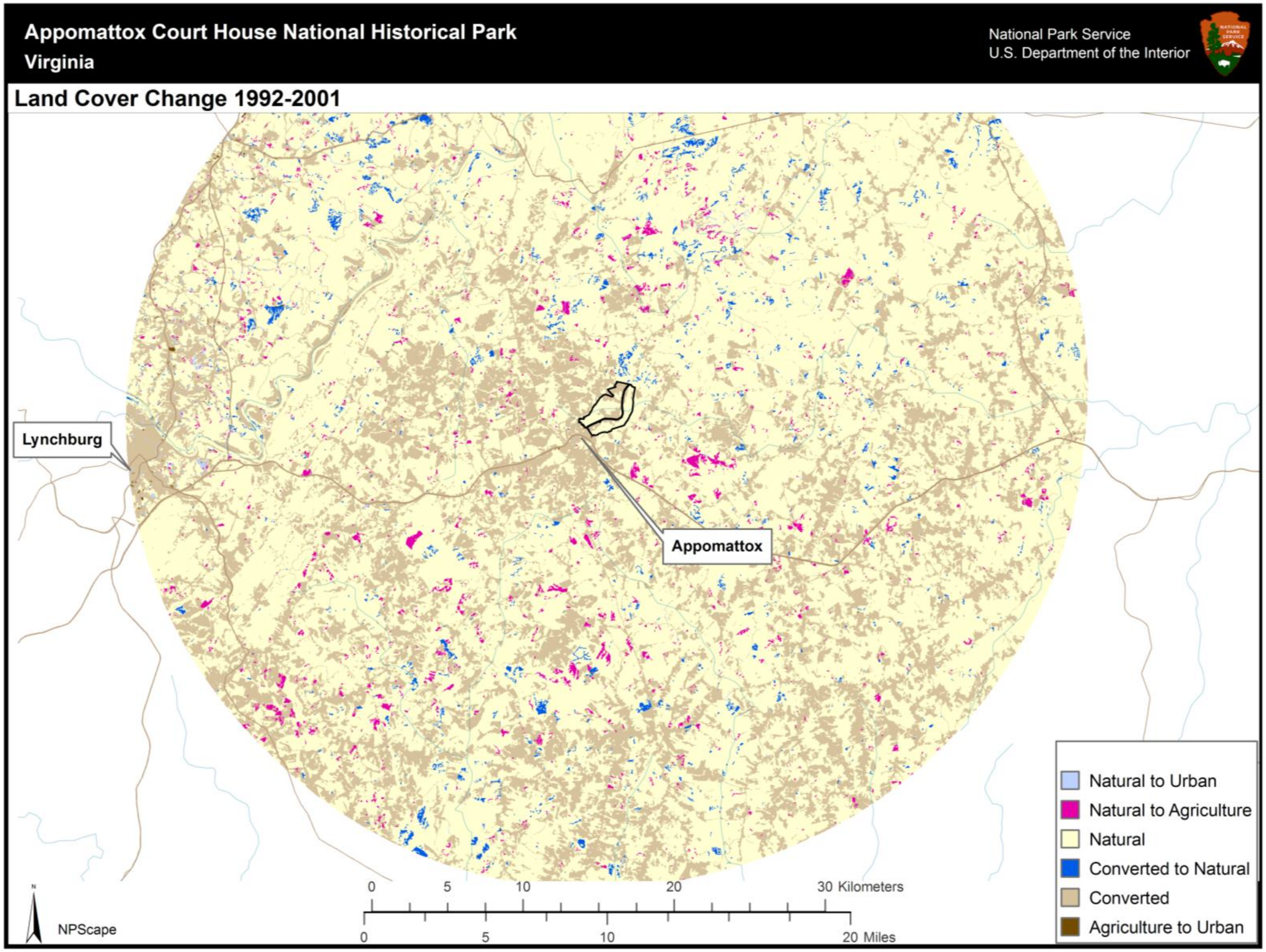

Figure 4. Land cover change 1992 to 2001 for area surrounding Appomattox Court House National Historical Park (30-km buffer, NPScape).

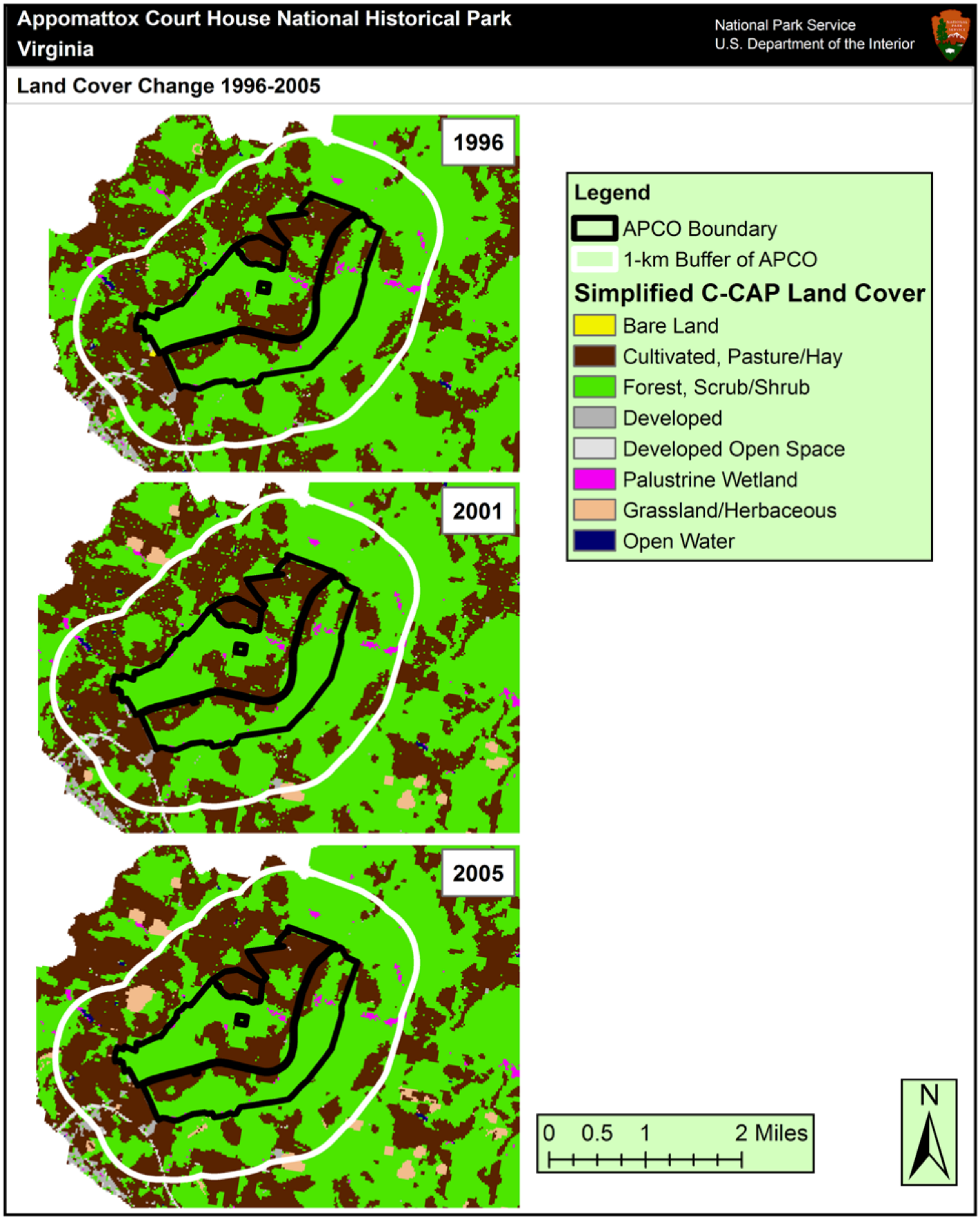

Figure 5. Three years of simplified C-CAP land cover classification within the 1-km buffer surrounding Appomattox Court House National Historical Park (APCO).

Table 4. Acreage and percent change between three years of land cover classifications within the 1-km buffer surrounding Appomattox Court House National Historical Park.

Land Cover Classification	1-km buffer acres '96	1-km buffer acres '01	1-km buffer acres '05	% change '96 to '01	% change '01 to '05	% change '96 to '05
Developed, High Intensity	7.1	8.0	9.3	12.5	16.7	31.3
Developed, Medium Intensity	0.9	1.3	1.3	50.0	0.0	50.0
Developed, Low Intensity	19.6	22.0	20.9	12.5	-5.1	6.8
Developed, Open Space	22.5	23.1	22.0	3.0	-4.8	-2.0
Cultivated Crops	678.3	660.1	681.4	-2.7	3.2	0.5
Pasture/Hay	845.3	871.3	901.1	3.1	3.4	6.6
Grassland/Herbaceous	4.9	5.6	58.9	13.6	960.0	1104.5
Deciduous Forest	1223.8	1220.1	1137.1	-0.3	-6.8	-7.1
Evergreen Forest	723.2	727.0	712.3	0.5	-2.0	-1.5
Mixed Forest	130.5	130.8	127.0	0.2	-2.9	-2.7
Scrub/Shrub	24.2	13.3	11.1	-45.0	-16.7	-54.1
Palustrine Forested Wetland	29.1	29.1	29.1	0.0	0.0	0.0
Open Water	7.6	7.6	7.6	0.0	0.0	0.0

Human Population

Although seemingly intuitive, several studies have quantitatively researched the relationship between human population and the degradation of the world's natural resources (Jones and Clark 1987, Forester and Machlist 1996, McKinney 2001, Parks and Harcourt 2002, Cardillo et al. 2004). In a 2001 study, nonnative plant and fish diversity were negatively correlated with human population (McKinney 2001). Parks and Harcourt (2002) found that the probability of species extinction around western U.S. national parks was significantly correlated with the surrounding human population density.

Appomattox County is part of the Lynchburg, VA, Metropolitan Statistical Area (MSA), which had a 2008 population estimate of 245,809 people and ranked 179th out of 363 MSAs nationwide. The total population for year 2000 in the Southside subdivision of Appomattox County was 6,405, while the 1990 total was 5,849. More recent data for the Southside district was not available, so we looked at Appomattox, the nearest town and county seat of Appomattox County. The 2008 population estimate in the town of Appomattox was 1,748, and the 2000 and 1990 population figures were 1,761 and 1,707, respectively. Figures 6 and 7 illustrate the population in the area surrounding Appomattox Court House NHP. Figures 8 and 9 display the projected population density for 2010 and 2020, respectively.

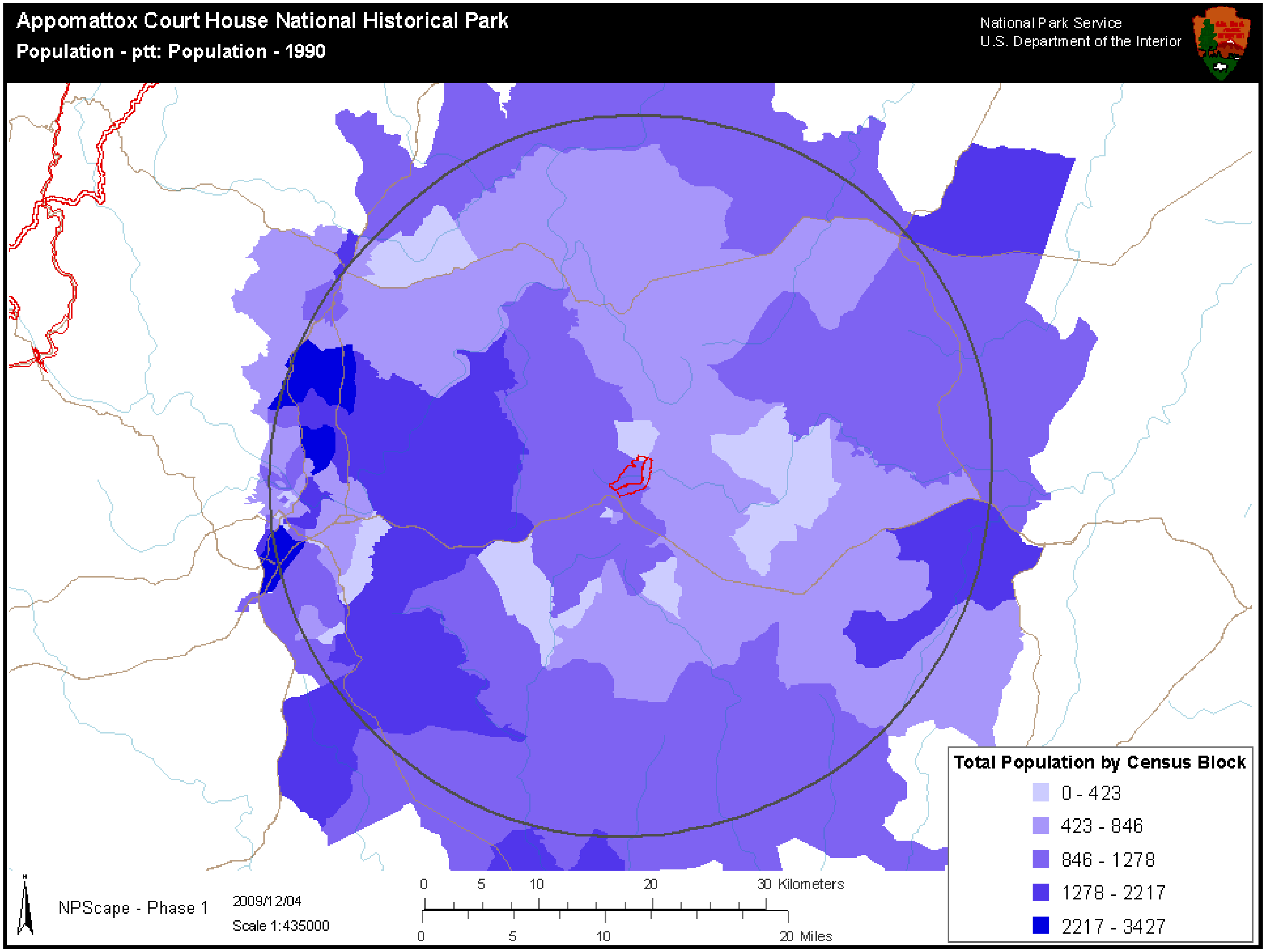

Figure 6. Human population (1990) for the area surrounding Appomattox Court House National Historical Park (NPS 2010a).

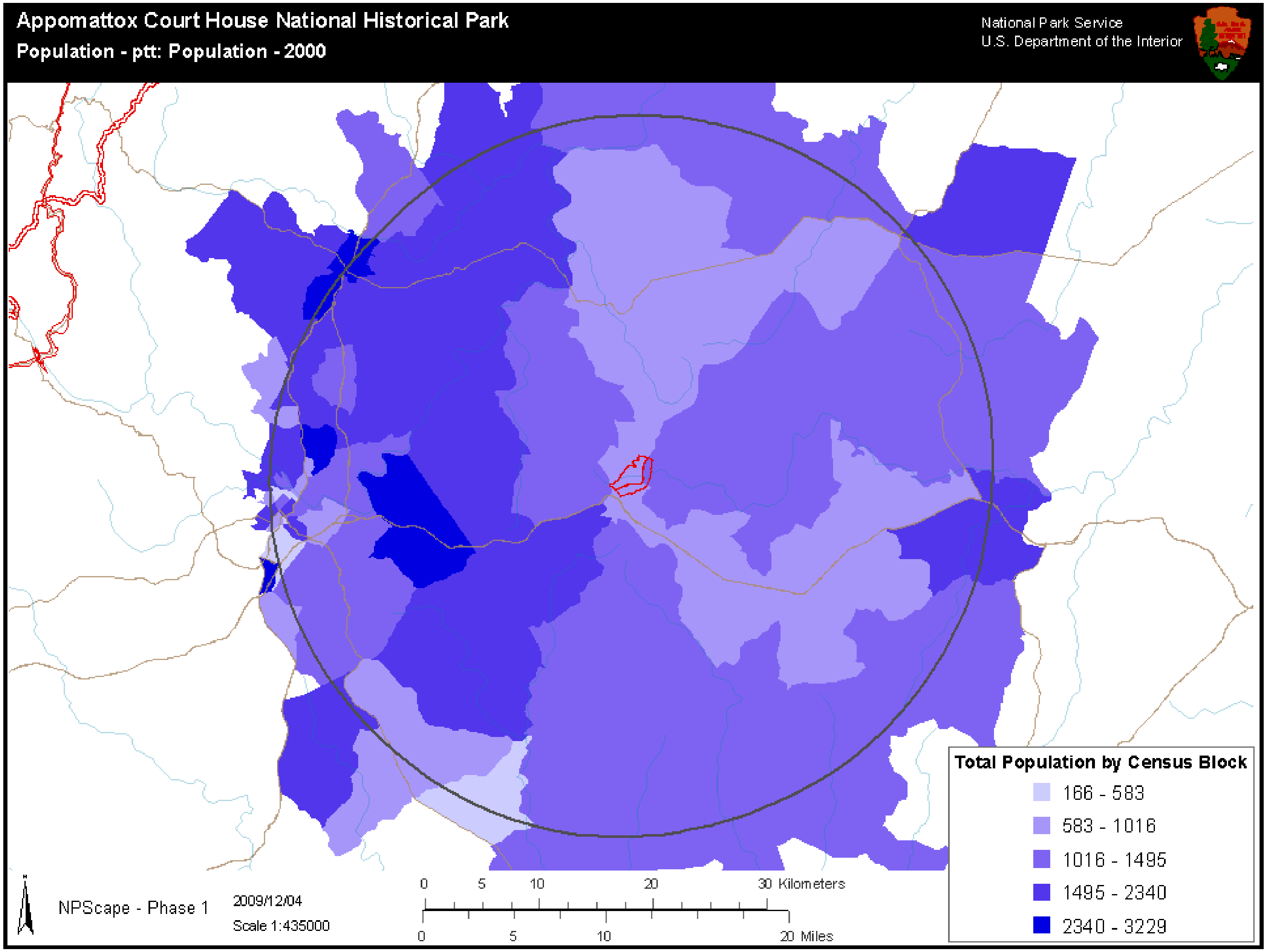

Figure 7. Human population (2000) for the area surrounding Appomattox Court House National Historical Park (NPS 2010a).

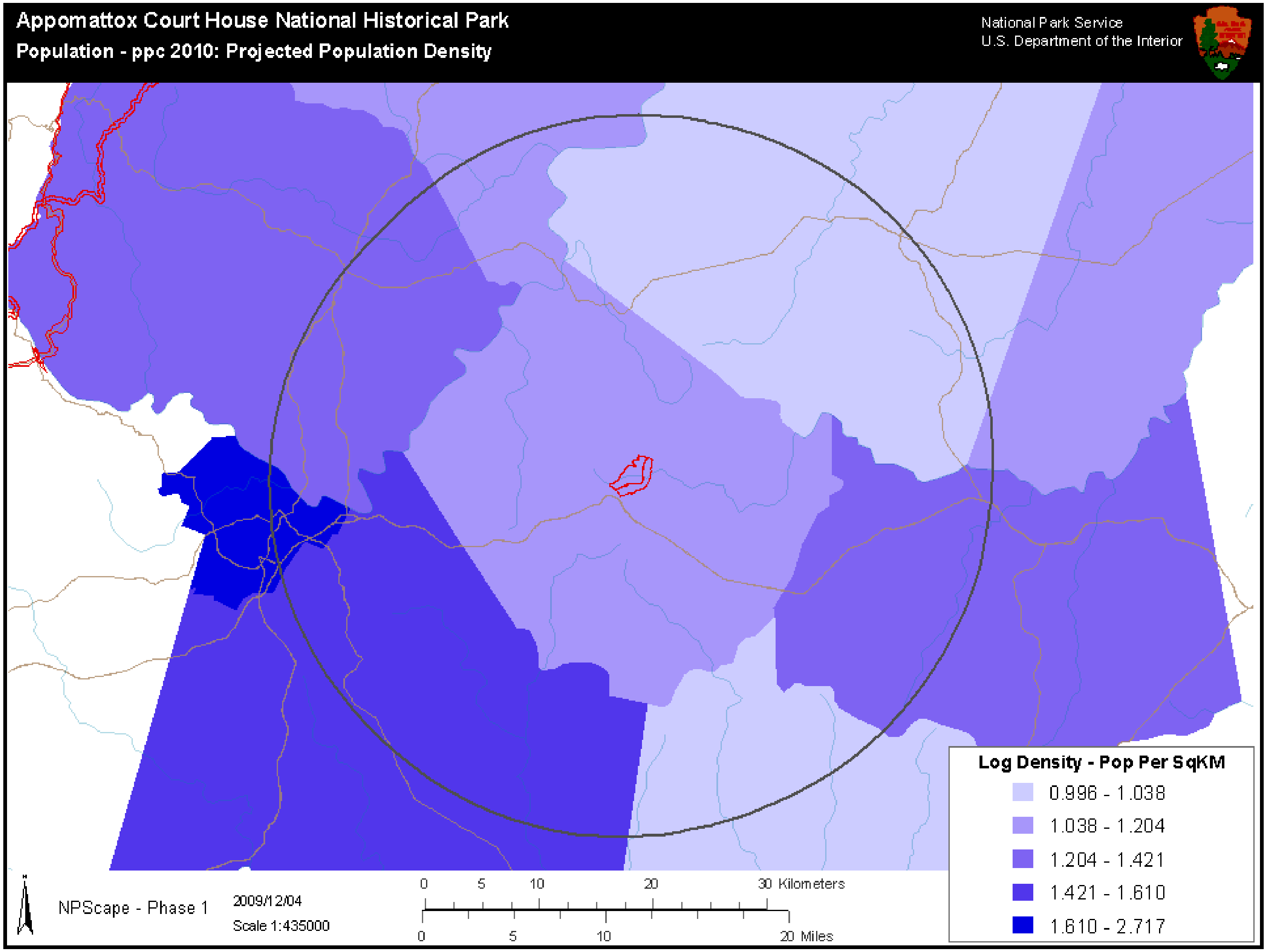

Figure 8. Projected human population density (2010) for the area surrounding Appomattox Court House National Historical Park (NPS 2010a).

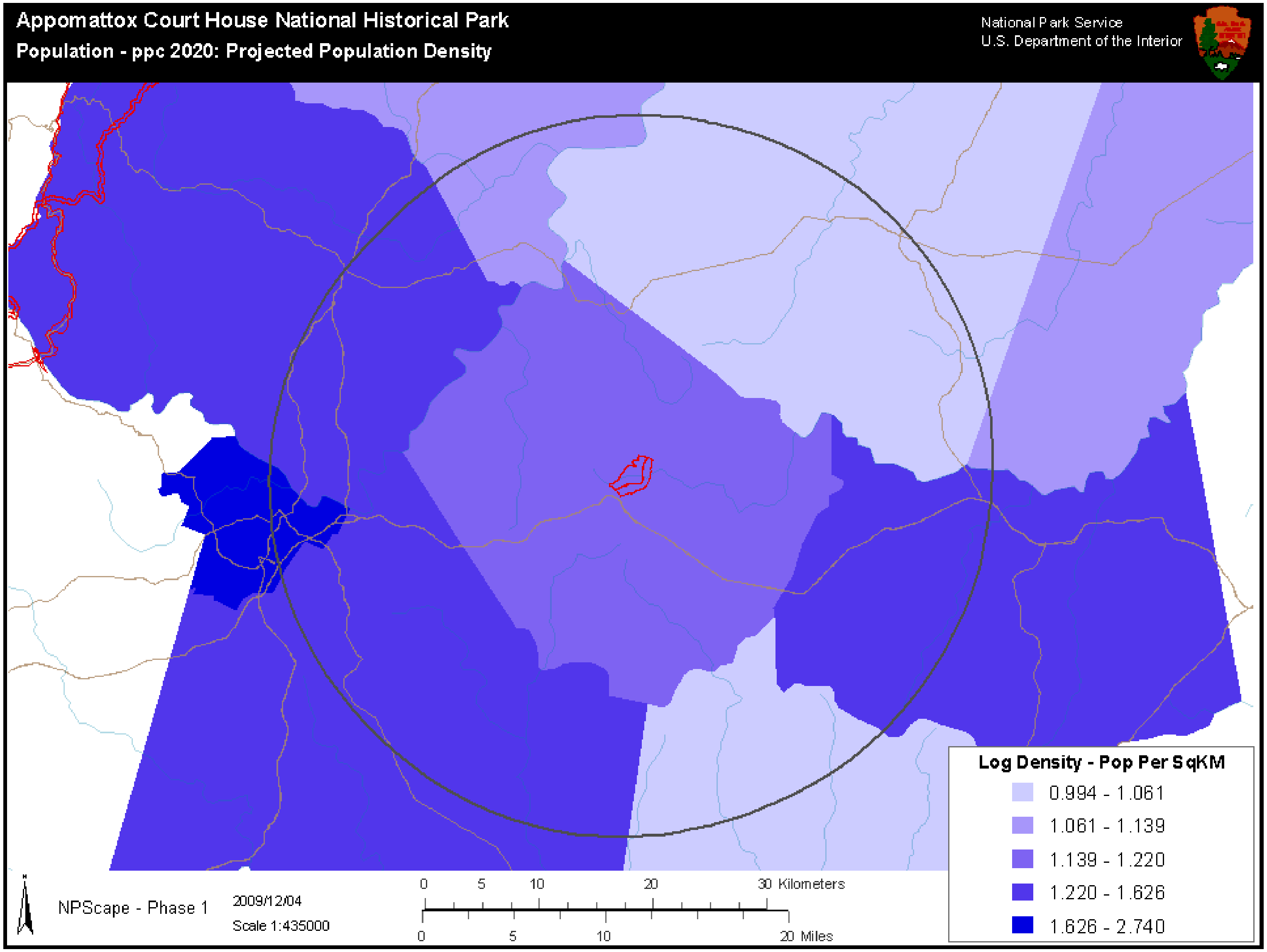

Figure 9. Projected human population density (2020) for the area surrounding Appomattox Court House National Historical Park (NPS 2010a).

Impervious Surface

Impervious surfaces within the park give a useful measure of the environmental condition, as impervious surfaces have a direct impact on overall hydrology and water quality (Schueler 2000, Hurd and Civco 2004). Increased impervious surface leads to degradations in water quality, hydrology, habitat structure, and aquatic biodiversity (Schueler 2000, Hurd and Civco 2004). In a review of eighteen studies that related stream quality to urbanization, Schueler (2000) suggests using three management categories (Table 5) to group streams by percent impervious surface. Sensitive streams are generally characterized by stable channels, good water quality, and good to excellent stream biodiversity. Schueler recommends watersheds containing streams with the "sensitive" classification should protect biodiversity and channel stability with watershed-wide impervious cover limits and site impervious cover limits. Impacted streams will often have unstable channels, fair water quality, and fair to good stream biodiversity.

Management objectives for "impacted" watersheds include maintaining critical elements of stream quality by instituting site impervious cover limits. Non-supporting streams will have highly unstable channels, fair to poor water quality, and poor stream biodiversity. It is recommended that downstream pollutant loads should be minimized for non-supporting streams, while additional infill and redevelopment is encouraged (Schueler 2000).

The majority of the park has 0–2% impervious surface. The City of Lynchburg and the Town of Appomattox have the highest concentrations of impervious surface in the surrounding areas within a 30-km buffer (Figure 10).

Table 5. Schueler (2000) related percent impervious cover to management category.

Impervious Cover	Management Category
1 to 10% impervious	Sensitive streams
11 to 25% impervious	Impacted streams
26 to 100% impervious	Non-supporting streams

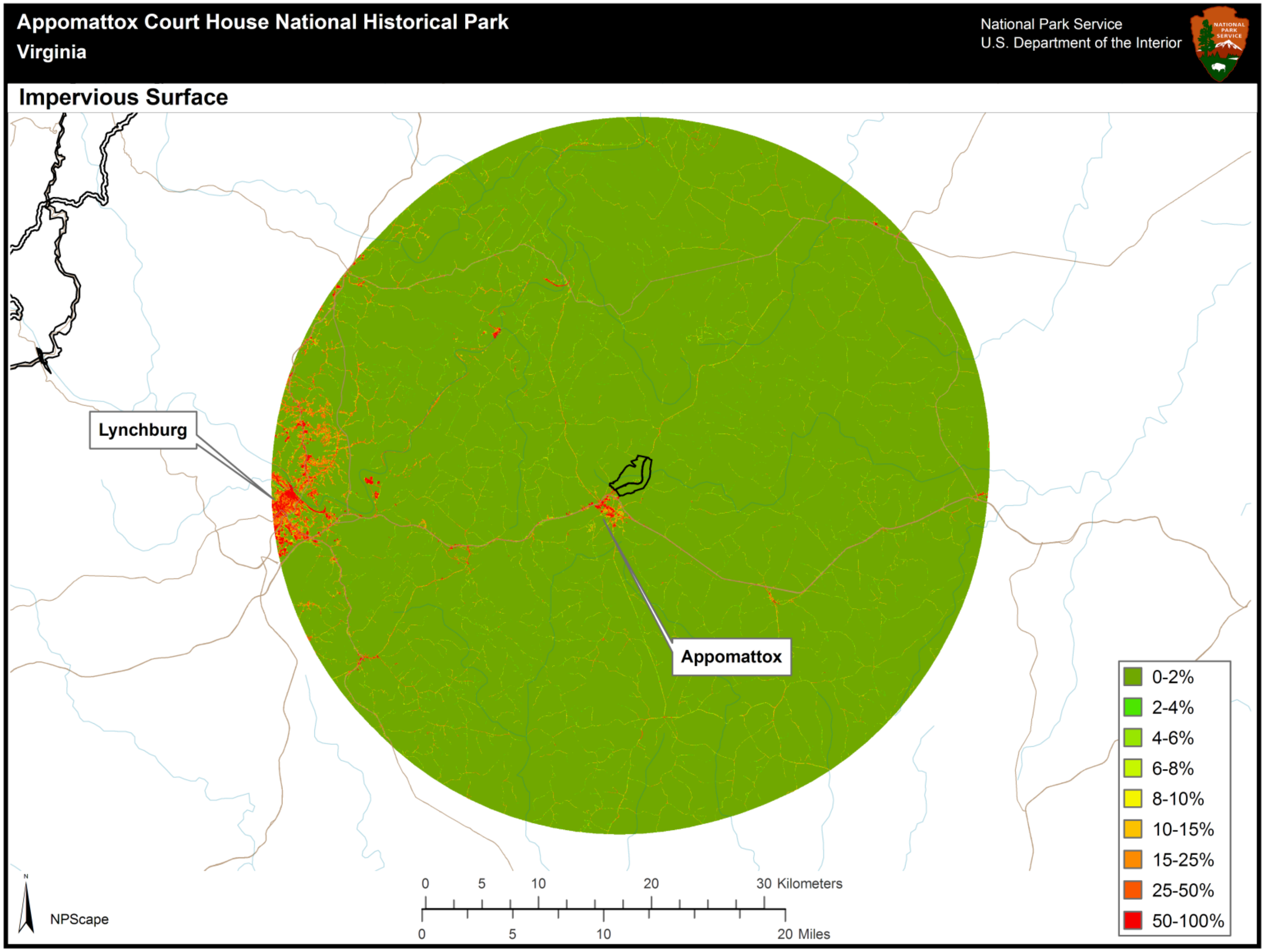

Figure 10. Impervious surface for Appomattox Court House National Historical Park and surrounding areas within a 30-km buffer (NPScape).

Development and Agriculture

Land development and urbanization can have dramatic impacts on the interplay between infiltration and runoff. As land is developed and covered with impervious surfaces (like roofs, roads, and parking lots) infiltration capacity of large areas can be lowered to zero with runoff rates dramatically increased. Changes in runoff rates can also come as the result of other development activities, including vegetation clearing, soil compaction, altered drainage patterns, ditching, and channelization on remaining soil-covered lands—shifting what historically may have been a predominately subsurface flow pattern to a predominantly surface flow pattern (Figure 11) (Booth and Jackson 1997). This can profoundly alter the magnitude, intensity, and duration of water discharges associated with precipitation events and result in the delivery of sediment and excess nutrient loads and pollutants into surface water systems by many orders of magnitude (Wolman and Schick 1967).

Figure 11. Drain pipe entering park boundary draining runoff from adjacent warehouse complex (November 2010).

Fire and Fuel

Fire exclusion practices have drastically changed the natural fire processes across the United States (Lear and Waldrop 1998, USGS 2000); however, prescribed fires are now being used more actively in regenerating oak (Brose et al. 1998) and pine (Lear and Waldrop 1998) stands within the Piedmont and Appalachians.

Fire has not been an imminent concern for Appomattox Court House NHP. Five fires have been recorded at Appomattox Court House NHP since 1972 (Table 6). The scope and original cause of these fires are unknown due to insufficient data. There has been only one fire within 20 miles of the park reported by the Geospatial Multi-Agency Coordination Group (GeoMAC 2009) since 2000 (Figure 12).

According to a simulated historical fire severity model (USDA Forest Service 2006), low severity fires accounted for essentially all fire occurrences at Appomattox Court House NHP (Appendix E). Mixed and replacement severity fires accounted for a small and relatively insignificant percentage of fires at Appomattox Court House NHP. Low severity fires cause less than 25% average replacement of dominant biomass, mixed severity fires cause between 25 and 75% replacement, and replacement severity fires cause greater than 75% average replacement of dominant biomass. Approximately 38% of Appomattox Court House NHP is in the Fire Regime Condition Class III, meaning there is high departure from historic vegetation. These data are intended to be used at a landscape scale (USDA Forest Service 2006), so caution should be taken with analysis of these data at a more detailed scale within Appomattox Court House NHP boundaries.

Fuel types (Figure 13) and fuel loads are existing threats that should be monitored at Appomattox Court House NHP. As dead and dry plant materials build up, the risk of more catastrophic fire events increases (USGS 2000). Appomattox Court House NHP has relatively high connectivity to neighboring forests, which should be considered when assessing overall fire risk.

Table 6. Wildfires reported at Appomattox Court House National Historical Park from 1/1/1972 to 12/31/2008, at the National Fire and Aviation Management Web Application (NWCG 2009).

WFMI ID	Fire Name	NPS ID	Protection Type	Date	Acres	Cause	Owner
236880	Old Shed	1001	Point of origin of fire located on NPS land protected by another Federal agency under a local mutual aid agreement	10/01/1981	0.1	N/A	NPS
236882	Steamboat	1	Support actions by NPS resources	08/02/1989	N/A	N/A	USFS
236883	Rotarymow	101	Point of origin of fire located on NPS land under NPS protection	02/20/2001	1.7	N/A	NPS
517559	Powerline	601	Point of origin of fire located on NPS land under NPS protection	03/13/2006	2.3	N/A	NPS
522150	River Ridge	602	Point of origin of fire located on NPS land under NPS protection	06/07/2006	1.1	N/A	NPS

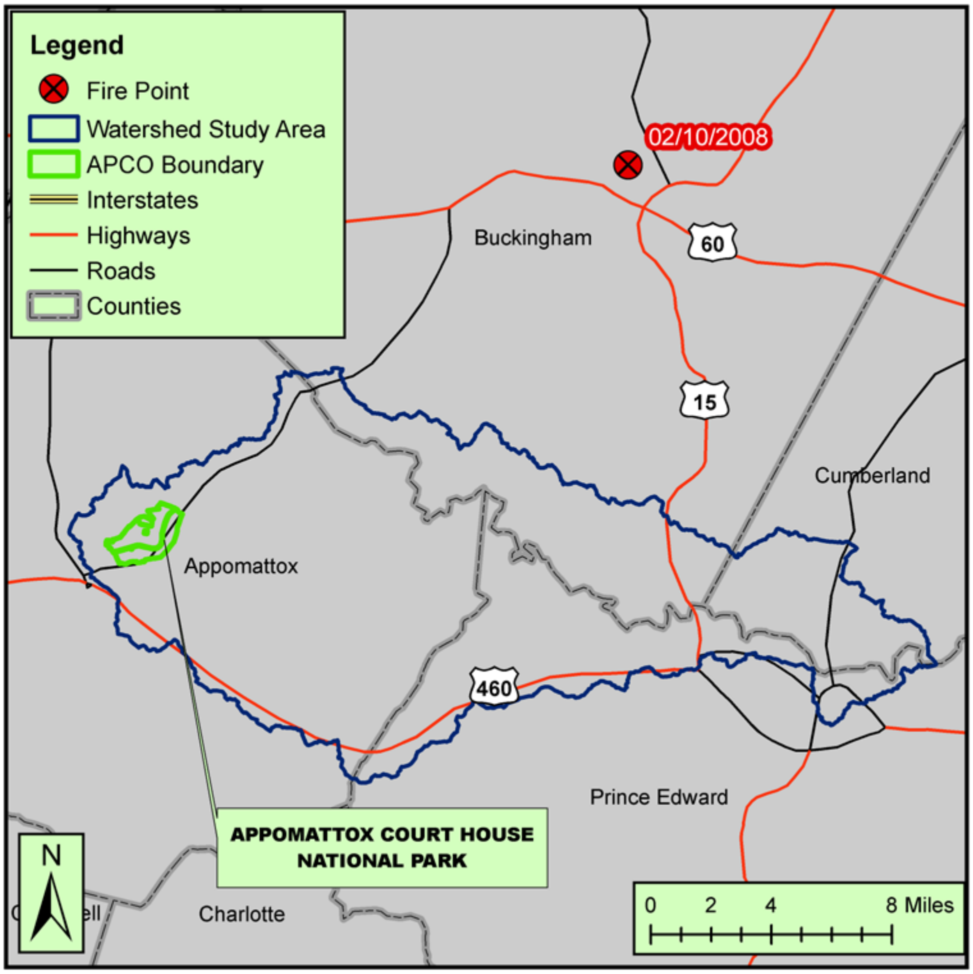

Figure 12. Wildfire site and the date it occurred, from 2000 to 2008 (GeoMAC 2009), within 20 miles of Appomattox Court House National Historical Park (APCO).

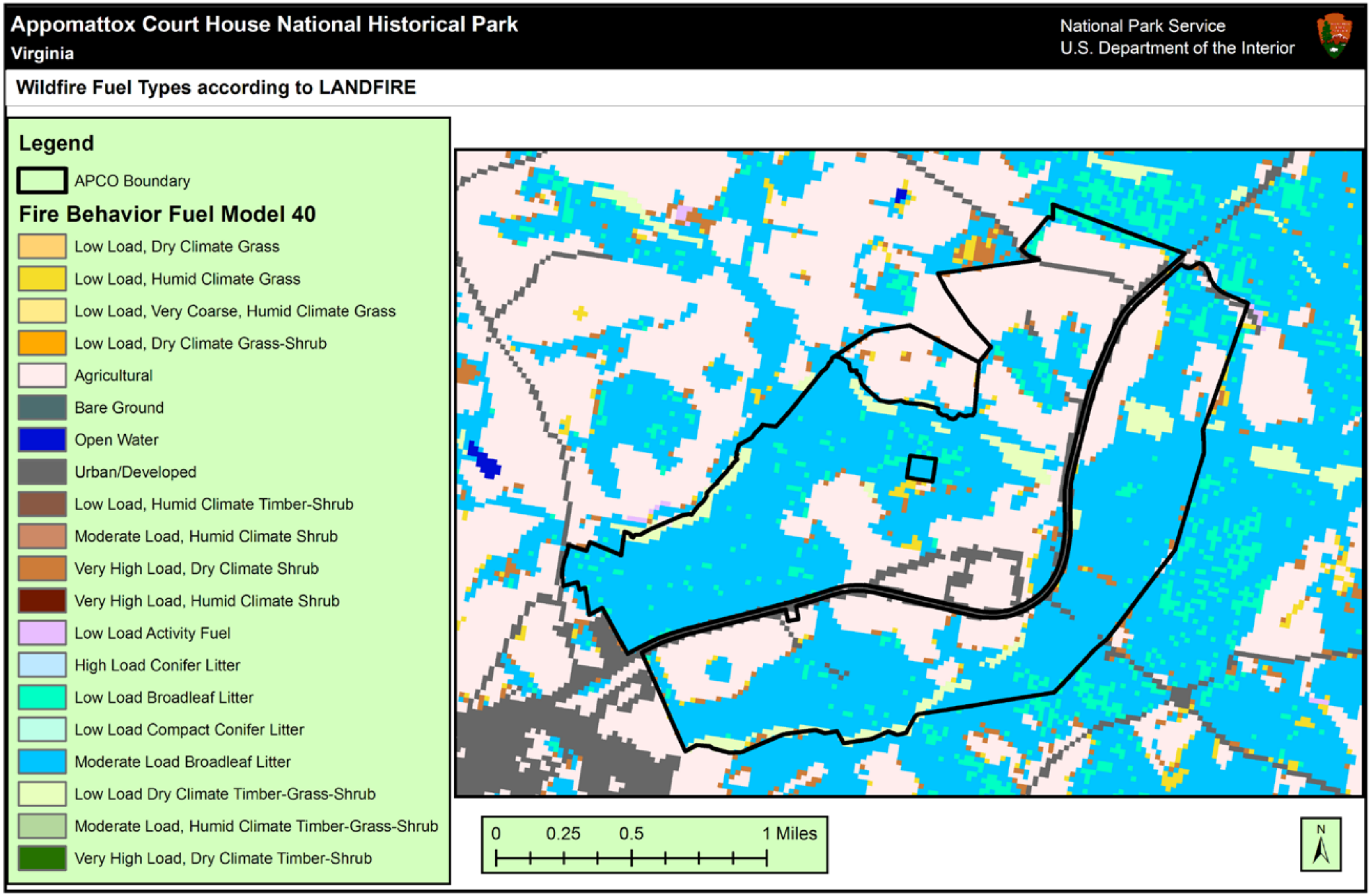

Figure 13. Wildfire fuel types according to LANDFIRE (USDA Forest Service 2006) in the region of Appomattox Court House National Historical Park (APCO).

Condition Status Summary for Landscape Dynamics

Appomattox is beginning to see encroaching development for the Lynchburg area. This encroachment of human population, increased traffic, and development is arguably the most important threat or stressor the park must consider. Development may lead to increasing point and non-point source pollution, affecting air and water quality. Increased vehicle emissions can occur as more people move to the area. In-park biological integrity may also be stressed from these outside influences. The amount of unnatural habitat within the park is minimal (Table 7); this seems primarily due to the goal of keeping the historical landscape and will likely not change drastically in the future.

Table 7. Landscape dynamics condition status summary.

MIDN Vital Sign/Indicator	Measure	Threshold Criteria	Current Condition	Comments
Surrounding land use change	Percent unnatural vegetation in the park	Conversion to unnatural habitat within the park will be minimized. Keep stable or reduce area of unnatural vegetation.	5.4% (Good)	
Land cover	Area covered by forest and grassland	The amount of forested and grassland habitat within the park will remain stable. Area covered by forest and grassland will remain at approximately 52% and 31%, respectively.	Forest = 926 ac Grassland = 559 ac	

Vegetation Communities

One vegetation mapping effort has been done at Appomattox Court House NHP (Patterson 2008). Field data collection occurred in May 2002, May and June 2003, and in April, May, and September 2004. Field work was completed in Appomattox Court House National Historical Park in 2005 (Figure 14).

Relative acreages and percentages of the major vegetation communities were assessed using an altered form of the (Patterson 2008) vegetation map (Table 8; Figure 15). The vegetation map (Patterson 2008) was altered by assigning a simplified ecological community to each of the polygons (Figure 16). We dissolved polygons based on the ecological community and combined (union) the ecological communities with the authorized boundary to include areas that were not federally owned. Two forested areas within the non-federally owned parcel in the north central region of Appomattox Court House NHP were delineated from the fields. We performed several operations in ArcGIS Toolbox (ESRI 2006) to simplify and repair geometry.

To include wetland and stream communities, we modified the resulting ecological communities by including more comprehensive stream and wetland layers. The stream layer from Appomattox Court House NHP (riverine.shp) was verified using the VBMP 2006 and 2007 high resolution imagery. The perennial stream lines were buffered by 10 feet on either side, clipped to the authorized boundary of the park, and merged with the ecological communities map. The park wetland layer (palustrine.shp) was also clipped to the authorized boundary of the park and merged with the vegetation communities map. The resulting ecological communities map is shown in Figure 16. Table 8 lists the relative percentages of communities as defined by Patterson (2008) along with updated acreages with all areas within the authorized boundary and more detailed wetland and stream communities added.

Table 8. Acres and percentages of delineated communities from (Patterson 2008) within Appomattox Court House National Historical Park from VBMP imagery.

Ecological Community	Acres	Percentage
Upland Forest	926.9	52.08
Wetland	104	5.84
Riparian Forest	95.2	5.35
Stream	14.9	0.84
Meadow/Field	559.1	31.42
Urban	79.5	4.47
Total	1,779.6	

Table 8 is on this page because the three figure mentions are all on landscape pages.

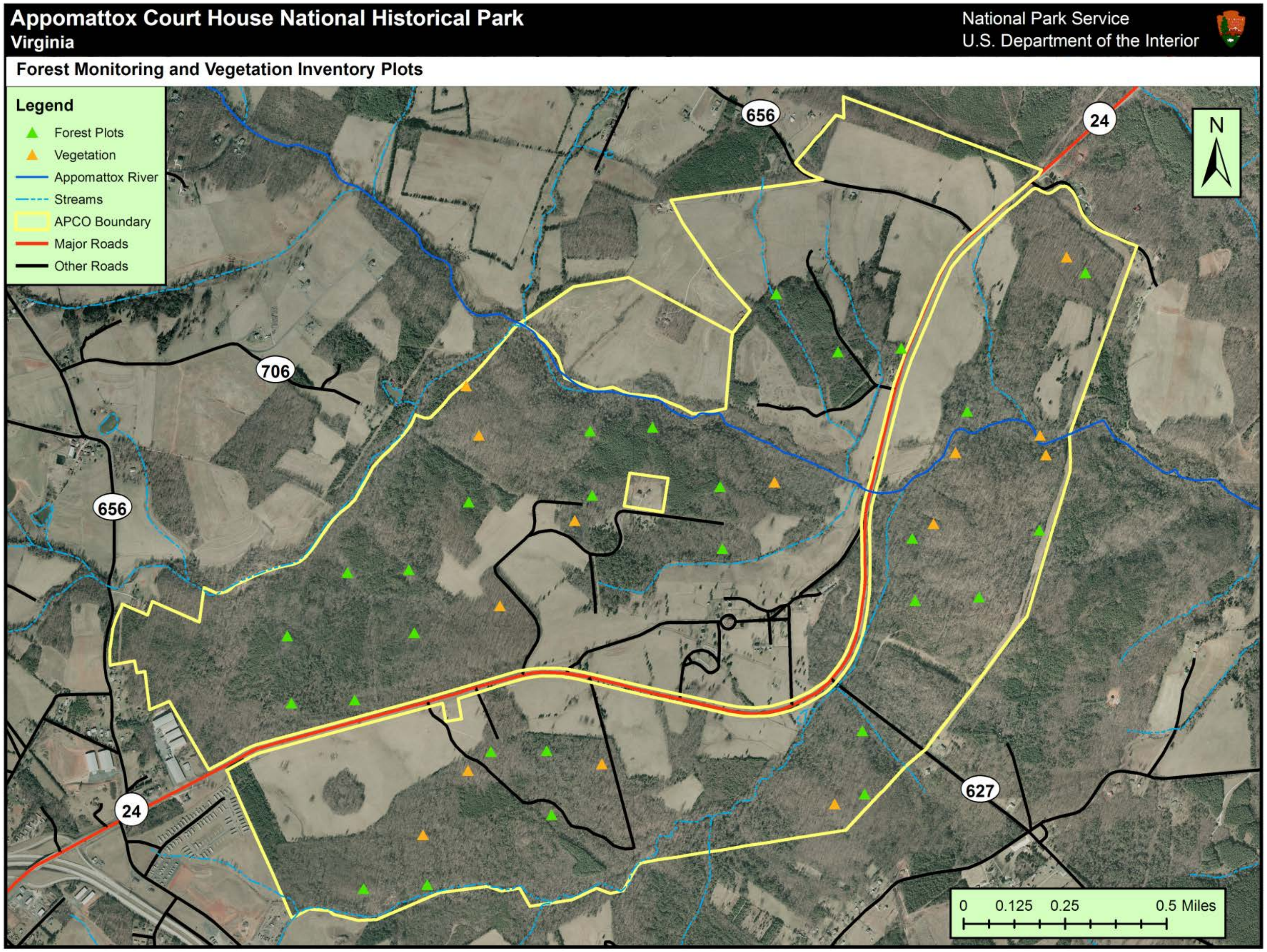

Figure 14. Forest monitoring and vegetation inventory plots.

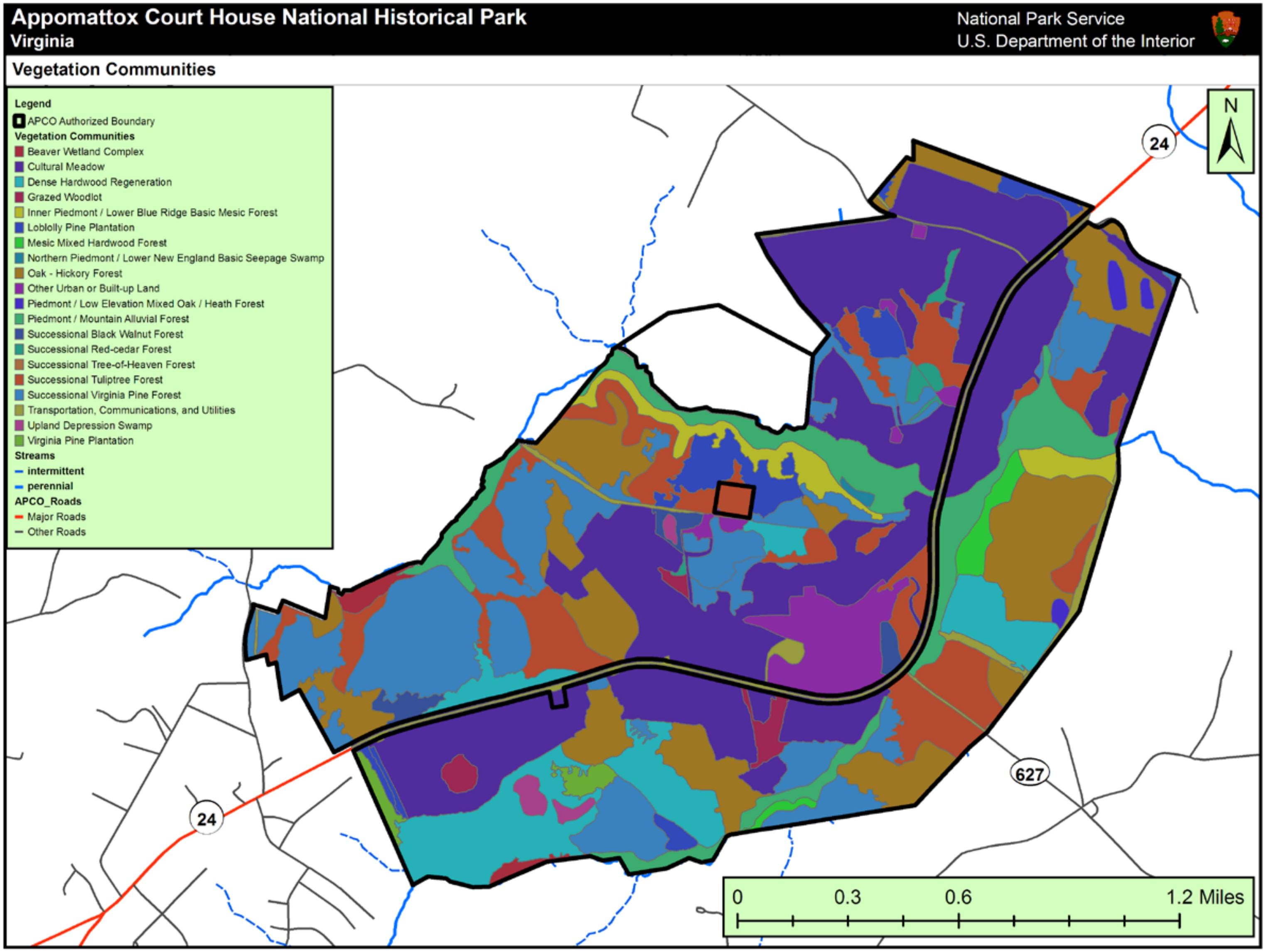

Figure 15. Appomattox Court House National Historical Park (APCO) vegetation communities from VDCR, Division of Natural Heritage (2000).

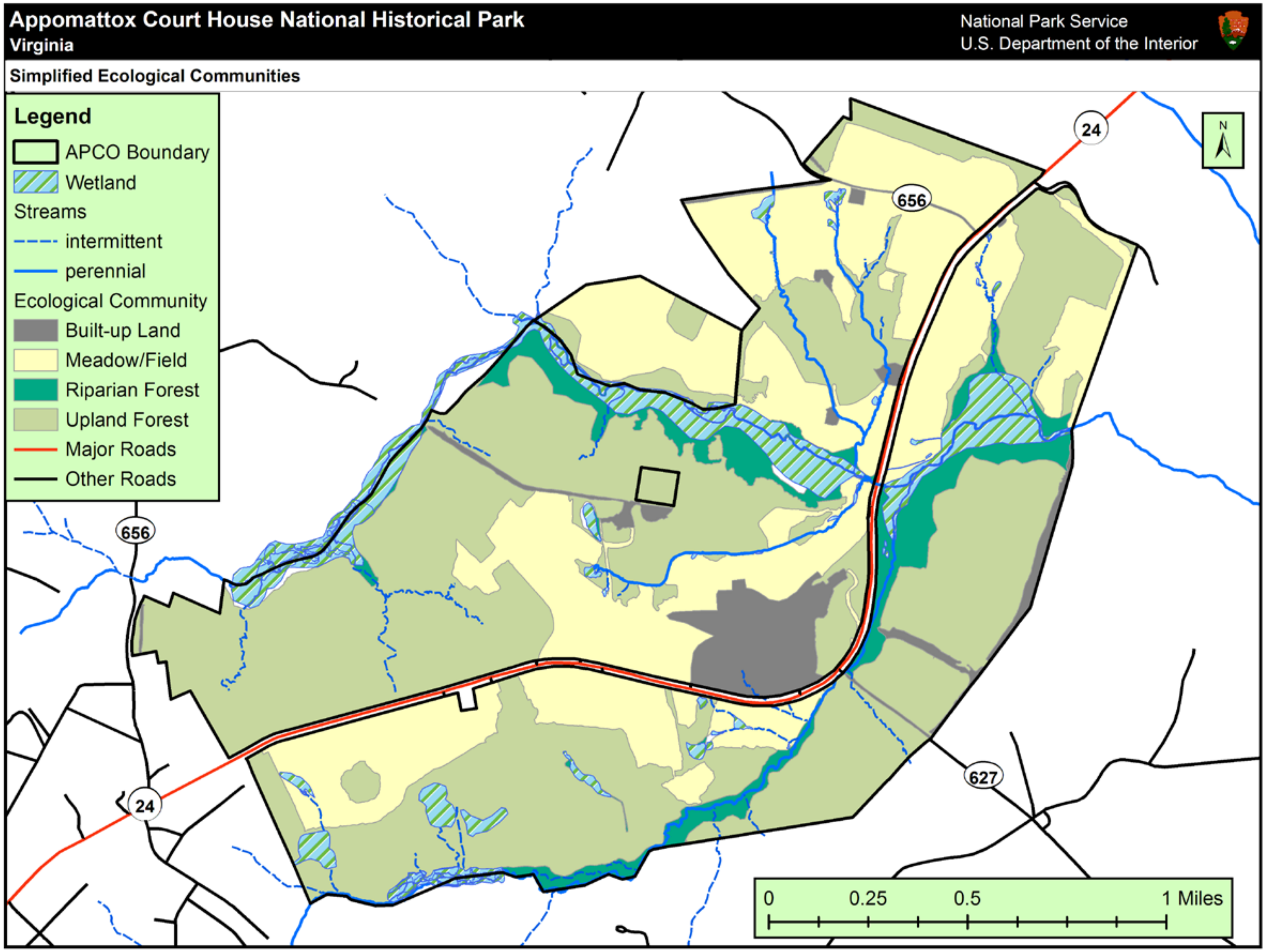

Figure 16. Ecological communities of Appomattox Court House National Historical Park (APCO), modified from (Patterson 2008) vegetation map (Environmental Concern 2002).

Nonnative and Invasive Plant Species

Invasive plant species comprise 27% (93 of 344) of all plant species at Appomattox Court House NHP, and 713 ac of the park have been impacted to some degree by invasive species (Figure 17). The plant species currently posing the largest threat to communities at Appomattox Court House NHP are multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), privet (*Ligustrum cuneata*), and tree of heaven (*Ailanthus altissima*) (Eick 2010); however, the NPS has an active program in place to control these species at Appomattox Court House NHP. As of the date of this publication, park staff have converted 70 ac to native warm-season grasses (NPCA 2008).

Ecologically Critical Areas and Other Unique Natural Resources

The Virginia Natural Heritage Program has identified two unique vegetation communities in the park, the Basic Seepage Swamp and Piedmont Upland Depressional plant communities (see the Wetland and Riparian Resources section and associated figure(s) for greater detail). Six natural communities, as defined in the Natural Communities of Virginia, are documented at Appomattox Court House NHP (http://www.dcr.virginia.gov/natural_heritage/nctoc.shtml):

1. Inner Piedmont / Blue Ridge Basic Mesic Forest,
2. Northern Piedmont / Lower New England Basic Seepage Swamp (state rare community),
3. Mesic Mixed Hardwood Forest,
4. Piedmont / Low Elevation Mixed Oak / Heath Forest,
5. Piedmont / Mountain Alluvial Forest,
6. Upland Depression Swamp (globally rare community).

These native plant communities are an important part of the park's natural resources and should be targets for conservation and management.

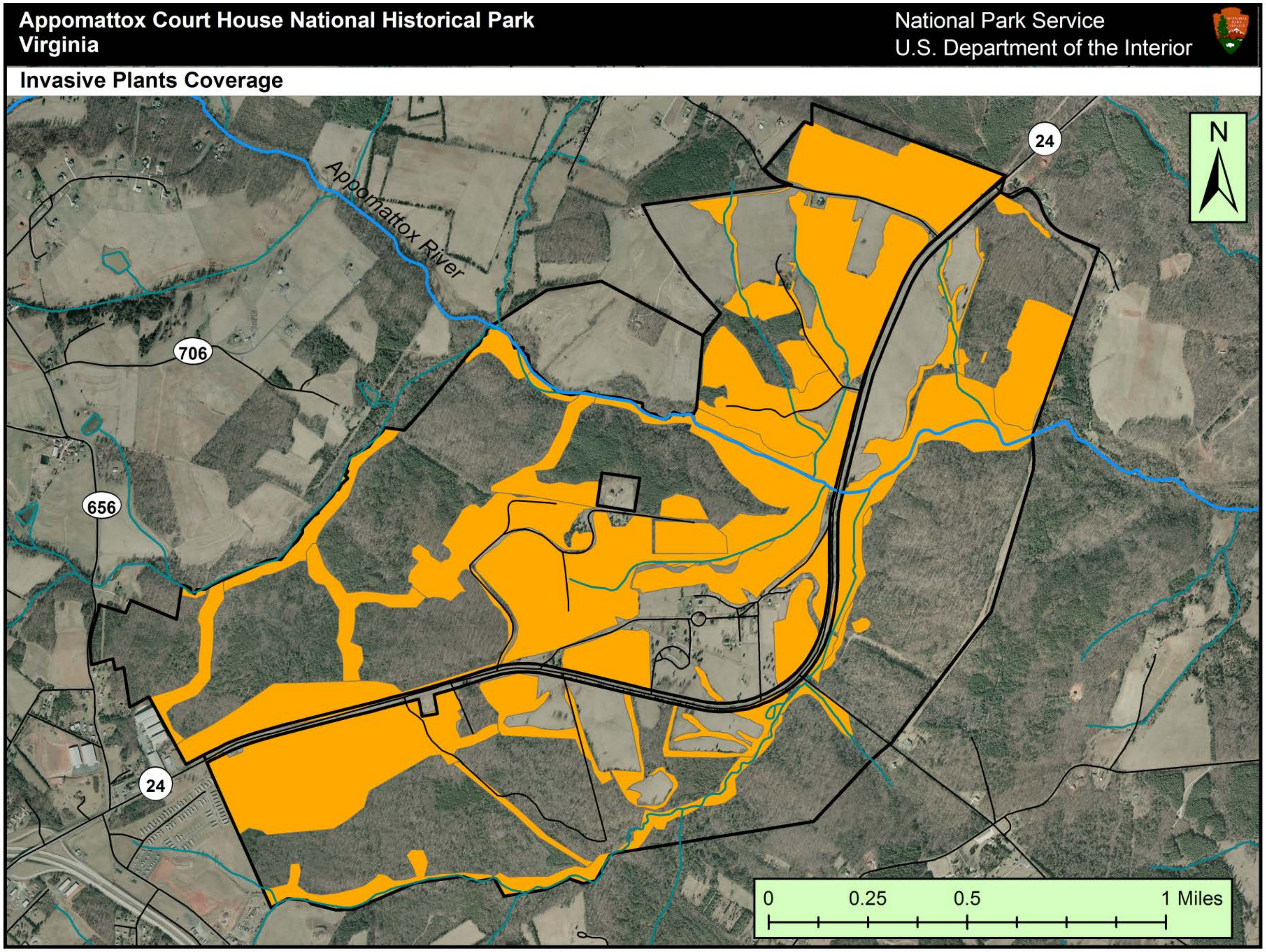

Figure 17. Invasive species coverage at Appomattox Court House National Historical Park (Eick 2010).

Forest Condition

I&M funded vital signs that are presently monitored at Appomattox Court House NHP include invasive exotic plants, native forest pests, exotic diseases/pathogens (plants), forest plant communities, and white-tailed deer (herbivory) (Comiskey and Callahan 2008). Forested habitats have the greatest avian species richness and the highest number of priority species of any habitat type at the park (Bradshaw 2007). Specific bird species can be a good indicator of the ecological condition of the forests. The wood thrush is an abundant breeder and the ovenbird is a common breeder at the park. The wood thrush prefers moist deciduous forests with dense, well-developed understory, and is a good indicator of upland forest. The ovenbird is a good indicator of closed-canopy, mature forests with a sparse understory. The wood thrush, Kentucky warbler, scarlet tanager, yellow-throated vireo, pileated woodpecker, and red-eyed vireo were chosen as indicators of forest condition.

Upland forests at Appomattox Court House NHP (Figure 18) consist of 762.0 ac of deciduous forest and 330.4 ac of evergreen forest. Upland forests in the Piedmont have undergone decades of logging, conversion to agriculture, and human disturbance. According to Patterson (2008), early successional forests include a large pine component, in addition to tulip poplar (*Liriodendron tulipifera)* and sweetgum *(Liquidambar styraciflua).*

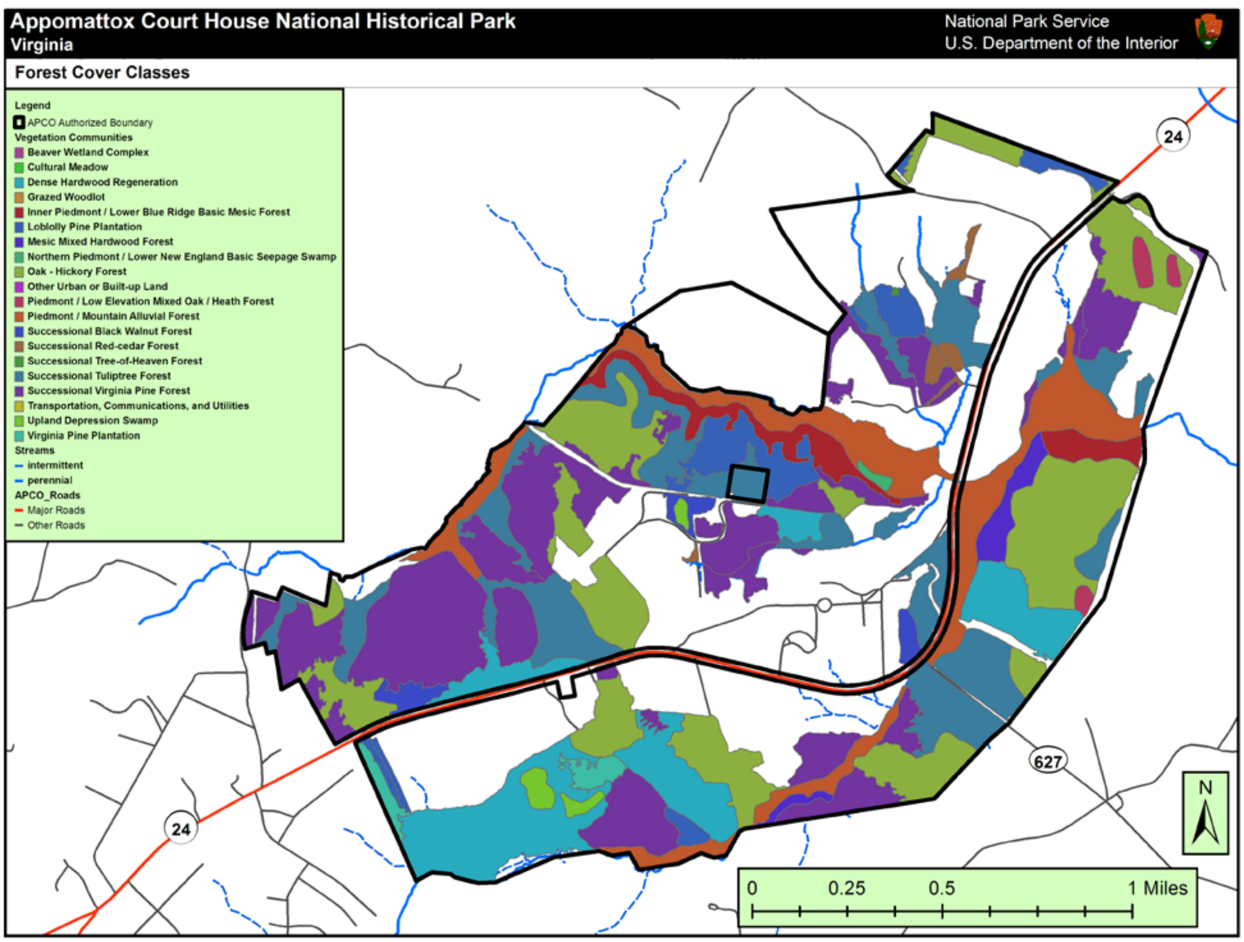

Figure 18. Forest cover classes (Virginia Division of Natural Heritage 2000).

Forest monitoring plots were established in 2007. Each year, seven plots were surveyed for exotic species resulting in a total of 28 forest monitoring plots at Appomattox Court House NHP. Trends per plot were not available at the time of this assessment as only one year of data per plot is recorded. Table 9 and Figures 19 and 20 display stocking density summary data from the first complete time step in the long-term forest monitoring program being coordinated through the Mid-Atlantic Inventory and Monitoring Network. The 2011 and upcoming 2012 field seasons will provide second surveys of the plots from 2007 and 2008 and better inform the park regarding how the aforementioned metrics are currently trending over time and what possible implications those results may have on forest health within the park. Unfortunately, little can be inferred at this time from the present data shown in Table 9 and Figures 19 and 20; however, the summaries do provide a necessary baseline for future comparisons and analysis. Exotic species have been identified in the majority of the 28 plots (Table 10 and Figure 21. Additionally, forest pests are listed as a MIDN Vital Sign (Comiskey and Callahan 2008). From 2007–2010, no forest pests were observed at Appomattox Court House NHP.

Table 9. Tree, sapling, and seedling stocking values (2007–2010).

Year	Average Trees/ha	Average Saplings/ha	Average Stocking/ha
2007	496.4	4285.7	58809.5
2008	535.7	1479.0	44881.0
2009	496.4	2403.4	61309.5
2010	510.7	2369.7	38690.5

Table 10. Number and percentage of forest monitoring plots with exotic species (2007–2010).

Year	Number of Plots with Exotics	Total Plots Surveyed	% Plots with Exotics
2007	5	7	71
2008	7	7	100
2009	7	7	100
2010	7	7	100

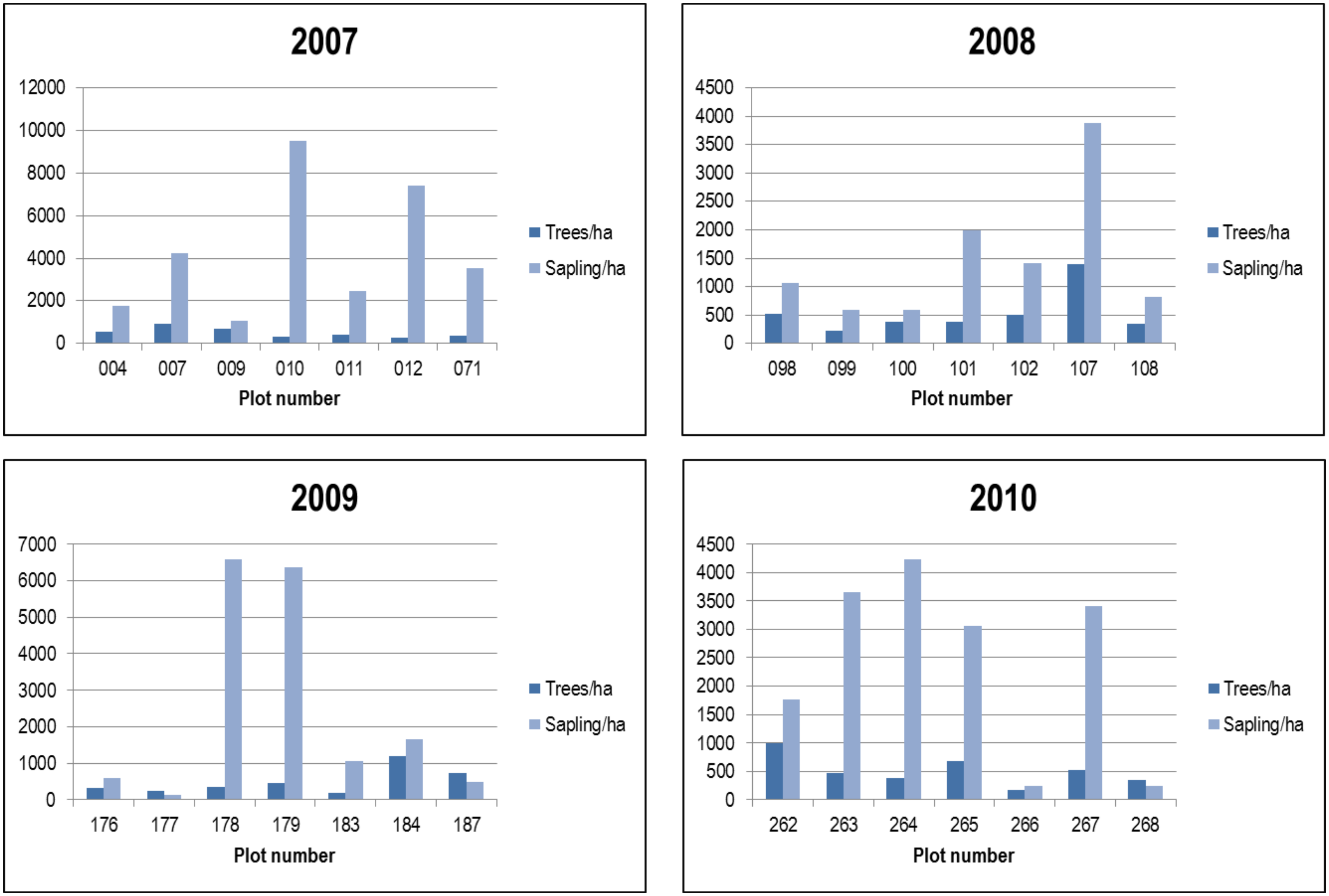

Figure 19. Tree and sapling stocking values (2007–2010).

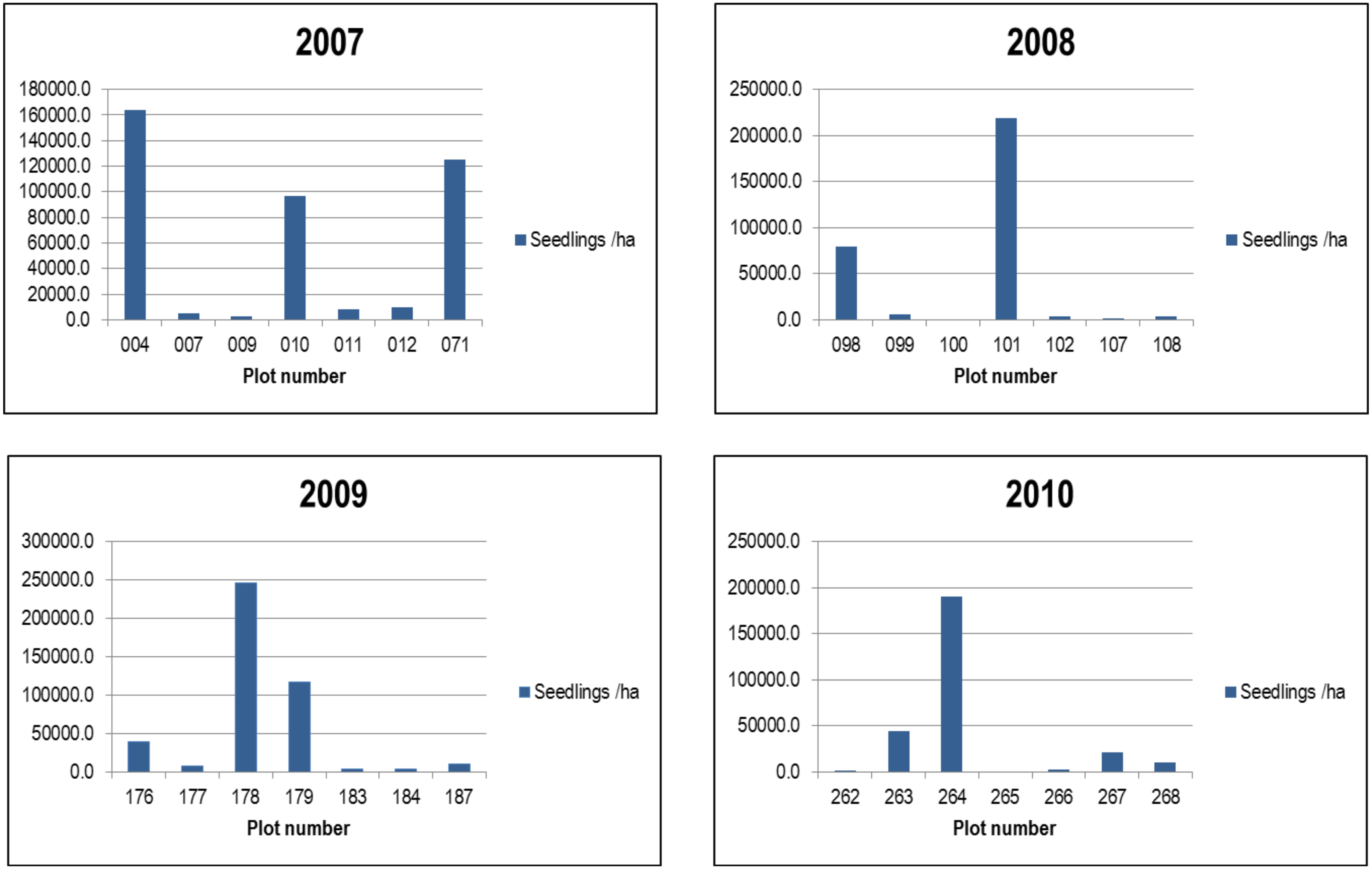

Figure 20. Seedling stocking (2007–2010).

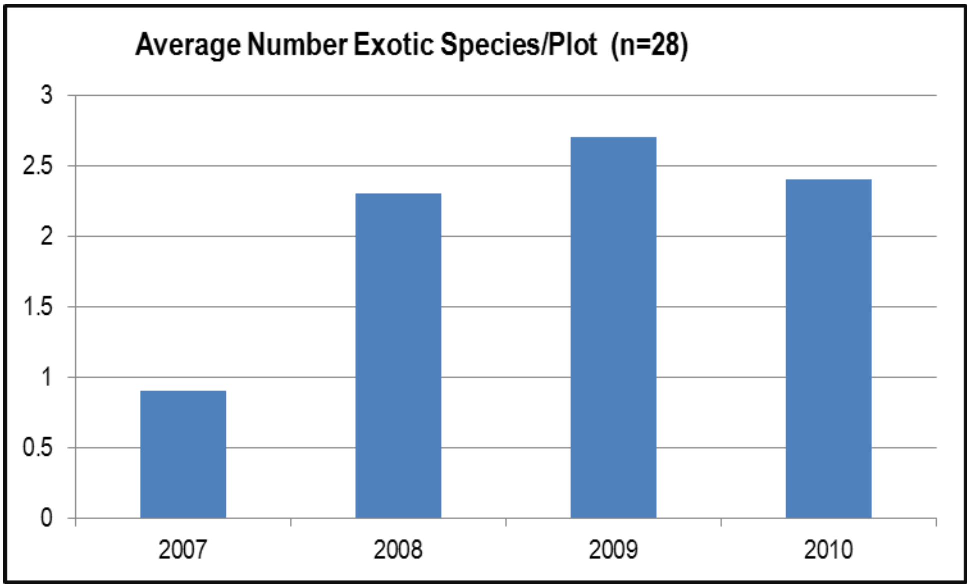

Figure 21. Average number of exotic species per plot from I&M forest monitoring plots (2007–2010).

Prescribed Fire

Prescribed fire is an important habitat management tool used in both the forests and grasslands at Appomattox Court House NHP. Two objectives of prescribed fire operations in forested communities are to reduce fuels to minimize the threat of catastrophic wildfire and to open the woodland to recreate the cultural landscape of the 1860s. Tree, seedling, herbaceous, and fuels data have been recorded for three years (2008–2010) (Figure 22). Surveys are ongoing to study changes to habitat in response to prescribed fire. Table 11 displays the results from the pre-burn survey in 2008.

Table 11. Pre-burn tree summary.

Plot Number	Trees/ha	Basal Area (sq. m/ha)	Total Trees/ha
1	580.0	33.1	580.0
2	590.0	29.5	590.0
3	770.0	16.8	770.0

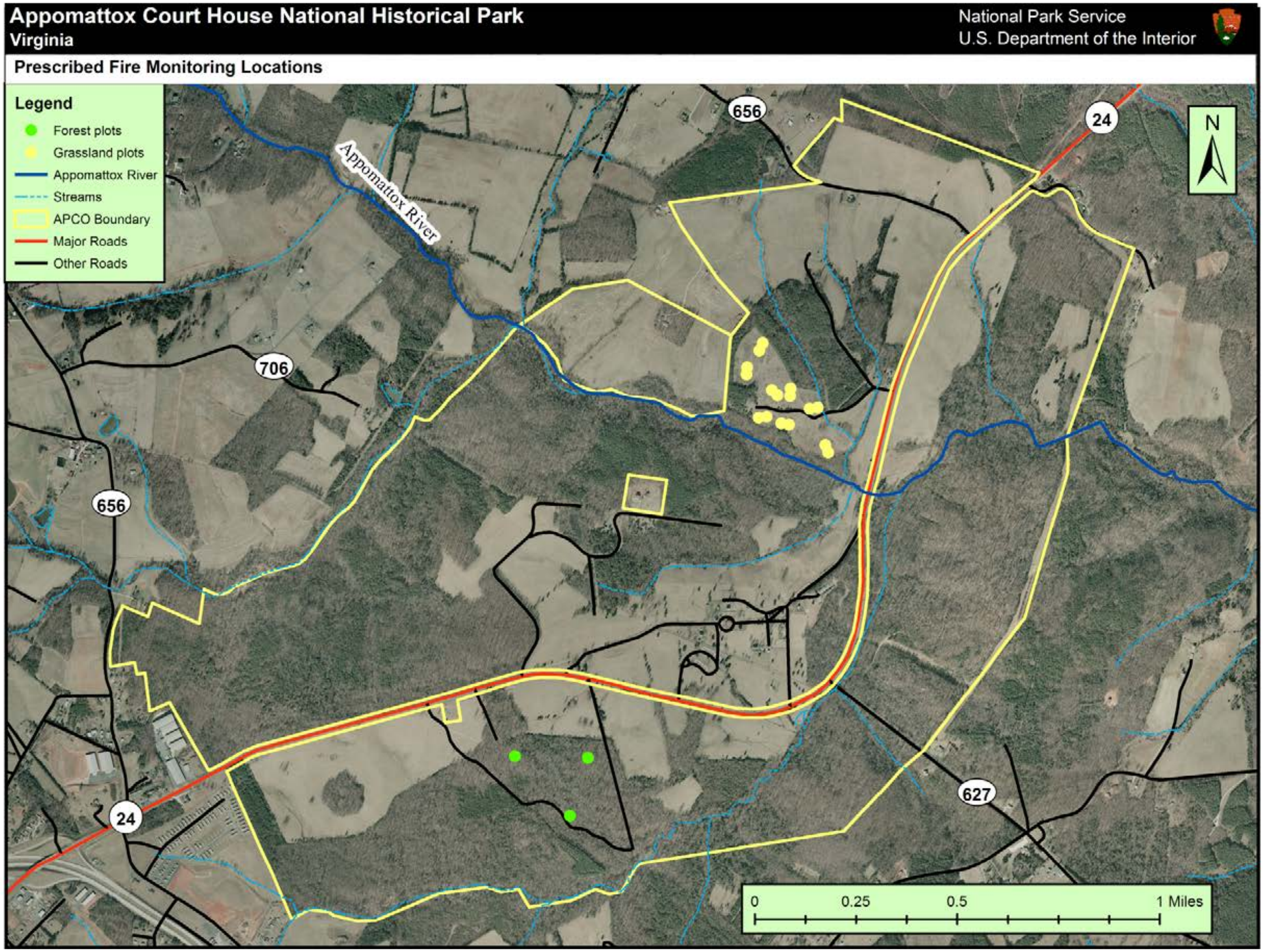

Figure 22. Forest and grassland prescribed fire monitoring plots (Forder 2010).

Grassland/Meadow Condition

Native grasslands have been altered to a greater degree than any other biome in North America, including forests (NABCI U.S. Committee 2009). Grassland birds are among the fastest and most consistently declining birds in North America; 48% are of conservation concern and 55% are showing significant declines (NABCI U.S. Committee 2009). Declines in grassland birds have been attributed to conversion of grasslands to cropland, increasingly intensive agricultural practices, and commercial and residential development. Most grassland species in the United States both breed and winter in grasslands, which makes it easier to determine the causes of these declines (Browder et al. 2002). Wolter et al. (2008) states the minimum size for productive grassland bird habitat is 20 ac, with 100 ac or larger being optimum. Much of the grassland habitat within the Mid-Atlantic Piedmont has been converted to other uses and divided among many owners with different management objectives. This results in patches smaller than the ideal size for many grassland birds.

Grassland/meadow is the second most common land cover community at Appomattox Court House NHP, covering 560.5 ac within the park (Patterson 2008). There are three fields with a patch size of greater than 50 ac (Figure 23). Currently, the majority of the fields are comprised of cool-season grasses (483.5 ac). Fields of warm-season grasses comprises 77 ac.

Appropriate land cover, soil quality, invasive species, priority species, and indicator species measures were chosen as indicators of the health of the meadows/fields at Appomattox Court House NHP. Specific bird species can be a good indicator of the ecological condition of the meadows/fields. The eastern meadowlark and grasshopper sparrow are common breeders at Appomattox Court House NHP. Grasshopper sparrows and eastern meadowlarks are true grassland species and are good indicators of quality grassland habitat (Carignan and Villard 2002, Kearney 2003). We chose two additional species, the northern bobwhite quail and Savannah sparrow, as indicators of grassland bird habitat.

Appomattox Court House has used agricultural leasing to maintain a portion of the cultural meadows. Of the 560 ac of cultural meadow, 192.8 ac (34%) is currently in pasture, 207.5 (37%) in fescue hay, and 39 ac (7%) in native grass hay. Throughout the years, the amount of fields used for cattle grazing has decreased; from 1999 to 2002 there was a 40% reduction. Measures have also been taken to reduce the negative impact of cows in streams and riparian areas (APCO GMP).

Prescribed Fire

To study changes to habitat in response to prescribed fire, eight point intercept plots were established in the Ferguson field in 2008. These plots contain all intercepted vegetation data identified to the species level. The years are 2008 pre-burn, 2009 1-year post-burn, and 2010 2-year post-burn (Figure 24). The management objectives for prescribed burn operations in the Ferguson field are to increase relative cover of native grasses by 10–20% within five years post-burn, and to decrease relative cover of nonnative grasses by 25–45% within five years post-burn (Forder 2010). The percentage of nonnative species for the three years' data was collected and the percentage of nonnative species was similar (26.2%, 29.8%, and 29.2% - see Figure 25).

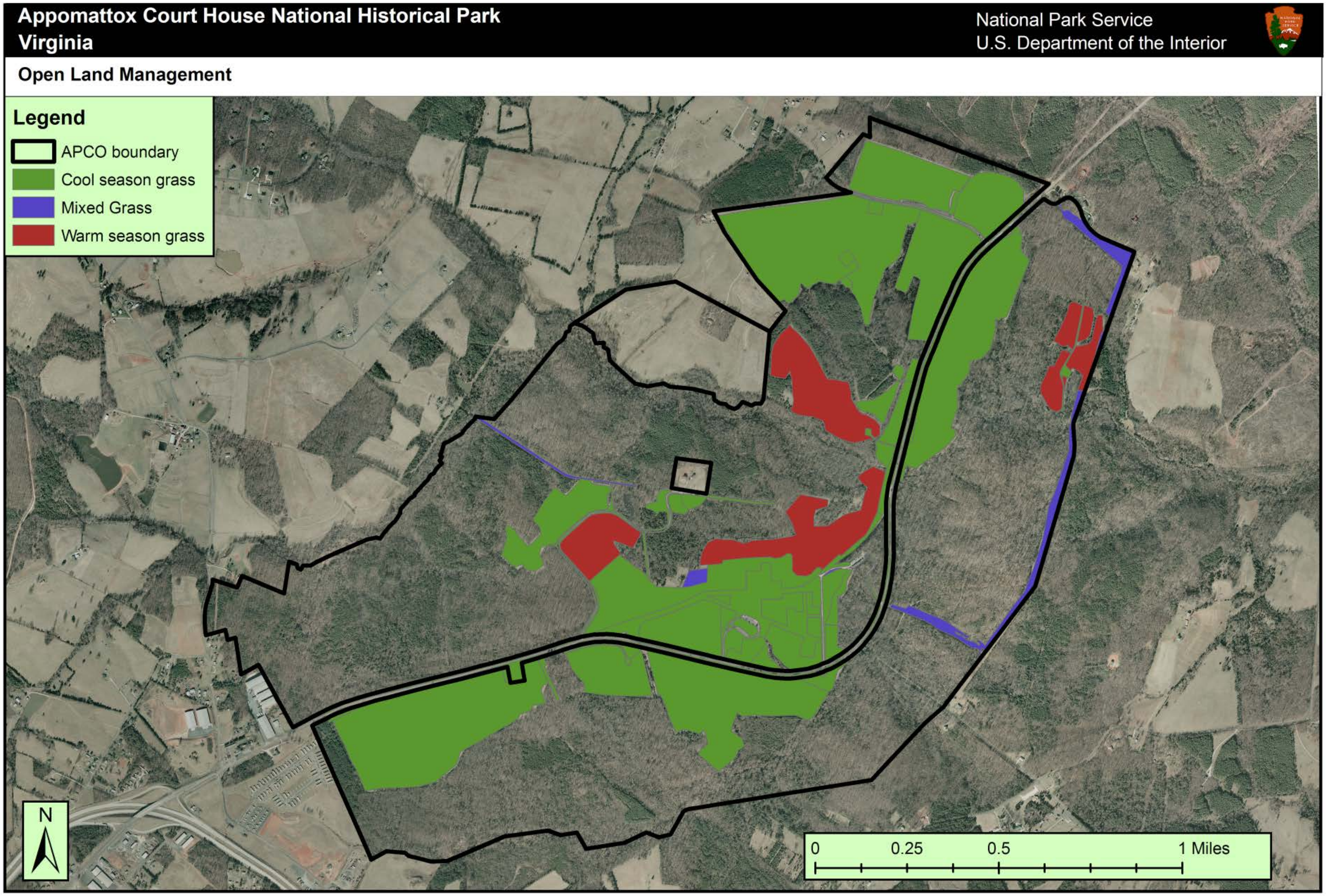

Figure 23. Open land management areas at Appomattox Court House National Historical Park (APCO).

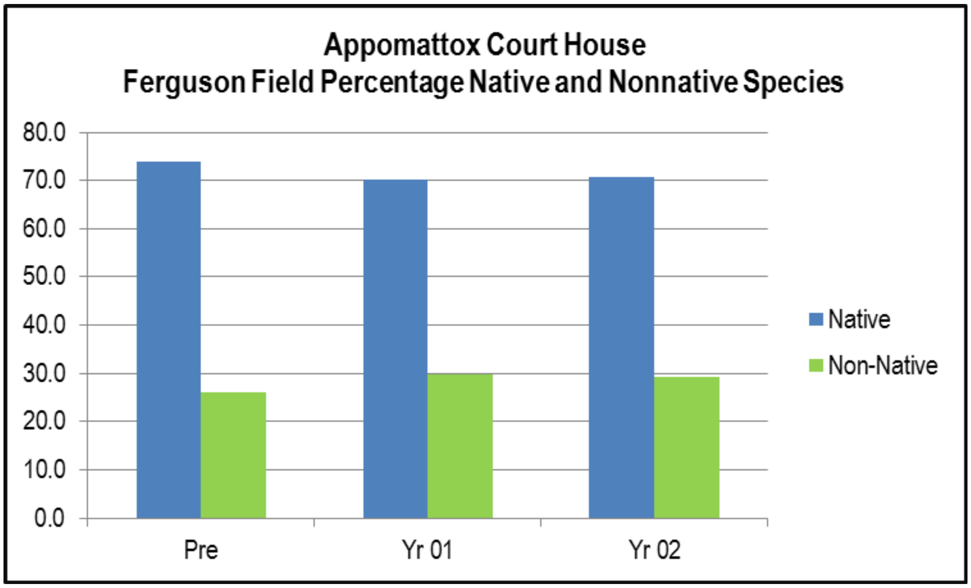

Figure 24. Percentage of native and nonnative species pre- and post-burn (Forder 2010).

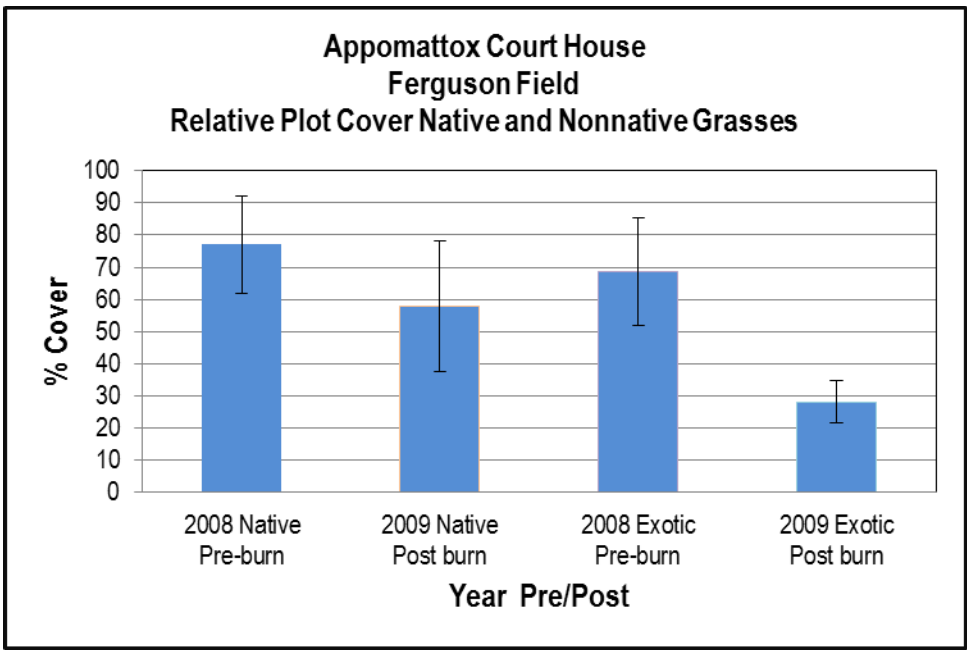

Figure 25. Ferguson field relative plot cover (bars represent standard error of the mean). Pre-burn % relative cover native grasses 77(±19.23); post % relative cover native 57.87 (±14.29); pre-burn % relative cover nonnative grasses 68.62(±16.57); and post-burn % relative cover nonnative grasses 28.12 (±6.55) (n=8, 1 burn) (Forder 2010).

After one burn treatment, native grasses decreased slightly; however, monitoring took place one month earlier than the year before. Nonnative grasses showed a significant decrease. New fescue growth was sprayed immediately post-burn, which decreased the cover of nonnative grasses (n=8) (Figure 26).

In addition to reducing hazardous fuels and the spread of exotic species, another management objective of prescribed burn operation is to reduce the relative percent cover of woody vegetation and increase the abundance of native grasses and forbs. From a cultural resources perspective, to emulate the cultural landscape associated with the Civil War Era, an open, park-like condition with little woody understory is the desired condition of wooded habitats at Appomattox Court House NHP. A reduction of 20–40% is desired within five years post-burn. After one year of treatment, woody species increased slightly. The increase was primarily attributed to an increase in *Rubus* species. However, as treatments continue in the future, the amount of woody vegetation will likely decrease (Figure 27).

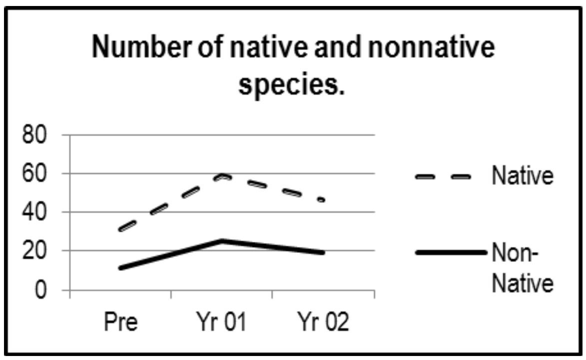

Figure 26. Number of native and nonnative species (pre- and post-burn).

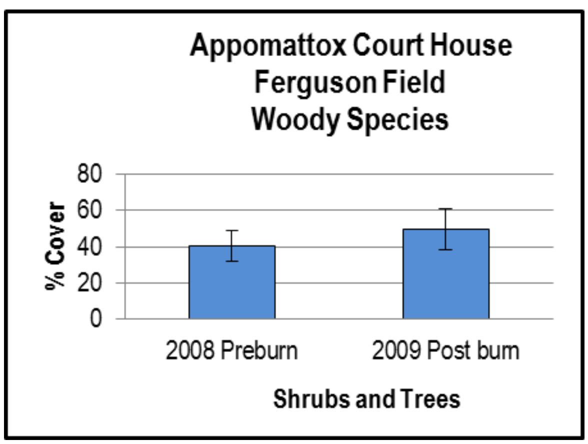

Figure 27. Pre- and post-burn results for woody vegetation results (bars represent standard error of the mean). Pre-burn % relative cover woody vegetation 40.5(±10.65); post-burn % relative cover woody vegetation 49.5 (±14.34) (n=8, 1 burn) (Forder 2010).

Condition Status Summary for Vegetation Communities

Grassland communities are the most common land cover class for the park, covering 560 ac (Patterson 2008). Managing grasslands for native warm-season grasses can have a great benefit to the overall quality of habitats for faunal species and ecological integrity of the park. To manage for grassland birds species, large tracts of grassland habitat should be kept intact. The fields that are either fescue dominated, leased hay fields (187 ac), leased pasturelands for cattle grazing (196 ac), or mowed should be minimized where possible.

Although data were not available for this assessment, deer browse damage is currently monitored at the park to determine impacts of deer and actions needed to reduce negative impacts to native vegetation communities. Also, the trend in soil acidification due to atmospheric acid rain and calcium-dust additions or direct agricultural inputs (lime and fertilizer) is important to know in order to determine if these inputs are causing changes in pH and the availability of soil nutrients, or increasing the likelihood of aluminum toxicity to introduced plants. Native plants may also become stressed and more susceptible to biological or weather damage if essential nutrients in the soil become depleted or unavailable due to erosion or changes in soil pH. Soil analysis of samples taken in the park in forested habitats began in 2010 to monitor acidification and nutrient availability and possible depletion. Data regarding forest stocking rates and species composition for tree, sapling, and seedling layers were collected in 2010. Currently, there is no regional list of optimal species for any of the forest types within APCO; however, these metrics can be assessed in the future. An overall summary matrix of the condition of the vegetation communities is shown in Table 12.

Table 12. Vegetation communities condition summary.

Category	Vital Sign/Indicator	Measure	Threshold Criteria	Current Condition	Comment(s)
Forest Health	Land cover	Percent total forest cover within park.	>59%=Good 31–58%=Fair <30%=Poor	62.9% (Good)	The amount of forested habitat within the park should remain stable.
	Key forest bird species	Population and/or presence of indicator species.	Population and/or presence of indicator species remain stable over time.	6 out of 6 species known to be present (Good)	Insufficient data to evaluate trends. Key species = wood thrush, Kentucky warbler, scarlet tanager, yellow-throated vireo, pileated woodpecker, red-eyed vireo
	Native forest pests	# species present % infestation by habitat	Park will not be negatively impacted by forest pests.	0 forest pests detected (Good)	gypsy moth hemlock wooly adelgid
	Invasive exotic plants	Average # exotic species / forest plot % plots with exotic species	Average of less than 0.5 invasive exotic species present per plot = Good Average of 0.5 to < 3.5 invasive exotic species present per plot = Fair Average of 3.5 or more key invasive exotic species present per plot = Poor	Average # exotic spp/plot = 2.1 (Fair) Average 93% of plots with exotics (Poor)	
	Soil quality	Acid Stress (average Ca:Al ratio); (proportion of plots below 1.00)	Soil Ca:Al ratio >4=Good Soil Ca:Al ratio 1–4=Fair Soil Ca:Al ratio <1=Poor	Unknown- data gap	
		Nitrogen Saturation (average C:N ratio); (proportion of plots below 20.0)	Soil C:N ratio >25=Good Soil C:N ratio 20–25=Fair Soil C:N ratio <20=Poor	Unknown- data gap	
	White-tailed deer density	Deer Population Density <8/km2 = Good >8/km2 = Significant Concern	A white-tailed deer population will be maintained in the park that allows for protection and restoration of native plant communities.	Unknown- data gap	

Category	Vital Sign/Indicator	Measure	Threshold Criteria	Current Condition	Comment(s)
Grassland integrity	Relative plot cover (%)	Grassland/meadow specialists vs. nonnatives	Increase relative cover of native grasses by 10%–20% within 5 years post-burn. Decrease relative cover of nonnative grasses by 25%–45% within 5 years post burn.	• Nonnative pre-burn = 68.62; Nonnative post burn = 28.12 • Native pre-burn = 77; Native post burn = 57.87	Three years of additional treatment and data are needed to determine if desired condition has been met.
	Woody species	Relative cover	Reduce relative percent cover of woody vegetation by 20%–40% within 5 years post burn.	Post % relative cover woody vegetation 49.5 (±14.34) (n=8, 1 burn)	Three years of additional treatment and data are needed to determine if desired condition has been met.
	Key grassland bird species	Population and/or presence of indicator species.	Population and/or presence of indicator species remain stable over time.	4 out of 4 species known to be present (Good)	Insufficient data to evaluate trends. Key species = grasshopper sparrow, eastern meadowlark, northern bobwhite quail, Savannah sparrow
	Soil quality	Acid Stress (average Ca:Al ratio); (proportion of plots below 1.00).	Soil Ca:Al ratio >4=Good Soil Ca:Al ratio 1–4=Fair Soil Ca:Al ratio <1=Poor	Unknown- data gap	
		Nitrogen Saturation (average C:N ratio); (proportion of plots below 20.0).	Soil C:N ratio >25=Good Soil C:N ratio 20–25=Fair Soil C:N ratio <20=Poor	Unknown- data gap	

Wetland and Riparian Resources

Riparian forests are subjected to many disturbances from timber harvesting, livestock grazing, and recreational development. Due to these competing uses, riparian forests have declined from historic levels and are now greatly reduced in area and connectivity. Riparian buffer strips are used extensively all over the world to control sedimentation, remove excess nutrients from surface runoff, ameliorate surface water temperature flux, and provide habitat and migration corridors for flora and fauna. Streams are physically linked via the riparian zone to their watersheds, and riparian areas are considered critical components of streams. In riparian zones, vegetation type and coverage also influence water quantity and quality. When riparian structure and function are diminished, the changes are reflected in both aquatic and riparian flora and fauna (Bryce et al. 2002). Much of the wetlands in the Mid-Atlantic region have been drained, developed, or otherwise converted.

Wetland mapping efforts for Appomattox Court House NHP occurred in 1981 and 2002. During the 2002 wetland survey, 28 unique palustrine and riverine systems were identified within the park boundary (Environmental Concern 2002). Patterson (2008) mapped three wetland classes on Appomattox Court House NHP during the overall vegetation mapping effort for the park. The Piedmont/Mountain Alluvial Forest type comprises 116.2 ac. This wetland type is occasionally flooded and is found on floodplains and terraces along the Appomattox River, Plain Run Branch, and one unnamed Appomattox River tributary. High quality examples of this wetland type are rare in the Mid-Atlantic region. Invasive species in wetland ecosystems can easily overrun native vegetation and are especially prevalent near trails and roads. Surrounding urban development and visitor use also influence the spread of nonnative species in this community type.

The Upland Depression Swamp class (8.3 ac) is a globally rare community. It occurs in poorly drained, seasonally flooded soils. One central and two southwestern areas of the park are classified as upland depression swamp (Figure 28). Soil disturbance is still evident from historic logging activities. Northern Piedmont / Lower New England Basic Seepage Swamp (1.7 ac) is found on the broad floodplain of the Appomattox River and is a state rare community. Appomattox Court House NHP is at the southern limit of its range.

We defined the riparian buffer as 50 feet on either side of the streams based on Virginia Department of Forestry (2002) best management practices for water quality. At Appomattox Court House NHP, 78% percent of the riparian buffer is forested, while 22% remains non-forested (20.3% in meadow/field and 1.5% in built-up land. According to the VDOF, forested buffers are more beneficial than grass buffers, with infiltration rates 10–15 times higher than grass buffers VRFBP (1998). If buffers consist of grasses and/or shrubs it is advisable not to mow or graze cattle along these buffers (Figure 29).

Nonnative species documented by Patterson (2008) in forested riparian habitats include: Amur peppervine (*Ampelopsis brevipedunculata*), Indian strawberry (*Duchesnea indica*), border privet (*Ligustrum obtusifolium*), Japanese honeysuckle (*Lonicera japonica*), Nepalese browntop (*Microstegium vimineum*), oriental ladysthumb (*Polygonum caespitosum* var. *longisetum*), and multiflora rose (*Rosa multiflora*).

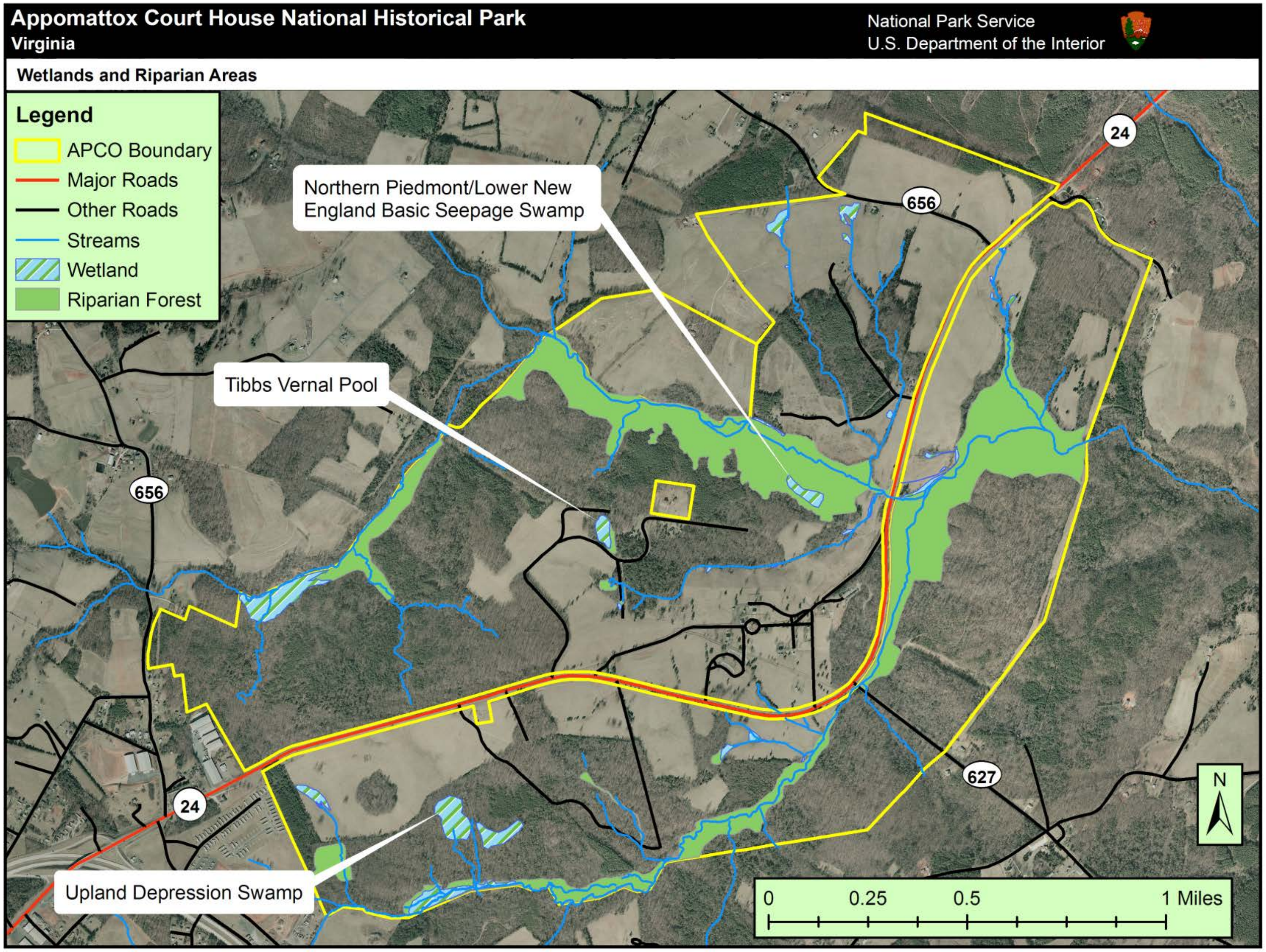

Figure 28. Wetlands and riparian areas of Appomattox Court House National Historical Park (APCO) (Environmental Concern 2002, Patterson 2008) (VBMP 2008).

Figure 29. Riparian forest stream where cattle have access (November 2010).

The Functional Capacity Index (FCI) is a measure of functional capacity of a wetland where 0.0 represents no functional capacity and 1.0 represents optimal functional capacity. The 2002 survey rated four wetland assessment areas (Table 13). Three of the four areas were rated <0.50.

Species restricted to one or a few habitat types represent better indicators than habitat generalists. The types of birds found in an area can indicate the ecological condition of that area (Bryce et al. 2002). Louisiana waterthrush is sensitive to declining stream quality and loss of riparian forest buffers (Kearney 2003); thus, when this species is utilizing an area, it is an indicator of the health of stream and riparian habitat. Louisiana waterthrush is listed as a breeder at Appomattox Court House NHP.

There are several species of amphibians and reptiles primarily associated with the Appomattox River and its riparian zone. One species, the mole salamander, is a state species of special concern and was found in a riparian zone along the Appomattox River and in Tibbs Ice pond (Mitchell 2006). Amphibians are good indicators of habitat quality and change due to their sensitivity to pollutants and environmental stressors. Habitat loss, environmental contaminants, and invasive species directly affect salamander and other amphibian populations. The vegetation along streams is important for the survival of many amphibian species and can provide shade.

Table 13. Wetland Functional Capacity Index Results (from Environmental Concern 2002).

Wetland	Wildlife FCI Score	Discussion
North Beaver Complex	0.69	This wetland complex has diverse interspersion of open water, emergent, scrub-shrub and forested wetlands. Vertical structure is diverse both horizontally and vertically. These features provide a rich structure for wildlife habitat.
Braided Stream Complex	0.48	Though not as complex as the north beaver complex, the varied streams along Plain Run Branch provide vegetation to water interspersion. Vertical structure also is above average with a fairly complex spatial pattern of shrubs and trees.
Grazed Emergent Wetland System	0.18	This system has been extensively used by cattle resulting in no vertical structure with a significant disturbance of wildlife habitat. Very little vegetation to water interspersion exists with channels exhibiting erosion.
Depressional Wetland System	0.46	This system has average vertical layers that are in fair condition. Seasonally, open water exists until summer allowing some vegetation to water interspersion.

When the vegetation is gone, the eggs may be exposed to lethal amounts of ultraviolet radiation. Riparian indicators may be an important addition to stream ecosystem assessments because they respond more directly to the terrestrial disturbances that precede changes in the aquatic environment.

Land development that encroaches on the riparian areas can have consequential influences on the physical properties of the water and the way it moves through surface water systems. Reduction of a stream's overhead canopy directly affects water temperature and the amount of leaf litter that enters the aquatic food chain (Booth and Jackson 1997). Loss of vegetation also means reduced filtering of pollutants and nutrients, causing negative effects to water quality.

Development can reduce the potential for woody material to be introduced into the stream channel that could otherwise serve as a stabilizing element to dissipate flow energy and help protect from stream bank erosion (Booth et al. 1996). If established, deep-rooted vegetation is replaced by shallow-rooted grasses or ornamentals (or not replaced at all), inherent stream bank stability and resistance to channel widening is lost (Booth and Jackson 1994). There is one instance of severe stream bank erosion at the park, a concrete bridge constructed in the 1970s (Figures 30 and 31).

Wetland Integrity

Measures used to assess the wetland communities at Appomattox Court House NHP were adapted from Faber-Langendoen (2009). Appendix F details the methods and datasets used for our analyses. Wetland integrity was rated using three metrics: 1) landscape connectivity; 2) buffer index; and 3) surrounding land use metrics.

Landscape connectivity is a measure of the percent of unfragmented landscape within a 500-m radius. Detailed methods of how we analyzed landscape connectivity can be found in Appendix F. We looked at non-riverine types only for Appomattox Court House NHP. The park scored 59.9%, which is categorized as fragmented (Figure 32).

Figure 30. Concrete bridge (circa 1970's); debris frequently clogs drain pipes, causing erosion of stream bank (November 2010).

Figure 31. Eroded stream bank (November 2010).

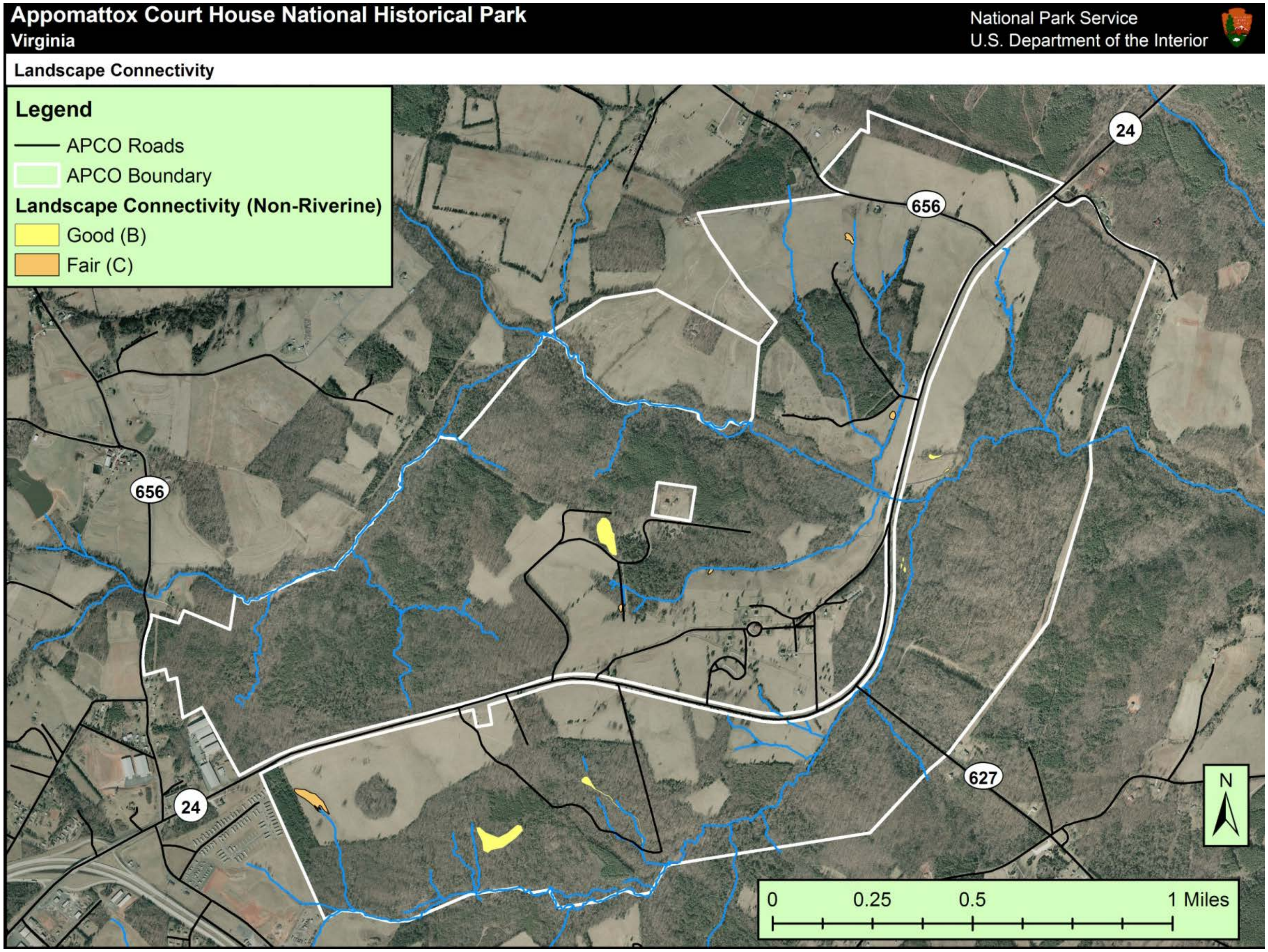

Figure 18. Landscape connectivity of non-riverine land cover (Faber-Langendoen 2009) (VBMP 2008).

Buffer index (see Figures 33, 34, and 35) is the overall area and condition of the buffer immediately surrounding a wetland. We used three methods where we: 1) identified and classified vegetated, non-anthropogenic land cover, 2) in a GIS, determined the percentage of the wetland perimeter adjacent to buffer, and 3) in a GIS, determined the average width of identified buffer, corrected for slope. Good quality wetland buffers are vegetated natural (non-anthropogenic) areas that surround a wetland. The buffer index for the park is rated as 28.8%. This means that the majority of wetland buffers at Appomattox Court House NHP have moderate cover of nonnative vegetation, with an average buffer width of 50–99 m, after adjusting for slope (Table 14).

Surrounding land use is a measure of the intensity of human-dominated land uses within a specific landscape area. We used three methods to analyze surrounding land use: 1) buffered the park boundary to landscape area as delineated by the 8-digit Hydrologic Unit Code (HUC); 2) ranked land cover by human impact; and 3) in a GIS-run analysis of land cover within the watershed. Each land use type occurring in the landscape area is assigned a coefficient ranging from 0.0 to 1.0, indicating its relative impact to the target system. Due to the rural setting of land surrounding Appomattox Court House NHP, the park scored 0.89, which is in the good range.

Condition Status Summary for Wetland/Stream Resources

Overall, the condition of the wetlands at Appomattox Court House NHP is rated as good. Two metrics (landscape connectivity and buffer index) rated fair, while surrounding land use and the extent of forested buffers rated as good. It is understood that mowing has to occur in certain areas to keep the landscape within the historical and cultural context. Though grass riparian buffers provide some protection of the streams and riparian area, they should be left uncut and ungrazed where possible.

According to Mitchell (2006), Tibbs Ice Pond is one of the most valuable habitats for many amphibians and invertebrates at the park. Tibbs Ice pond scored in the good range for buffer index condition and connectivity. Park managers should work to maintain those buffers to help protect the wetland's integrity. Cattle that graze up to and in streams are one threat to wetland and riparian resources. In a few areas, cattle graze on park property without any barriers to streams and riparian habitats. This can have a detrimental effect on faunal species present at the park. Trends of invasive plant cover in the wetland and riparian areas were not available for this assessment, but can be useful for future assessments. Condition status summaries for the wetlands can be viewed in Table 14.

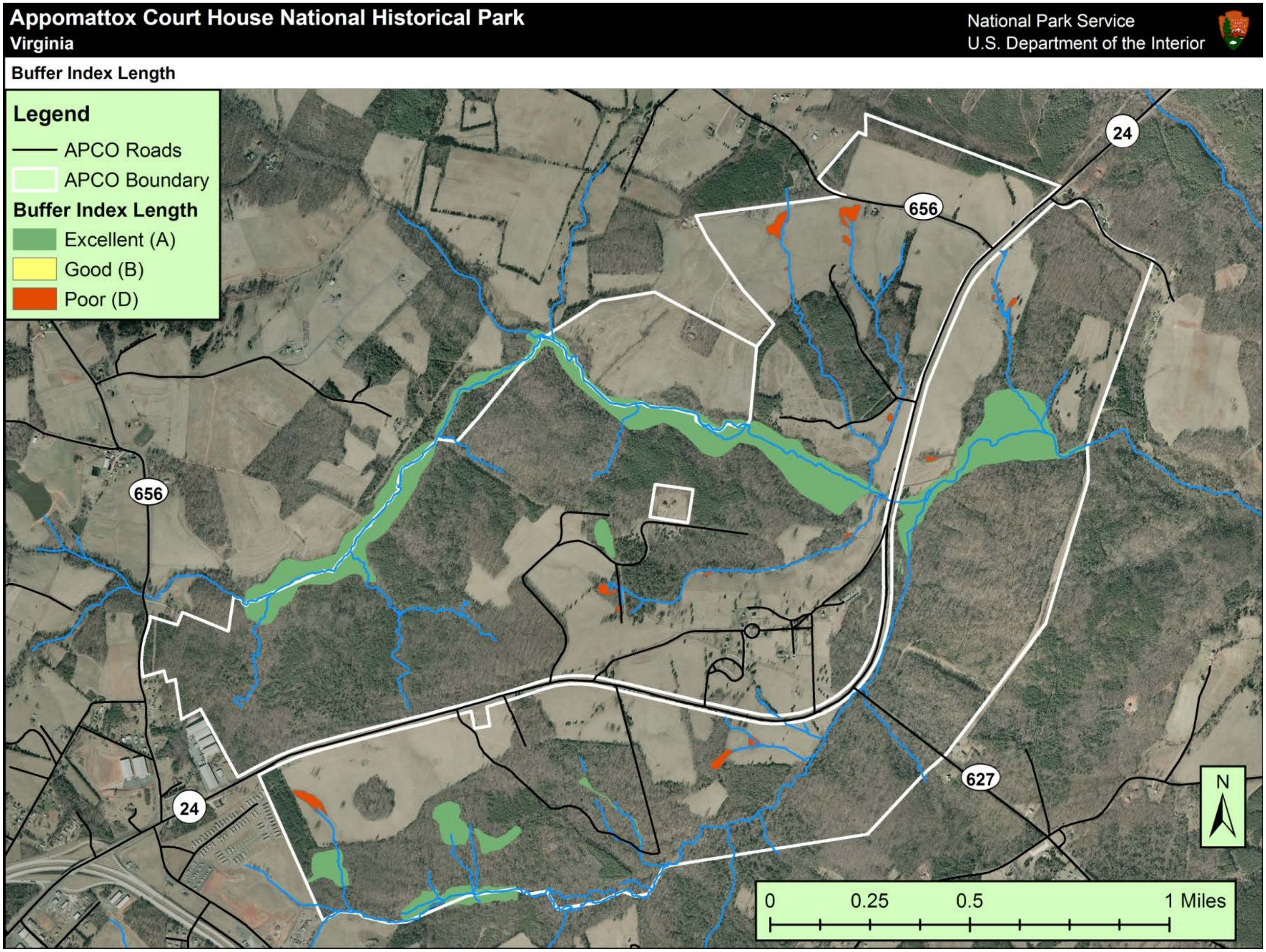

Figure 19. Wetland buffer index length (Faber-Langendoen 2009) (VBMP 2008).

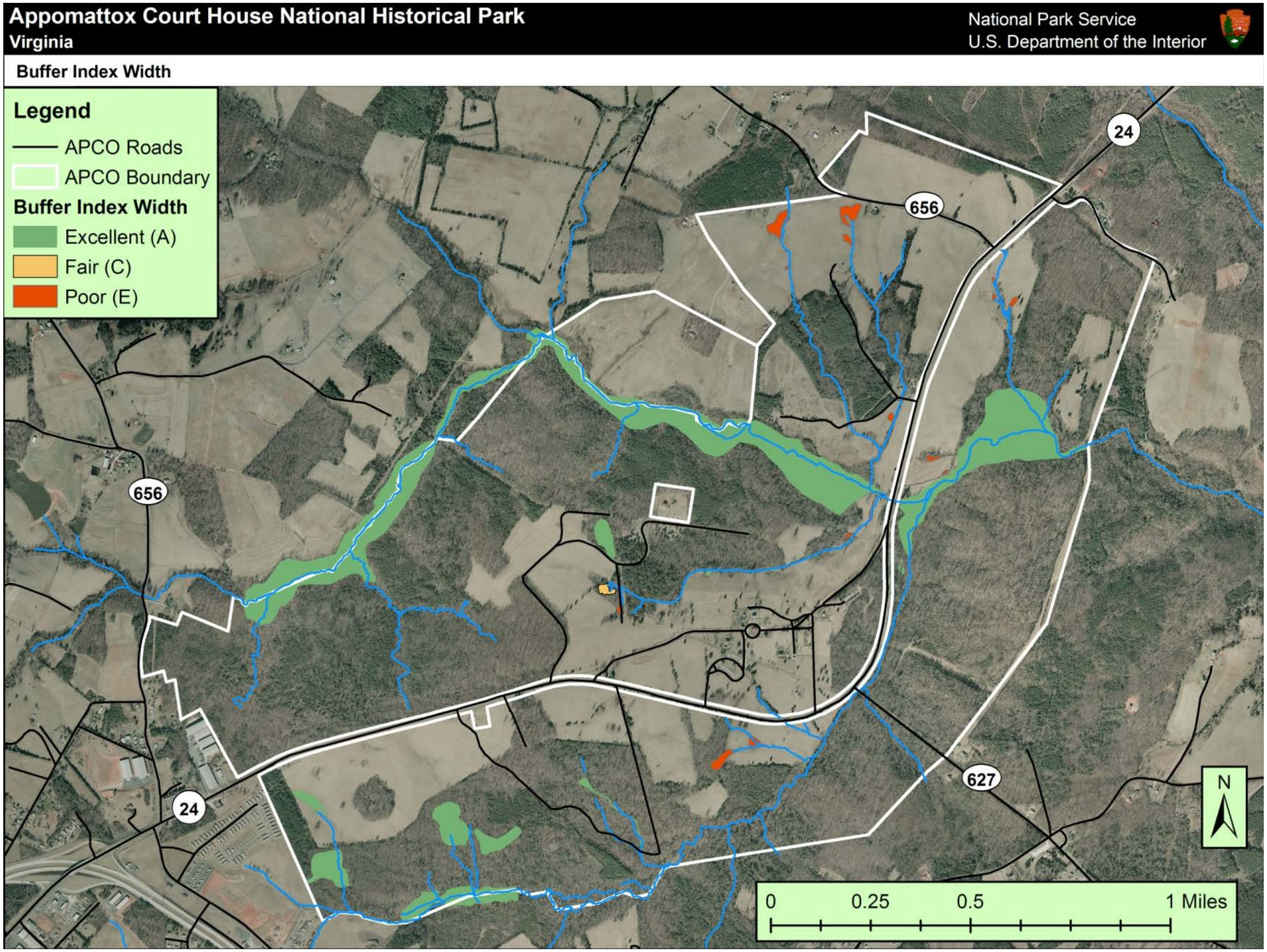

Figure 20. Wetland buffer index width (Faber-Langendoen 2009, VBMP 2008).

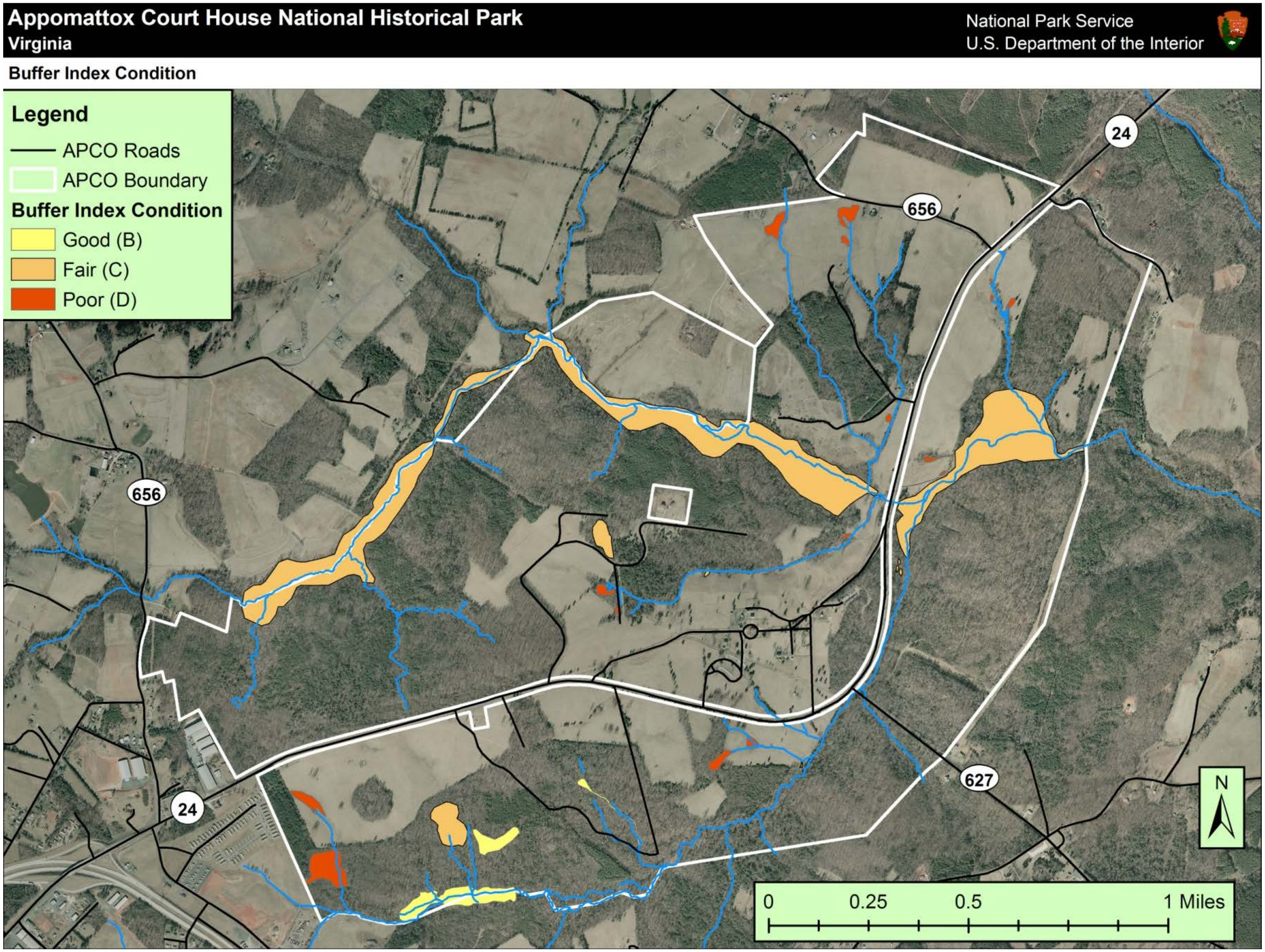

Figure 21. Wetland buffer index condition (Faber-Langendoen 2009, VBMP 2008).

Table 14. Wetland/Riparian resources condition status summary.

MIDN Vital Sign/Indicator	Measure	Threshold Criteria	Current Condition	Comments
Extent of wetlands	Area of wetlands present	Wetland areas of the park are dominated by native plant species and the extent of wetlands remains stable or increases over time.	104 ac	Trends can be evaluated in the future.
	Percent forested riparian buffer within park: We defined the riparian buffer as 50 feet on either side of the streams based on Virginia Department of Forestry (2002) best management practices for water quality.	The area (width) of forested riparian buffer located along waterways will remain stable or increase over time to promote protection of water quality, stabilize stream/river banks, and provide habitat for native wildlife species. Increase or keep constant % forested riparian buffer area on the park. >75% = Good 50–75% = Fair <50% = Poor	Percent forested riparian buffer within park = 78% (Good)	
Surrounding land use index	A measure of the intensity of human dominated land uses within a specific landscape area (such as a catchment) from the center of the occurrence. Each land use type occurring in the landscape area is assigned a coefficient ranging from 0.0 to 1.0 indicating its relative impact to the target system.	Excellent = 1.0–0.95 Good = 0.80–0.95 Fair = 0.4–0.8 Poor = < 0.4	0.89 (Good)	Metrics and ratings from Faber-Langendoen (2009)
Landscape connectivity	Non-riverine: A measure of the percent of unfragmented landscape within 500 m radius.	Excellent = Intact, 90–100% natural habitat around wetland\ Good = Variegated, 60–90% natural habitat Fair = Fragmented, 20–60% natural habitat Poor = Relictual, <20% natural habitat	59.9% (Fair)	Metric and ratings from Faber-Langendoen (2009)
Buffer index	An index of the overall area and condition of the buffer immediately surrounding the wetland, using three measures: (1) percent of wetland with buffer (length), (2) average buffer width (with slope correction), and (3) buffer condition. Wetland buffers are vegetated, natural (non-anthropogenic) areas that surround a wetland.	See Appendix F	Length = 36.7% (Fair) Width = 148.1 m (Good) Condition = 28.8% (Fair)	Metric and ratings from Faber-Langendoen (2009)

Biological Integrity

Ideally, an assessment of the biotic communities at Appomattox Court House NHP would consist of the complete range of plants and animals known to occur within the park, as well as the full suite of species found on pristine tracts of similar habitat in the same landscape. The biotic assessment would be performed on the full spectrum of animals and plants from each taxonomic class over several years. Species absences or species located that were not part of that suite of native species would represent decreases in biotic integrity from the reference scenario. Such a complete assessment is beyond the scope of this project. We can, however, use existing datasets for a few of these taxa to permit some insight as to the likely state of biotic communities at Appomattox Court House NHP. There have been a few investigations of animals and plants at Appomattox Court House NHP over the past 10 years (see Tables 15 and 16 and Figure 36). Complete species lists of species and the relevant abbreviations for those lists can be found in Appendixes G through M.

Table 15. List of available animal and plant surveys at Appomattox Court House National Historical Park.

Year data collected	Community target for survey	Citation
2002, 2004	Fish (Appendix I)	Atkinson, James B. March 2008. Fish Inventories of Mid-Atlantic and Northeast Coastal and Barrier Network Parks with Virginia, Maryland and Pennsylvania. Technical Report NPS/NER/NRTR—2008/113. National Park Service. Philadelphia, PA.
2003, 2004	Amphibians and reptiles (Appendices J and K)	Mitchell, J. C. 2006. Inventory of Amphibians and Reptiles of Appomattox Court House National Historical Park. National Park Service, Northeast Region. Philadelphia, PA. Technical Report NPS/NER/NRTR—2006/056.
2002, 2003	Birds (Appendix L)	Bradshaw, D. December 2007. Appomattox Court House National Historical Park Avian Inventory. Technical Report NPS/NER—2007/088. National Park Service. Philadelphia, PA.
2003, 2004	Mammals (Appendix M)	Pagels, J. F., A. D. Chupp, and A. M. Roder. December 2005. Survey of Mammals at Appomattox Court House National Historical Park. Technical Report NPS/NER/NRTR—2005/030. National Park Service. Philadelphia, PA.

Table 16. Data sources used for measures of biological integrity within Appomattox Court House National Historical Park.

Indicator	Measure	Data Source
Fish	Jaccard's Index of Similarity, species richness	APCO species list, NatureServe watershed reference list, VaFWIS species list, Atkinson (2008)
Amphibians	Jaccard's Index of Similarity, species richness	APCO species list, reference list from Mitchell (2006), VaFWIS species list
Reptiles	Jaccard's Index of Similarity, species richness	APCO species list, reference list from Mitchell (2006), VaFWIS species list
Birds	Jaccard's Index of Similarity, species richness	APCO species list, Bradshaw (2007), BBS reference list, VaFWIS species list
	Community trends	BBS data for Southern Piedmont
Mammals	Jaccard's Index of Similarity, species richness	APCO species list, reference list from Pagels et al. (2005), VaFWIS species
Invasive Species	Percent Invasive/ exotic Species	APCO species list

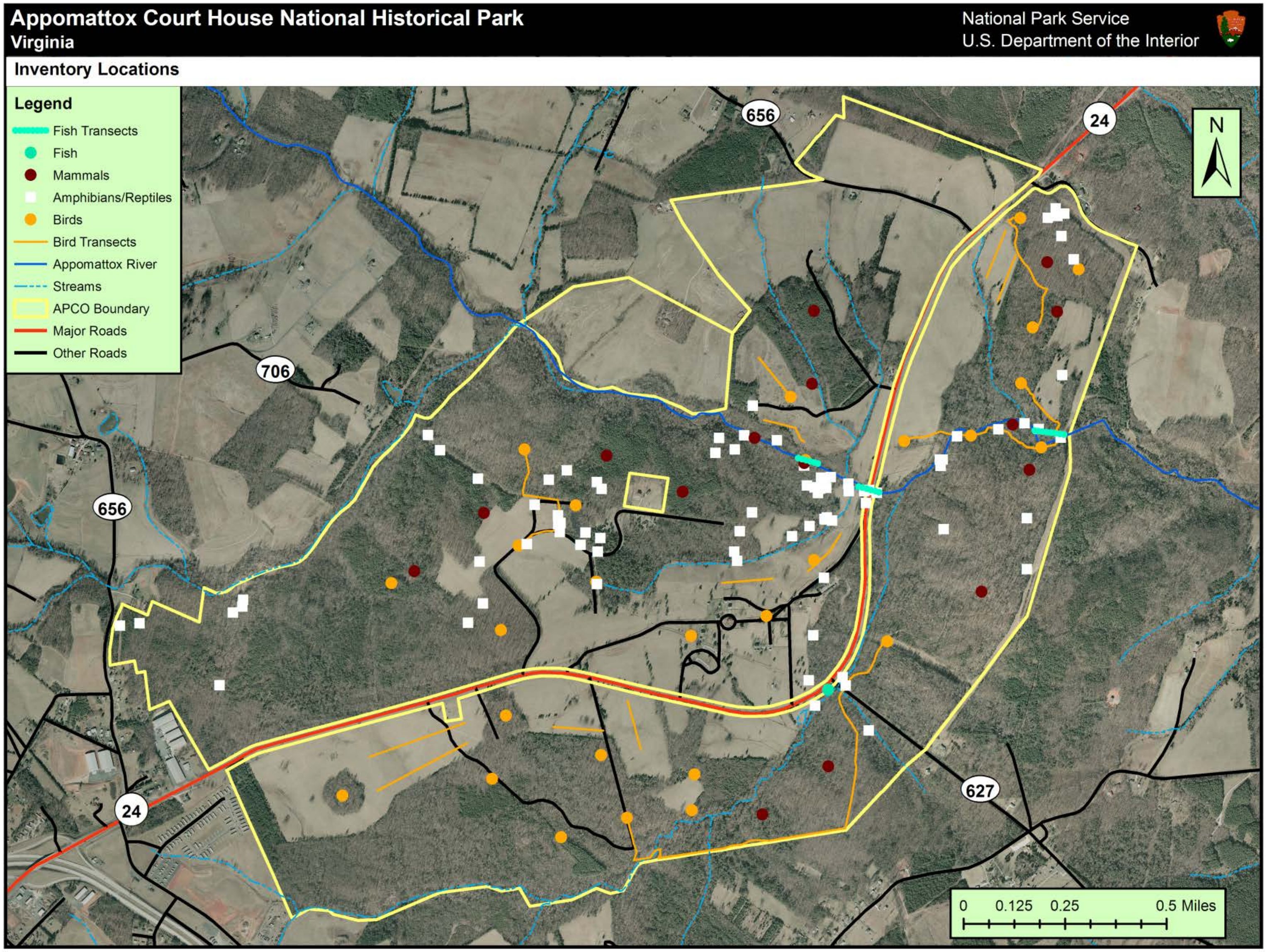

Figure 36. Inventory locations at Appomattox Court House National Historical Park (APCO).

These studies have been synthesized into a species information database by the NPS (Certified Organisms: NPSpecies 2009). With this system, users can extract predicted species lists for each park in the system including Appomattox Court House NHP. We utilized this database to generate lists of species (by taxa) expected to occur within Appomattox Court House NHP.

Attempts at locating and utilizing appropriate reference datasets for comparison to Appomattox Court House NHP community information were more problematic. Such information is either not readily available or is considered suspect for these purposes. Without defensible reference community assemblages, any assessments drawn using them would be suspect. We elected to focus on those communities for which the most defensible information was available. We also looked to the existing NPS Inventory and Monitoring (I&M) Vital Signs Program for the MIDN to provide some guidance as to which species communities were considered important enough for future monitoring efforts.

To determine quantitative measures of biotic condition, we used the Jaccard Index of Similarity for comparisons with other species lists for the state of Virginia. The Jaccard Index of Similarity is a simple method for comparing species diversity between two different samples or communities (Krebs 1999). The value is calculated by dividing the number of species found in both samples (a) by the number found in only one sample or the other (b, c):

$$S_j = a / (a+b+c).$$

Per discussion with NPS personnel, we gave a good condition status to those indicators with a Jaccard's Index of Similarity ≥0.50, and a fair condition status to those ≥0.25. Scores <0.25 were given a poor condition status. These values can be updated and refined in subsequent years as more information becomes available.

Fish

Fish were inventoried in 2002 and 2004 (Atkinson 2008). One of the highlights from the fish inventories, was the diversity of darters (fantail, longfin, johnny, and stripeback) encountered within the Appomattox River (Atkinson 2008). Many darter species are intolerant of siltation, pollutants, and habitat disturbance. Additionally, darters are the most imperiled group of North American fishes, with one-third of all darters population in some degree of decline (Grabarkiewicz and Davis 2008).

The biotic species list compiled from the NPS biotic database (Certified Organisms: NPSpecies 2009) indicates there are 30 fish species that utilize Appomattox Court House NHP habitats for some period of their annual or seasonal life requisites. We compared native fish species documented at Appomattox Court House NHP to native fish that occur in the Appomattox watershed based on NatureServe data. Percent similarity of native fish collected in the NPS unit was 0.40. Clearly, many of these species are without habitat at Appomattox Court House NHP; however, the Atkinson report did not list species expected to occur at the park.

Amphibians

Amphibians are good indicators of habitat quality and change due to their sensitivity to pollutants and environmental stressors. Habitat loss, environmental contaminants, and invasive species directly affect salamander and other amphibian populations. Recent declines in amphibian production elsewhere in the region make them of further interest as part of this assessment. Vegetation along streams is important for the survival of many amphibian species because of the shade it provides. When the vegetation is gone, eggs may be exposed to lethal amounts of ultraviolet radiation. Additionally, salamanders can be negatively impacted by various introduced game species such as bullfrogs and species of predatory fish (Kiesecker and Blaustein 1998).

Amphibians (and reptiles) were recently inventoried at Appomattox Court House NHP (Mitchell 2006). Mitchell (2006) employed a variety of survey methods aimed at compiling the most comprehensive list of amphibians present at the park. Our assessment was completed using the amphibian species documented during this effort. A total of 19 species of amphibians (nine anurans, 10 salamanders) were observed for Appomattox Court House NHP as part of this survey. This study suggests that six additional amphibian species (four anurans, two salamanders) have ranges coincident with Appomattox Court House NHP, but were not observed. Presumably, this is due to a lack of specific local-scale habitat conditions that these species require, precipitation patterns during the survey period, and low encounter rates with very secretive species. The species expected to occur, but not observed during this survey effort include northern cricket frog (*Acris crepitans)*, Fowler's toad (*Bufo fowleri),* eastern narrow-mouthed toad (*Gastrophryne carolinensis)*, eastern spadefoot (*Scaphiopus holbrookii)*, eastern mud salamander *(Pseudotriton montanus)*, and northern red salamander *(Pseudotriton ruber)*.

The Jaccard Similarity Index between the observed species and the potential assemblage is 0.72. However, this value represents the most conservative application of this score. A number of these are without habitat at Appomattox Court House NHP.

Reptiles

We completed a community composition analysis for reptiles similar to our methods for amphibians listed above. Reptiles (and amphibians) were surveyed recently (Mitchell 2006) using similar methods. A total of 14 reptiles were found at Appomattox Court House NHP. The survey suggests the potential for 13 additional species with overlapping ranges (although habitat may not be found at the park). This yields a Jaccard Similarity Index of 0.52.

Species expected to occur, but not observed during this survey effort include stinkpot (*Sternotherus odoratus)*, six-lined racerunner (*Cnemidophorus sexlineatus)*, broad-headed skink (*Eumeces laticeps)*, ground skink (*Scincella lateralis)*, northern copperhead (*Agkistrodon contortrix),* corn snake (*Elaphe guttata*)*,* eastern hog-nosed snake (*Heterodon platirhinos*), mole kingsnake (*Lampropeltis calligaster*), eastern kingsnake (*Lampropeltis getula*), rough greensnake (*Opheodrys aestivus*)*,* red-bellied snake (*Storeria occipitomaculata*), eastern ribbonsnake (*Thamnophis sauritus*)*,* and smooth earthsnake (*Virginia valeriae*).

Mitchell (2006) states that, in a recent survey of eastern box turtles in Virginia, most box turtles observed had high levels of organochlorine pesticide in their system, which is evident by the presence of aural abscesses. The eastern box turtle is a long-lived species and can accumulate chemicals from the environment over many years, thus may be an excellent indicator of ecosystem condition and health. There was no evidence of turtles with aural abscesses on Appomattox Court House NHP during Mitchell's survey.

Birds

Browder et al. (2002) states numerous reasons why birds are excellent indicators for monitoring habitat change: 1) individual bird species are associated with particular habitats; 2) changes in species composition and abundance can be evident relatively quickly after a disturbance; 3) systematic and extensive bird surveys are currently conducted across the United States and southern Canada (Audubon Breeding Bird Survey, Christmas Bird Count, etc); 4) groups of bird species can be used to develop associations with habitats that are predictive of the relative level of anthropogenic disturbance; and 5) birds are important to a large segment of the public, so the public may relate to concerns about changes in bird communities better than to those of other taxa, such as plants or invertebrates.

Roughly 140 bird species breed within the Mid-Atlantic Piedmont Carter et al. 2000). Six species have a disproportionately large share of their global populations breeding within the Mid-Atlantic Piedmont. Land management activities in this region have a major role in sustaining their populations over the long-term (Kearney 2003). These species are: wood thrush, Acadian flycatcher, scarlet tanager, Louisiana waterthrush, eastern wood-pewee (deciduous forest species), and the prairie warbler (early successional species). All of these species are documented as breeding at Appomattox Court House NHP.

Birds were inventoried at Appomattox Court House NHP in 2002 and 2003 (Bradshaw 2007). The survey documented 99 species that utilize Appomattox Court House NHP habitats for some period of their annual or seasonal life requisites. Our assessment was completed using the bird species documented during this effort; see Figure 37 for a park showing bird survey locations.

Another means for assessing the biotic condition of the birds at Appomattox Court House NHP was to examine the population trends for each species. From a management perspective, Appomattox Court House NHP would like to see each species either at, or moving towards, population levels desired for management. These levels will differ depending on the status of the species. For example, we assume that rare species populations would be desirable if they are increasing. The opposite would be true of exotic or nuisance species.

Using the BBS data for the Southern Piedmont region, we were able to establish observation trends for 45 species known to breed at Appomattox Court House NHP. We used the statistical output to determine if the slope of the line was significantly different from zero. If so, it was classified as either "increasing" or "decreasing" for the period. We calculated this slope value for two periods. The first period was for the entire survey period (1966–2007). The second period was for the last 28 years only (1980–2007). Comparisons between these periods will allow us to determine if any non-significant, long-term trends are changing more recently. We categorized trends as "acceptable" or "unacceptable" by using a simple management matrix for each class of species in the set (Table 17). These three classes were species of "concern," "nuisance," or "breeder." These values were used to determine the overall management acceptability of population trends for the bird community.

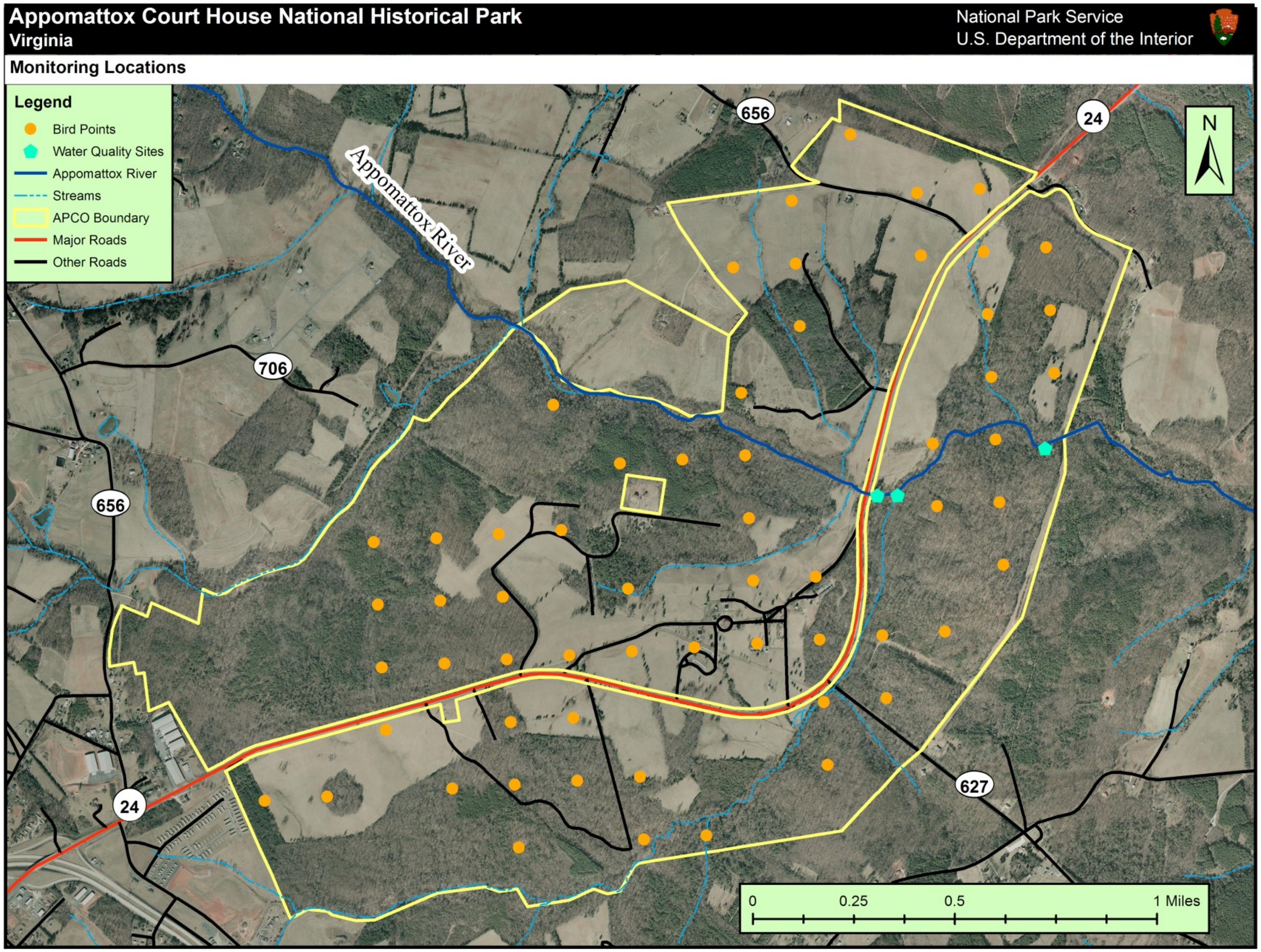

Figure 37. Bird monitoring locations at Appomattox Court House National Historical Park (APCO).

Table 17. Management matrix used to categorize avian population trend combinations for BBS data from the Southern Piedmont region.

Period 1 1966–2007	Period 2 1980–2007	Management Evaluation		
		SGCN	Nuisance/Nonnative	Other
increasing	increasing	acceptable	unacceptable	acceptable
decreasing	increasing	acceptable	unacceptable	acceptable
not significant	increasing	acceptable	unacceptable	acceptable
increasing	decreasing	unacceptable	acceptable	unacceptable
decreasing	decreasing	unacceptable	acceptable	unacceptable
not significant	decreasing	unacceptable	acceptable	unacceptable
increasing	not significant	unacceptable	unacceptable	acceptable
decreasing	not significant	unacceptable	acceptable	unacceptable
not significant	not significant	unacceptable	unacceptable	acceptable

A total of 25 of the 45 (56%) species were deemed "acceptable" based on their observed trends in the Southern Piedmont region. Five out of the 15 (33%) Species of Greatest Conservation Need (SGCN) from the VA Wildlife Action Plan (VDGIF 2005) were deemed "acceptable" based on their observed trends. The remaining SGCN observation trends were deemed "unacceptable" (n=10).

This result suggests that the majority of the breeding birds in the landscape surrounding, and perhaps including, Appomattox Court House NHP are not experiencing significant long- or short-term declines. It is important to note that this does not provide any proof that these species are stable at Appomattox Court House NHP, as there are no long-term data on breeding bird observations at Appomattox Court House NHP.

The bird community at Appomattox Court House NHP is reported to contain 64 species listed as "breeder." These species are associated with all the vegetation communities at Appomattox Court House NHP. We elected to first compare this suite of species to that of known breeders from the surrounding landscape. The reference list of breeding birds was synthesized from data compiled as part of the ongoing USGS Breeding Bird Survey (BBS) effort n(USGS 2008). We selected BBS routes from the surrounding landscape that had several years of survey data in them from 1966–2008 (Figure 38). We selected 10 routes for building the reference species list. We compiled the total number of species seen on each route over the 43-year period. We then counted the number of routes on which a species was observed during that period. Those species seen on at least eight routes were used to compile the reference breeding bird list (n=78) for Appomattox Court House NHP. A total of 59 species were found on both the BBS reference list and species list for Appomattox Court House NHP. The Jaccard Index of Similarity between the reference breeding bird list and the breeding bird list from Appomattox Court House NHP was 0.71.

The Bradshaw (2007) study suggests that nine additional bird species have ranges coincident with Appomattox Court House NHP but were not observed during the survey period. The Jaccard Similarity Index between the observed species and the potential assemblage is 0.92.

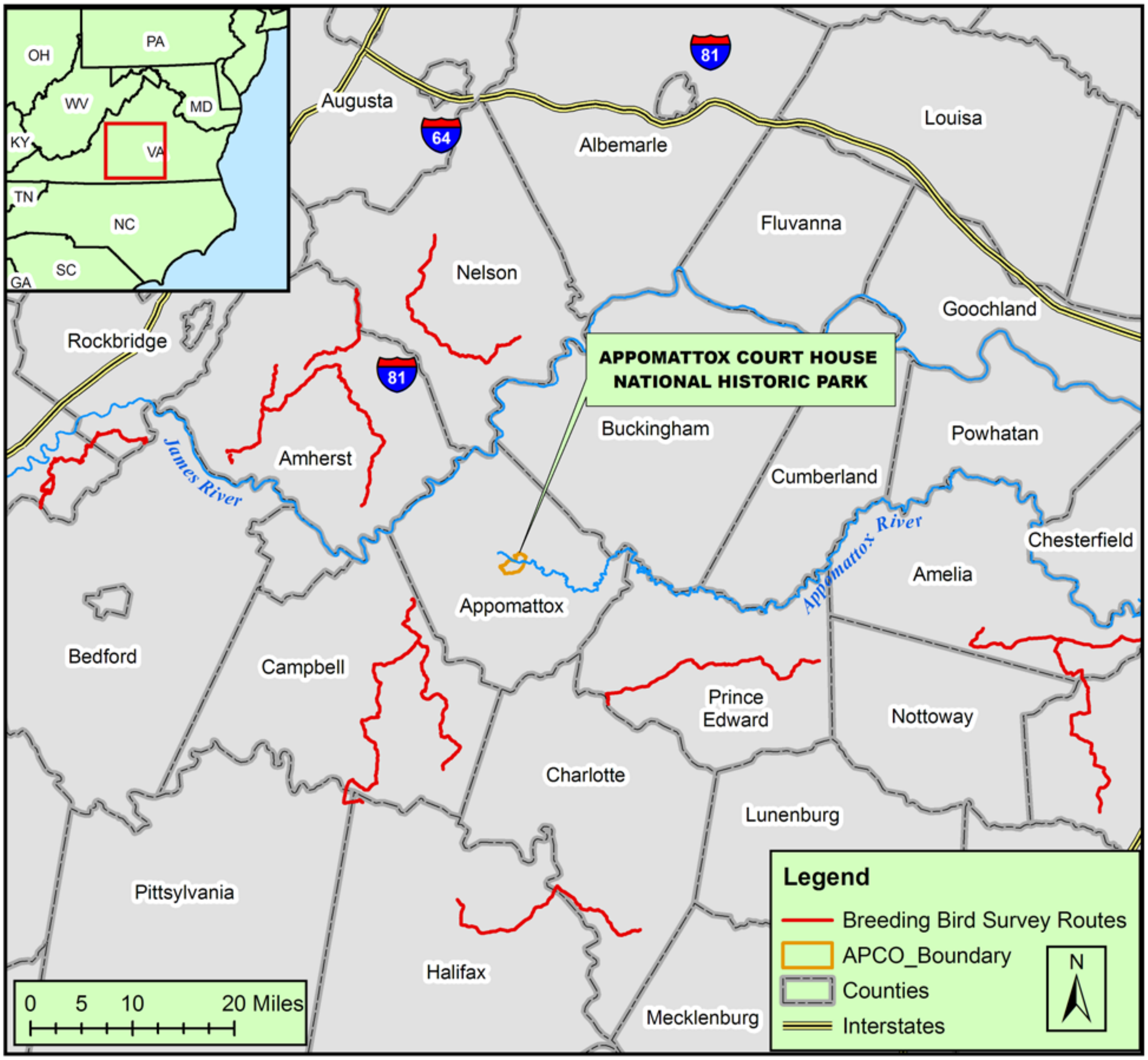

Figure 38. USGS Breeding Bird Survey (BBS) Routes in the area surrounding Appomattox Court House National Historical Park (APCO) that were chosen for the assessment.

Mammals

Mammals were inventoried at Appomattox Court House NHP (Pagels et al. 2005). Pagels et al. (2005) employed a variety of survey methods aimed at compiling the most comprehensive list of mammals present at the park. Our assessment was completed using the mammal species documented during this effort.

There were 21 species documented at Appomattox Court House NHP during the Pagels et al. (2005) survey. This study suggests that 17 additional mammal species have ranges coincident with Appomattox Court House NHP but were not observed. Several of the species not observed are rarely captured by methods used in this mammal survey, these include the American mink (*Mustela vison*), long-tailed weasel (*Mustela frenata)*, least weasel (*Mustela nivalis*), bobcat (*Felus rufus*), coyote (*Canis latrans*), northern river otter (*Lontra canadensis*), eastern mole (*Scalopus aquaticus*), and the star-nosed mole (*Condylura cristata*).

The feral dog (*Canis familiaris*), feral cat (*Felis catus*), house mouse (*Mus musculus*), and Norway rat (*Rattus norvegicus*) are four nonnative species that are likely to be present at the park, but are not confirmed. The Jaccard Similarity Index between the observed species and the potential assemblage is 0.55.

Invasive Species

Invasive species, particularly those that are exotic, have the potential to degrade native species and their habitat. They occupy habitat niches that would otherwise support native species, thereby, degrading native species communities. We used information from the Appomattox Court House NHP strategic plan (NPS 2006) to assess the status and percentage of invasive species within the park boundaries.

Invasive species are present at Appomattox Court House NHP (Table 18). Invasive fish species comprise 13% of all fish species and are the greatest proportion among taxa with data.

Table 18. Proportion of invasive species by taxa at Appomattox Court House.

Taxonomic Group	# Native species	# Nonnative species	% Nonnative
Fish	26	4	13
Amphibians	19	0	0
Reptiles	14	0	0
Birds	97	2	2
Mammals	21	0	0

Species of Greatest Conservation Need

There are 27 species of greatest conservation need documented at Appomattox Court House NHP (Table 19). This is 10% of the total number of high priority species identified for the state of Virginia (VDGIF 2005). There are 23 high priority birds found at the park, 24% of the 96 species identified for the state of Virginia.

Table 19. Total number of species documented at Appomattox Court House National Historical Park, number of Species of Greatest Conservation Need (SGCN) from the VA Wildlife Action Plan (VDGIF 2005), and % of SGCN in Virginia that are found at the park.

Taxonomic Group	# Species documented at APCO[1]	# unconfirmed APCO spp.	# SGCN	# SGCN at APCO	% SGCN at APCO
Birds	99	0	96	23	24
Amphibians	19	1	32	1	3
Reptiles	14	0	28	2	7
Mammals	21	0	24	0	0
Fish	30	1	96	1	1

[1]Including nonnative species.

Condition Status Summary for Biological Integrity

Overall condition status for amphibians, reptiles, birds, and mammals received a good score. Fish received a fair score. Bird trend acceptability received a good value, and the overall condition status for biological integrity is in the good range (Table 20).

In the future, surveys should not only focus on species inventory, but should also address abundance and population trends which, over time, will provide better information to complete biotic community assessments. The following are specific knowledge gaps identified:

1. Unknown population trends of majority of all faunal and floral species.
2. Impacts of illegal hunting and hunting with dogs.
3. Impact of Route 24 traffic on faunal species.
4. Visitor impact on park flora and fauna.

Some of the threats to the natural biotic communities and at-risk species of Appomattox Court House NHP can be observed within its administrative boundary. Appomattox Court House NHP, as well as many parks in the MIDN, was established for cultural and historical reasons. Management activities for cultural resources within our national parks can potentially pose a threat to natural resources. Although cultural resources represent a small portion of the park's total acreage, they are very important to the park's mission. Maintenance of roads, trails, and open spaces that maintain the cultural landscape may challenge the best management practices for natural resources; however, in some cases the protection of the cultural resources has led to protection of the natural landscape as well (Comiskey and Callahan 2008).

Some of the most immediate and potentially severe threats to biotic diversity are related to habitat change. Habitat degradation and loss are caused by internal and external agents. The most immediate threats and stressors to habitat degradation and loss within Appomattox Court House NHP are:

1. Increased potential spread of invasive species.
2. Unknown impacts of visitor use on park natural resources.
3. Large population of cattle grazing on park property.
4. Change in land use in surrounding areas can reduce connectivity to similar habitats adjacent to the park, thus changing the suite of species utilizing the park.

Table 20. Biological integrity condition status summary.

Vital Sign / Indicator	Measure	Threshold Criteria	Current Condition	Comment(s)
Fish communities	Species richness	Wildlife communities (fish, amphibian, birds, mammals) will be dominated by native species and existing populations will remain stable or increase over time.	30 fish species currently occur in park.	Future faunal surveys will be beneficial to monitor relative abundances and diversity over time. Insufficient data to evaluate trends.
	Reference species list Jaccard's Index of Similarity	≥ 0.50 = Good ≥ 0.25 = Fair < 0.25 = Poor	0.40 (Fair)	Score is based on species expected to occur in the Appomattox watershed. Suitable habitat at APCO is not available for many of these species.
Bird communities	Species richness and abundance of breeding birds	The existing richness and abundance of obligate grassland and forest breeding bird communities in the park will remain stable or increase over time.	99 bird species currently occur in park.	
	Reference species list Jaccard's Index of Similarity	≥ 0.50 = Good ≥ 0.25 = Fair < 0.25 = Poor	0.92 (Good)	
	Population trends (regional)	Each species either at, or moving towards, population levels desired for management.	56 % of species rated 'acceptable'.	Insufficient data to evaluate trends on APCO.
Amphibian communities	Species richness	The existing richness of amphibian communities in the park will remain stable or increase over time.	19 amphibian species currently occur in the park.	Insufficient data to evaluate trends.
	Reference species list Jaccard's Index of Similarity	≥ 0.50 = Good ≥ 0.25 = Fair < 0.25 = Poor	0.72 (Good)	
Reptile communities	Species richness	The existing richness and abundance of reptile communities in the park will remain stable or increase over time.	14 species of reptile currently occur in the park.	Insufficient data to evaluate trends.
	Reference species list Jaccard's Index of Similarity	≥ 0.50 = Good ≥ 0.25 = Fair < 0.25 = Poor	0.52 (Good)	
Mammal communities	Species richness	The existing richness and abundance mammal communities in the park will remain stable or increase over time. Species richness = 21 or greater.	21 species of mammal currently occur in the park.	Insufficient data to evaluate trends.
	Reference species list Jaccard's Index of Similarity	≥ 0.50 = Good ≥ 0.25 = Fair < 0.25 = Poor	0.55 (Good)	
State SGCN	Species presence/absence; number of populations parkwide per species	The existing number and population of state-listed SGCN will remain stable or increase over time. 27 or more state-listed SGCN species present.	27 SGCN occur in the park.	Insufficient data to evaluate trends.

Water Resources

Hydrology

Hydrology involves the study of water and how it moves across the earth's surface, through the soil and underlying rock, the atmosphere, and vegetation. One way to monitor water as it moves through the hydrologic system is to monitor the flow and discharge rates of streams in an area. The flow of a stream is a measure of the rate at which water moves through the stream channel. The term discharge can refer to the total outflow of a water course or drainage basin. These terms are sometimes used interchangeably as indicators of the amount of water (by rate or volume, respectively) moving through a system. Flow rates are inherently variable and unique to each surface water system, so there is not one standard measure of a "good" flow, but changes in flow outside of normal ranges can be an indicator of changes in the system.

The USGS rates current discharge by comparing the values to the actual flow. Using this comparison, the USGS gives streamflow conditions a rating of excellent, good, fair, or poor. If the flow rate is within 2% of the actual flow it is rated excellent, within 5% it is considered good, within 8% fair, and outside of 8% it is rated poor. The good, fair, and poor rankings are an assessment of the ability to make a flow estimation for a given location, though it is not a rating of the health of the flow. Because there is no other standard available to rate the streamflow, this was used to evaluate hydrology in Appomattox Court House NHP.

Permeability refers to the rate at which water is able to flow through a soil, which affects the amount of infiltration. Infiltration capacity is the amount of precipitation that can be absorbed into the soil. Infiltration of precipitation is a critical source of water for plant growth and biotic development of the land. This process also moves many materials in and out of the soil and drives important physical and chemical processes, as well as providing the primary source for streamwater and groundwater recharge by through-flow. Any precipitation that cannot be brought into the soil through infiltration will result in direct runoff. This balance between infiltration and runoff plays a very important role in the hydrologic cycle.

Groundwater recharge is highly variable because it is determined by local and regional precipitation and runoff, which are highly variable and are influenced by topographic relief, and the capacity of the land surface to accept infiltrating water on a watershed level. Almost all recharge in the Piedmont is from precipitation that enters the aquifers through the porous regolith. Most of the recharge takes place in inter-stream areas where water moves laterally through the regolith and discharges to a nearby stream or depression during or shortly after a precipitation event. Some of the water, however, moves downward through the regolith until it reaches the bedrock where it enters through fractures or solution openings (USGS 2009a). The Piedmont regional aquifer system has been shown to be comprised, in some part, by "young" waters (present for less than 50 years) and therefore is considered susceptible to contamination from near-surface sources (Nelms et al. 2003).

There are no specific state standards available for hydrology because of the high variability based on the stream. The only way to evaluate hydrology is by comparing current flow to previous levels. Data points collected inside Appomattox Court House NHP were few, and all exceeded the temporal cutoff of five years, making it difficult to rate current stream hydrology. However, based on the information available, we rated streamflow as poor. Of the 16 observations available, 12 were rated poor by the USGS, two were rated fair, and the remaining two were rated good. These observations were rated by the USGS based on comparisons between the recorded flow and actual flow. These ratings are only based on observations taken at four different time periods in one year. These conditions may also have more to do with the climate conditions at the time of sampling, rather than any obstructions or disturbance that might be adversely affecting the flow regimes of the park waterways (Eick 2010) and may not reflect current conditions at Appomattox Court House NHP.

Streamflow (Discharge)

We found a limited amount of data available from stream gauging stations (USGS 2009b) from streams that flow through the park (Table 21). The number of data points reported is low (n=4) at each station and no data are reported after December 1999. More recent data was available along Holiday Creek, near Andersonville, VA. Although Holiday Creek does not flow through the park, it may be used as a comparison for trends occurring in Appomattox Court House NHP when in-park data becomes available. Availability of hydrologic data was limited to streamflow (discharge); the metric stage could not be located.

The four stations listed in Table 21 provided the only hydrologic data available inside the park boundary. Additional information on how streamflow varies throughout the year can be seen in Figure 39 for Holiday Creek. Although the information in Figure 39 is taken from Holiday Creek, a water body outside of Appomattox Court House NHP, it may provide useful information on monthly variation of streamflow in the region. In contrast to precipitation, the lowest streamflows are in the summer, particularly in July and August. July and August on average accumulate the highest and third highest amount of rain respectively, compared to other months (September having the second most) (Southeast Regional Climate Center 2009). Interestingly, it seems evaporation plays a significant role in the streamflow dynamics throughout the year.

Table 21. Flow rate of USGS sites in Appomattox Court House National Historical Park from 03/1999–12/1999.

Station[1]	Latitude	Longitude	Datum	Max Flow[2] Rate (ft^3/s)	Min Flow[3] Rate(ft^3/s)
0203879450	37.379167	78.824167	NAD27	2.97	0.43
0203880090	37.3675	78.816111	NAD27	2.72	0.08
0203880175	37.3825	78.788611	NAD27	14.8	0.36
0203880250	37.383611	78.781111	NAD27	16.1	1.92

[1]Station 0203879450: Appomattox River at SR 656 near Appomattox, VA, (03/99–12/99) n=4;
Station 0203880090: Plain Run Branch at Appomattox, VA (03/99–12/99) n=4;
Station 0203880175: Plain Run Branch at Mouth near Appomattox, VA (03/99–12/99) n=4;
Station 0203880250: Appomattox at East Park BNDRY near Appomattox, VA (03/99–12/99) n=4.
[2]Occured on 09/29/99 or 9/30/99.
[3]Occured on 06/29/99.

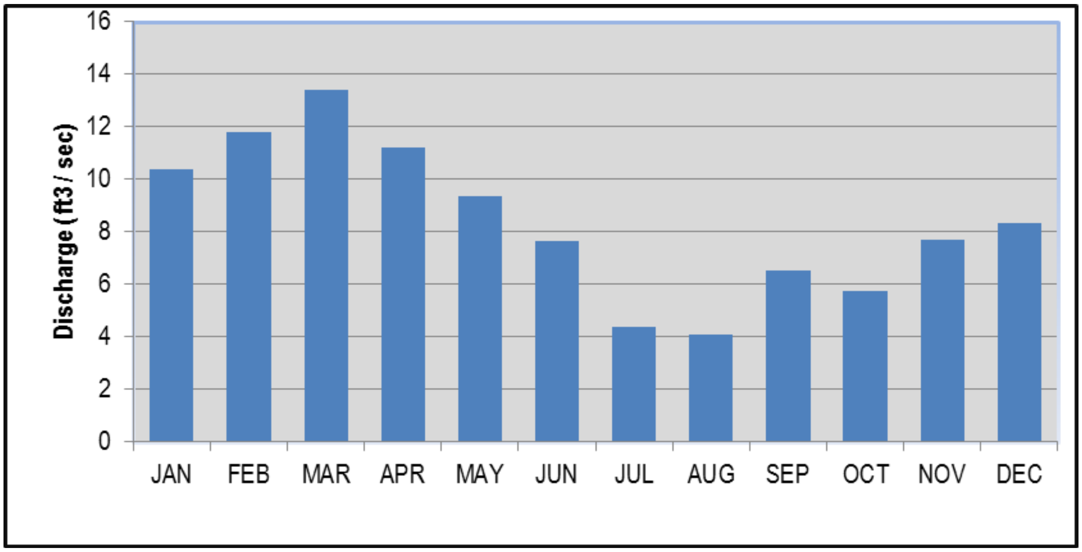

Figure 22. Average discharge (ft^3/sec) by month of Holiday Creek, near Andersonville, Virginia from 1967–2008.

Water Quality

Virginia Water Control Law mandates the protection of existing high-quality state waters and provides for the restoration of all other state waters so they will permit reasonable public uses and will support the growth of aquatic life. The adoption of water quality standards under Section 62.1-44.15(3a) of the law is one of the State Water Control Board's methods of accomplishing the law's purpose.

Water quality standards consist of statements that describe water quality requirements. They also contain numeric limits for some specific physical, chemical, biological, or radiological characteristics of water. These statements and numeric limits describe water quality necessary to meet and maintain uses such as swimming, other water-based recreation, public water supply, and the propagation and growth of aquatic life.

Standards include general and specific descriptions, because not all requirements for water quality protection can be numerically defined. The standards are intended to be adjusted constantly to reflect changes in law, technology, and information available to the Water Board and DEQ. The water quality at Appomattox Court House NHP was evaluated using the parameters dissolved oxygen, pH, temperature, bacterial contamination (*E. coli*), and conductivity. Macroinvertebrate data was also evaluated to assess overall stream health. Data sources used for assessing water quality at Appomattox Court House NHP are listed in Table 22.

Table 22. Data sources used for measures of water quality for Appomattox Court House National Historical Park.

Indicator	Measure	Data Source
Hydrology	Streamflow (Discharge)	USGS (2009b)
Stream Condition	Dissolved Oxygen	DEQ (2009)
	pH	DEQ (2009)
	Temperature	DEQ (2009)
	E.coli	DEQ (2009)
	Conductivity	DEQ (2009)
Macroinvertebrates	Family Biotic Index (FBI)	Gannicott and Shahady (2004)

From 2002–2004, Lynchburg College conducted water sampling on seven sites within the Appomattox Court House National Historical Park boundary (Gannicott and Shahady 2004). The sampling sites were along the Appomattox River, Plain Run Branch, and other tributaries within the park. Water chemistry was monitored over one year, using point samples at each site once each season. Some of the data from this report are referenced here as an indication of the conditions within the park over five years ago. Data reported are based on the summary tables presented in the original report. Additional analysis was not possible without access to the original underlying data sets.

To represent more recent water quality conditions we selected five stations within the Vaughans Creek watershed (HUC 0208020702) closest to Appomattox Court House NHP. We requested data from VA DEQ Monitoring Station Retrieval System (VA DEQ 2009) from the five closest sites with available data from 2004–present. None of these stations reported data for all key water quality parameters examined relevant to State standards, and data reporting and/or sampling efforts are inconsistent between and within sites. Locations of the monitoring stations are provided in Table 23 and Figures 40 and 41.

Table 23. Water quality monitoring stations with data reported between 2004 and present used to characterize water quality around Appomattox Court House National Historical Park.

Site	Latitude	Longitude	Distance from APCO	Description	Water body
2-APP152.57	37.36722	-78.7486	2.00 miles	Appomattox River at Rt. 616	Appomattox River
2-ARS000.11	37.36389	-78.7475	2.15 miles	Rt. 627	South Fork
2-RGH000.35	37.33583	-78.6961	5.56 miles	Rt. 627 bridge	Rough Creek
2-SUA001.54	37.33444	-78.6672	7.02 miles	Suanee Creek at Rt. 627	Suanee Creek
2-SUA003.80	37.31306	-78.7089	5.97 miles	Suanee Creek at Rt. 619	Suanee Creek

Figure 40. Water quality monitoring stations at Appomattox Court House National Historical Park (APCO) used by Gannicott and Shahady (2004); approximate locations; latitude, and longitude not reported.

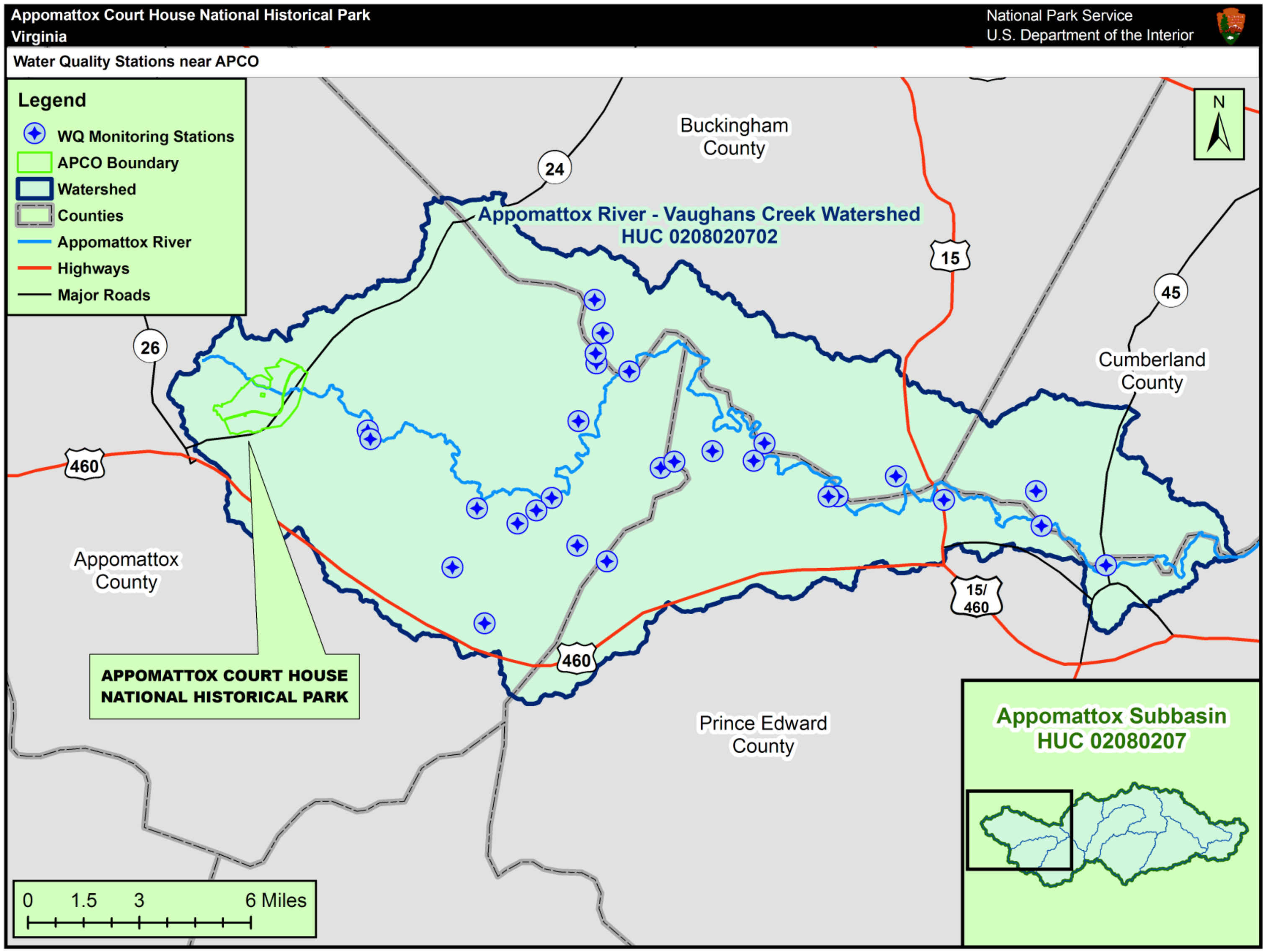

Figure 23. Location of water quality monitoring stations in proximity to Appomattox Court House National Historical Park (APCO).

Dissolved Oxygen

Dissolved oxygen (DO) is a relative measure of volume of oxygen, O_2, dissolved in water, and is often measured in mg/L. It is considered relative because temperature, pressure, and salinity affect the capacity of water to hold oxygen. Both high (i.e. supersaturation) and low DO concentrations can be harmful in aquatic systems, though low DO concentrations are more common. Low DO concentrations may result from excess organic matter in aquatic systems, as aerobic (oxygen-consuming) decomposition breaks down organic material. Low DO levels are most prevalent during the warm summer months when water temperatures rise and mixing of the water column is reduced.

The addition of excess nutrients from allochthonous inputs (coming from outside the aquatic system) can greatly affect DO levels. Nutrients can increase the biological oxygen demand (BOD) and therefore lower DO concentrations in water. This process occurs because nutrients can stimulate the growth of algae and other aquatic plants, which eventually die. Once dead, this organic material is decomposed by oxygen-consuming processes, resulting in low DO. Nutrients often enter aquatic systems from agricultural runoff, stormwater runoff, waste-water treatment plants, and septic systems (USEPA 2008e). According to the U.S. EPA, nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of water degradation in the U.S. (USEPA 2008d).

Virginia water quality standards list criteria for DO in surface water systems in the state based on the classification category of the water body. Standards for Class VI waters (natural trout waters) are the most restrictive, allowing for a minimum level of 6.0 mg/L and daily average not below 7.0 mg/L. Appomattox Court House NHP lies in the Piedmont geographic region of the state where the standard is a minimum of 4.0 mg/L and a daily average not below 5.0 mg/L (

Daily averages for dissolved oxygen were not available to compare with the minimum daily average reported for the Virginia state standard (5.0 mg/L for Class III waters). All dissolved oxygen values were taken no more than once over a 24-hour period, so they could only be compared to the single sample minimum of 4.0 mg/L. Data reported by Gannicott and Shahady (2004) were collected at each of the seven sites, four times from July 2003 to May 2004. The data had a minimum value of 6.02 mg/L (Site 2), a maximum of 13.03 mg/L (Site 4), and a mean of 8.84 mg/L. Of the 28 samples reported, no DO levels fell below the single sample standard of 4.0 mg/L for Class III waters (Piedmont zones).

Dissolved oxygen data was also evaluated from the Virginia DEQ Water Quality Data Retrieval System. The five water quality monitoring stations closest to Appomattox Court House NHP with data available from the past five years were used as an indicator of current conditions at the park. We found DO data reported by the DEQ 78 times from 2004 to 2008 at stations in the Vaughan’s Creek subwatershed (HUC-0208020702) (Table 24). All values were well over the Class III single sample minimum of 4.0 mg/L (minimum reported value 7.3 mg/L) and the average at each site was at least 9.6 mg/L. These five stations indicate very healthy dissolved oxygen values, and the data available would pass even the most restrictive Virginia state standards. Since no values reported fell below the single sample Virginia standard of 4.0mg/L, Appomattox Court House NHP received a good rating for dissolved oxygen levels.

Table 24. Dissolved oxygen data collected from the Virginia DEQ Water Quality Data Retrieval System. Sites from the Vaughan's Creek Watershed (HUC 0208020702) closest to Appomattox Court House National Historical Park with available data from 2004–present were selected.

Station ID	Observations	Date Range (month/year)	Minimum (mg/L)	Mean (mg/L)	# Below Standard
2-APP152.57	9	07/2005–11/2006	7.8	10.4	0
2-ARS000.11	8	01/2007–03/2008	8.2	10.8	0
2-RGH000.35	8	01/2007–03/2008	8.3	10.6	0
2-SUA001.54	20	01/2004–12/2007	7.8	10.3	0
2-SUA003.80	21	07/2005–12/2007	7.3	9.6	0

pH

pH measures the relative amount of free hydrogen and hydroxyl ions in a solution, determining how acidic or basic (alkaline) a solution is. The pH values are expressed from 0–14, lower values being more acidic (more free hydrogen ions), higher values more alkaline (more free hydroxyl ions). A pH of 7.0 is considered neutral. pH is measured on a logarithmic scale, every unit represents a tenfold change. For example, a pH of 4.0 is ten times more acidic than a pH of 5.0, and one-hundred times more acidic than a pH of 6.0. Most aquatic organisms prefer a pH between 6.5–8.0; a pH outside this range can stress the physiological systems of organisms and reduce reproduction (USEPA 2006). The solubility of heavy metals and biological availability of nutrients is also affected by different pH levels. In the lower pH range, heavy metals tend to be more soluble, increasing their toxicity. pH can also change the form of phosphorus and its availability to aquatic organisms. Virginia water quality standards list acceptable pH levels as 6.0–9.0 for all classes except swamp waters, where natural levels may be much more acidic (

pH data was collected four times at each of the seven sites in the Gannicott and Shahady (2004) report. Of the 28 readings reported, values ranged from 6.1 (Site 4) to 7.4 (Sites 2, 3 & 8), with a median of 6.8. Section 9 VAC 25-260-50 of the 2008 Virginia Water Quality Standards lists the pH numeric criteria for all waters as 6.0–9.0 (with exception to swamp waters). All of the values collected by Gannicott and Shahady fell within the VA water quality standards.

We also evaluated pH data from the Virginia DEQ Water Quality Data Retrieval system (Table 25). The five water quality monitoring stations closest to Appomattox Court House NHP with data available from the past five years were used as an indicator of current conditions at the park. Of the 74 observations available in the Vaughan's Creek Watershed reported from January 2004 to March 2008, no values fell outside of the acceptable range of the Virginia Water Quality Standards for pH; therefore, pH received a good rating.

Table 25. pH data collected from the Virginia DEQ Water Quality Data Retrieval System. Sites from the Vaughan's Creek Watershed (HUC 0208020702) closest to Appomattox Court House National Historical Park with available data from 2004–present were selected.

Station ID	Observations	Date Range (month/year)	Minimum	Median	Maximum	# Exceeding Standard
2-APP152.57	9	07/2005–11/2006	6.2	7.1	7.5	0
2-ARS000.11	8	01/2007–03/2008	6.9	7.5	8.1	0
2-RGH000.35	8	01/2007–03/2008	6.9	7.6	7.7	0
2-SUA001.54	20	01/2004–12/2007	6.2	7.5	7.7	0
2-SUA003.80	21	07/2005–12/2007	6.0	7.2	7.7	0

Temperature

All aquatic organisms have optimal temperature ranges in which to live, and an organism outside its optimal temperature range can become stressed or even die. Biological and chemical processes are also temperature dependent. Dissolved oxygen and conductivity are directly affected by temperature change (colder water can hold more dissolved oxygen and is less conductive). Temperature change in aquatic systems is becoming more of a problem in developing areas because of effluents and the increase in impermeable surfaces. Concrete, buildings, and paved surfaces pose barriers to rainwater and stop it from entering the soil below. In addition to collecting wastes, the water draining off hot pavement (particularly in the summer) has a higher temperature than water entering a stream through groundwater.

Virginia water quality standards list criteria for temperature in surface water systems in the state based on the classification category of the water body. Standards for Class IV are the most restrictive, allowing for a maximum of 20ºC for natural trout waters, since trout are very sensitive to warm waters. Appomattox Court House NHP lies in the Piedmont geographic region of the state where the standard is a maximum of 32ºC. The standards also specify that any rise above natural temperatures shall not exceed 3ºC; standards for hourly temperature change for natural trout waters are more restrictive.

The water quality data reported by Gannicott and Shahady (2004) recorded temperatures quarterly for one year. The water temperatures at the seven sites ranged from 2.2ºC (Site 2; January, 2004) to 22.3ºC (Site 8; July, 2003). The average summer temperature of all seven sites was 21.3ºC (see Table 26 summary).

We also evaluated temperature data from the Virginia DEQ Water Quality Data Retrieval system (Table 27). The five water quality monitoring stations closest to Appomattox Court House NHP with data available from the past five years were used as an indicator of current conditions at the park. Section 9 VAC 25-260-50 of the 2008 Virginia Water Quality Standards lists the temperature standard for the Piedmont Zones not to exceed 32ºC. All of the temperature data reported by Gannicott and Shahady (2004) (n=28) fell well below 32ºC (maximum reported: 22.3ºC). Of the available Virginia DEQ data since 2004 (n=45), no temperatures exceeded the standard (maximum reported: 25.1ºC). It is important to note that these data do not necessarily show the highest temperatures of the year, just the highest from the available data. Since all reported data met the state standard, temperature received a good rating.

Table 26. Dissolved oxygen, pH, and temperature water quality standards from 9 VAC 25-260 Virginia Water Quality Standards.

Class	Description of Class	Dissolved Oxygen (mg/L)	pH	Maximum Temperature (ºC)
I	Open Ocean	Minimum of 5.0	6.0–9.0	-
II	Tidal Waters	Minimum of 4.0, Daily Avg. 5.0	6.0–9.0	-
III	Non-Tidal Coastal Waters and Piedmont Zones	Minimum of 4.0, Daily Avg. 5.0	6.0–9.0	32
VI	Mountainous Zones Waters	Minimum of 4.0, Daily Avg. 5.0	6.0–9.0	31
V	Stockable Trout Waters	Minimum of 5.0, Daily Avg. 6.0	6.0–9.0	21
VI	Natural Trout Waters	Minimum of 6.0, Daily Avg. 7.0	6.0–9.0	20
VII	Swamp Waters	*	4.3–9.0	*

*This classification recognizes that the natural quality of these waters may fall outside of the ranges for DO and pH set forth above as water quality criteria; therefore, on a case-by-case basis, criteria for specific Class VII waters can be developed which reflect the natural quality of the water body. Virginia Pollutant Discharge Elimination System limitations in Class VII waters shall meet pH of 6.0–9.0.

Table 27. Temperature data collected from the Virginia DEQ Water Quality Data Retrieval System. Sites from the Vaughan's Creek Watershed (HUC 0208020702) closest to Appomattox Court House National Historical Park with available data from 2004–present were selected.

Station ID	Observations	Date Range (month/year)	Maximum (ºC)	Date of Maximum	# Exceeding Standard
2-APP152.57	9	07/2005–11/2006	23.0	07/12/2005	0
2-ARS000.11	8	01/2007–03/2008	25.1	07/09/2007	0
2-RGH000.35	8	01/2007–03/2008	24.9	07/09/2007	0
2-SUA001.54	20	01/2004–12/2007	24.2	07/08/2004	0
2-SUA003.80	21	07/2005–12/2007	23.1	07/12/2005	0

Bacterial Contamination (Fecal Coliform: *E. Coli* and Enterococci)

Fecal coliform bacteria (which includes both *E. coli* and enterococci) contamination is the most common form of bacterial contamination in many water bodies. Its presence in aquatic environments is a human health hazard and may indicate the presence of other dangerous pathogens as well. Fecal coliform bacteria often enter waterways through the direct discharge of untreated (or insufficiently treated) human waste and agricultural and municipal runoff.

There are two basic methods for testing water for bacteria, the membrane filter method and the multiple-tube fermentation method. The membrane filter method involves filtering samples through various pore sizes, followed by the incubation of the filtered material on a nutrient medium. The number of bacterial colonies are counted and stored as CFUs (colony forming units). The multiple tube fermentation method uses a specified amount of the sample and a nutrient broth and is then incubated. The amount of gas or turbidity in the water is used to determine the most-probable-number (MPN) of the bacteria.

In 1986, the EPA published Ambient Water Quality Criteria for Bacteria-1986 (USEPA 1986). Before the publication of this document, EPA recommended the use of fecal coliform as an indicator organism to protect people from gastrointestinal illness in recreational waters and recommended numeric criteria for fecal coliform upon which many state standards (including

Virginia) were based. However, in EPA epidemiological studies, *E. coli* and enterococci were found to exhibit the strongest correlation to swimming-associated gastroenteritis. *E. coli* were related to swimming-associated gastroenteritis in freshwaters only and enterococci in both fresh and marine waters. EPA subsequently recommended the use of *E. coli* or enterococci for fresh recreational waters and enterococci for marine recreational waters because levels of enterococci more accurately predict acute gastrointestinal illness than levels of fecal coliforms. Fecal coliforms as a group were determined to be a poor indicator of the risk of digestive system illness. However, many states continue to use fecal coliforms as their primary health risk indicator. In states where water quality standards are still based on fecal coliforms as the indicator bacteria, monitoring fecal coliforms are the best way to insure compliance with state water quality standards. However, to better determine the health risk from recreational water contact, results of EPA studies suggest considering switching to the *E. coli* or enterococci method for testing fresh water.

Virginia has state restrictions for *E. coli* and enterococci, but continues to regulate total fecal coliforms. Table 28 provides standards for *E. coli* and enterococci concentrations based on 9 VAC 25-260-170 Virginia Water Quality Standards.

The Virginia Water Quality Standards state that "fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a calendar month, nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 ml of water." Since there is *E. coli* data available on the Virginia DEQ website, we will use this to determine the current condition of waters outside of the park.

Gannicott and Shahady (2004) monitored *E. coli* within the park, taking samples seven times over a two-year span (2002–2004) at all seven sites. Of the 48 samples taken, 19% (*n*=9) were over the single sample maximum of 235 cfu/100 ml of water for recreational waters (at least one at each site besides Site 2), with a maximum of 7,420 cfu. Data do not meet the criteria for comparison to the geometric mean standard (two or more samples taken within a calendar month value).

We also evaluated *E. coli* data from the Virginia DEQ Water Quality Data Retrieval system (Table 29). The five water quality monitoring stations closest to Appomattox Court House NHP with data available from the past five years were used as an indicator of current conditions at the park. Virginia Water Quality Standards (9 VAC 25-260) specify a maximum geometric mean of 126 cfu (colony forming units) and single sample maximum value of 235 cfu for *E. coli* bacteria per 100 ml of water. Of all available Virginia DEQ data since 2004 (*n*=64), 15 exceeded the single maximum sample standard (23%). These data do not meet the criteria for comparison to the geometric mean standard.

VA DEQ (2008) states that waters can have up to 10.5% exceedances of water quality standards for *E. coli* parameters and still can be classified as fully supporting their designated use. Data taken within the park, and more recent DEQ data taken nearby, report exceedances of >10.5%. This suggests that there are potential problems with *E. coli* levels outside the expected range of natural variability in and around Appomattox Court House NHP. As such, *E. coli* conditions are assessed as having a poor rating.

Table 28. Maximum *E. coli* and enterococci bacteria standards per 100 ml of water from 9 VAC 25-260 Virginia Water Quality Standards.

Bacteria Type	Geometric Mean[1]	Single Sample Maximum[2]	Other Criteria
Fecal coliform	200	--	Not more than 10% of the total samples taken during any calendar month to exceed 400 fecal coliform bacteria
Freshwater[3] *E. coli*	126	235	--
Saltwater and Transition Zone[3] enterococci	35	104	--

[1] For two or more samples taken during any calendar month.
[2] No single sample maximum for enterococci and *E. coli* shall exceed a 75% upper one-sided confidence limit based on a site-specific log standard deviation. If site data are insufficient to establish a site-specific log standard deviation, then 0.4 shall be used as the log standard deviation in freshwater and 0.7 shall be as the log standard deviation in saltwater and transition zone. Values shown are based on a log standard deviation of 0.4 in freshwater and 0.7 in saltwater.
[3] See 9 VAC 25-260-140 C for freshwater and transition zone delineation.

Table 29. *E. coli* data collected from the Virginia DEQ Water Quality Data Retrieval System. Sites from the Vaughan's Creek Watershed (HUC 0208020702) closest to Appomattox Court House National Historical Park with available data from 2004-present were selected.

Station ID	Observations	Date Range (month/year)	Mean (#/100mL)	Maximum (#/100mL)	# Exceeding Standard	% Exceeding Standard
2-APP152.57	8	07/2005–11/2006	97.5	200	0	0%
2-ARS000.11	8*	01/2007–03/2008	233	650	2	25%
2-RGH000.35	8	01/2007–03/2008	179	480	2	25%
2-SUA001.54	20*	01/2004–12/2007	282	2000	6	30%
2-SUA003.80	20*	07/2005–12/2007	216	1000	5	25%

* Some values were under the detectable limit or "off-scale high." When under the detectable limit, values were stored as the limit of detection (100/100mL). Off-scale high values were listed as the highest value known to be less than the amount of colonies.

Conductivity

Electrical conductivity is a measure of water's ability to carry an electric current. It is dependent on the amount of inorganic dissolved solids in the water. Distilled water has a very low specific conductance, while saltwater has a high specific conductance. The conductivity of water provides a good estimate of dissolved metals or other substances in water. Conductivity in streams and rivers are greatly influenced by the geology of the area. A few examples of materials that can increase conductivity when dissolved in water are chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations. Conductivity is measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µs/cm). It is affected by temperature change; with warmer water having a higher conductivity. For this reason, specific conductance is usually presented at 25ºC for consistency (USEPA 2006).

There are no state standards for conductivity—possibly due to its high variability depending on substrate; however, it is still important to monitor as an indicator of the measure of dissolved solids. Abrupt changes in conductivity may indicate that water or wastes are being diverted into the stream from a new source. Effluents and pollution can raise the conductivity of a water body; however, oil and other organic compounds do not conduct electrical current very well, and so may lower the conductivity of the water. Low conductivity values may also indicate that the water in a stream is subject to relatively high precipitation and run-off inputs in relation to the volume of flow from groundwater inputs, and so may also be subject to more dynamic flow and temperature fluctuations. Conductivity can also indicate the degree to which a watershed's bedrock and mineral soil resists erosion. The conductivity of rivers in the United States generally ranges from 50 to 1500 µmhos/cm. Studies of inland freshwaters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µmhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates. Industrial waters can range as high as 10,000 µmhos/cm (USEPA 2006).

The EPA (2006) states "the conductivity of rivers in the United States generally ranges from 50 to 1500 µmhos/cm." It adds "studies of inland freshwaters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µmhos/cm." The 28 values taken by Gannicott and Shahady (2004) had an average of 100 µmhos/cm and a maximum of 146 µmhos/cm (Site 7). Of the available DEQ data since 2004 (n=66), the maximum value reported is 109 µmhos/cm, and a mean of 72 µmhos/cm.

Since all reported values fall outside the suggested range of 150 -1500 µmhos/cm it "could indicate that the water is not suitable for certain species of fish or macroinvertebrates." However, low values of conductivity are not necessarily bad; it simply indicates low dissolved solids. It could reflect characteristics of the substrate or where the water comes from. It may indicate the stream is more "precipitation dominated," because low-conductivity streams typically have less groundwater input than high-conductivity streams (Dartmouth College 2009). The lower conductivity values reported here may be an artifact of natural background conditions rather than an indication of impairment. There are no VA water quality standards for conductivity, but since these values show dissolved solids levels at lower than optimal levels, conductivity is assessed as poor.

The most recent conductivity data available from the Virginia DEQ Water Quality Data Retrieval system for which all five stations near Appomattox Court House NHP had data available are summarized in Table 30.

Table 30. Specific conductance data collected from the Virginia DEQ Water Quality Data Retrieval System. Sites from the Vaughan's Creek Watershed (HUC 0208020702) closest to Appomattox Court House National Historical Park with available data from 2004-present were selected.

Station	Observations	Date Range	Mean (µmhos at 25ºC)	Maximum (µmhos at 25ºC)
2-APP152.57	9	07/2005–11/2006	89	99
2-ARS000.11	8	01/2007–03/2008	84	109
2-RGH000.35	8	01/2007–03/2008	48	54
2-SUA001.54	20	01/2004–12/2007	77	93
2-SUA003.80	21	07/2005–12/2007	63	76

Macroinvertebrates

Benthic (stream-bottom dwelling) macroinvertebrate assemblages reflect a broad range of trophic levels, life cycles, and conditional tolerances and so provide valuable information for interpreting cumulative land use effects and are also well-suited for assessing site-specific impacts. Macroinvertebrate sampling is an efficient and relatively inexpensive method that is widely accepted as a means to monitor ecosystem health. Data collected can be an important component of any habitat monitoring program, identify potentially vulnerable habitat, provide a mechanism for tracking land use impact changes over time, and facilitate compliance with legal mandates—including the Clean Water Act (CWA).

Gannicott and Shahady (2004) report that, based on several metrics of evaluation of macroinvertebrate communities, the surface waters at Appomattox Court House NHP during the course of their study "is suggestive of a Virginia Piedmont stream system with minimal impact from industrial and urbanization sources of pollution." Four sites were rated individually but no overall numeric scores are available.

We found no more recent data on macroinvertebrate populations in and around Appomattox Court House NHP. The lack of overall numeric scores from Gannicott and Shahady (2004) and the lack of current macroinvertebrate data prevent the use of macroinvertebrates in the final assessment tables. Surveys for macroinvertebrates took place in 2009 and 2010 (by R. Voshell); however, results were not final as of the date of this assessment.

Condition Status Summary for Water Resources

For water quality measures, either the standard is met, resulting in a rating of good, or fails to be met, resulting in a rating of poor. We were unable to point to a standard that would indicate a value range that would result in a rating of fair. It is impossible to rate water quality within Appomattox Court House NHP without complete and recent in-park data. Where indicated, we used surrogate data from streams near the park. We rated data quality poor overall due to the lack of recent in-park data. The Mid-Atlantic Network is now collecting water quality data at three sites inside the park on a quarterly basis and monitoring macroinvertebrates on an annual basis; however, this data was not available for this assessment.

The lack of data collected in the park prevented a higher rating for many of the measures (see Table 31). Irregular monitoring and reporting are the most significant impediments to a thorough assessment of water quality in and around Appomattox Court House NHP. The work conducted by Gannicott and Shahady (2004) provides a valuable consideration of many water quality issues from within park boundaries, but given the temporal variability of water conditions, any conclusions drawn based upon their data are diminished by the fact that they are over five years old. Available data provide some insight into water quality conditions at Appomattox Court House NHP and in the surrounding Vaughan's Creek Watershed (HUC 0208020702), but current water chemistry or biological data are not available from within park boundaries.

Water quality is rarely an issue that belongs wholly to a single management unit. Public outreach and engagement in local and regional water quality issues can be an important component of efforts to preserve the integrity of water systems in and around Appomattox Court House NHP. Condition assessments would be more robust if supported by current data generated from inside park boundaries. One potential way to gather on-site information is through volunteer programs

Table 31. Water resources condition status summary.

Vital Sign/Indicator	Threshold Criteria	Current Condition	Comment(s)
Annual mean water temperature	Mean annual water temperature will not exceed 32ºC	≤25.1ºC (Good)	Water quality stations closest to APCO were used for this assessment. Significant data constraint: no in-park water quality data was available for this assessment.
DO	DO≥7ppm	≥7.3 mg/L minimum (Good)	
pH	pH=6–9	6.0≤pH≤8.1 (Good)	
Bacterial contamination (*E. coli*)	<10.5% of values exceeding 235 cfu/100 ml of water	23.4% exceeded 235 cfu/100mL (Poor)	
Aquatic macroinvertebrates	TBD	Unknown	Results of macroinvertebrate survey conducted by R.Voshell (2009–2010) not yet available.

like the Virginia Save Our Streams Program (VA SOS) who gather water quality data using benthic macroinvertebrate sampling methods. Additional monitoring of the other water quality parameters discussed here generated from inside Appomattox Court House NHP would be invaluable to monitoring efforts. Establishing a regular water quality monitoring program within the park would allow managers to establish seasonal and site-specific baseline values that would in turn allow for detection of sudden changes from specific input events, the tracking of changes over time, and aid in the identification of the nature and origin of any perturbations.

Threats to water quality include agricultural runoff from crop fields and cattle; municipal and industrial wastewater discharges; mining and quarrying operations; and recreational uses. In-park threats to water resources include cattle that are grazed to capacity on many of the fields. Given the higher percentages of *E. coli* measures that exceeded recommended values, any potential sources of bacterial contamination should be identified and removed or mitigated. *E. coli* is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. The most likely component of any effort to reduce *E. coli* contamination in the waters of Appomattox Court House NHP is to deny cattle direct access to surface water systems with fencing, alternative water sources, etc., and support efforts to inform land owners on a local and regional level of the importance of preserving water quality.

Parkwide Resources

Soils

Appomattox Court House NHP, and most of the Piedmont Physiographic Province, is underlain by dense, almost impermeable bedrock that yields water primarily from secondary porosity and permeability provided by fractures. The bedrock is partly covered by glacial deposits of unconsolidated weathered rock material, alluvium, and soil called regolith. The region is primarily underlain by bedrock aquifers classified as crystalline-rock and undifferentiated sedimentary-rock aquifers. Water in crystalline-rock aquifers is present in fractures in the rock and in the weathered material that overlies the rock (USGS 2009a). Increased erosion surrounding the park directly impacts stream sedimentation within Appomattox Court House NHP. Potential environmental concerns from soil erosion, flooding, and extreme acidity, aluminum saturation, and nutrient status are also important.

Approximately 50% of the soils at Appomattox Court House NHP are comprised of Mecklenburg-Poindexter complex and Cullen clay loam soils (Table 32). Mecklenburg series soils are characterized by slow to medium runoff with slow internal drainage, while Poindexter and Cullen series soils are classified as having medium to rapid runoff. These soils are classified as well-drained with low or slow to moderate permeability (USDA NRCS 2009c).

Several soil-based assessments can be assembled from current soil data using the NPS soil database and an extension that runs on ArcGIS (ESRI 2006), the USDA Natural Resource Conservation Service Soil Data Viewer (2008). The assessments we found most useful for park assessment include potential erosion hazard for off-road and off-trail traffic and flooding frequency class. Explanations from USDA Natural Resource Conservation Service Soil Data

Table 32. Soil types within Appomattox Court House National Historical Park.

Soil Name	Acreage	Percent
Mecklenburg-Poindexter complex, 7–15 percent slopes	445.4	25.0
Cullen clay loam, 2– 7 percent slopes	438.9	24.7
Iredell loam, 2– 7 percent slopes	287.5	16.2
Wehadkee loam, 0–2 percent slopes, frequently flooded	175.4	9.9
Chewacla loam, 0– 2 percent slopes, frequently flooded	127.0	7.1
Mecklenburg-Poindexter complex, 15– 25 percent slopes	94.6	5.3
Pacolet-Louisburg complex, 7– 15 percent slopes	54.7	3.0
Mecklenburg loam, 2– 7 percent slopes	49.7	2.8
Appomattox-Cullen complex, 2–7 percent slopes	32.0	1.8
Cecil sandy loam, 2–7 percent slopes	28.8	1.6
Poindexter gravelly silt loam, 25–60 percent slopes	14.5	0.8
Altavista loam, 0–2 percent slopes, occasionally flooded	14.4	0.8
Iredell loam, 7–15 percent slopes	10.8	0.6
Mattaponi-Cecil complex, 2–7 percent slopes	3.6	0.2
Mecklenburg-Poindexter complex, 2–7 percent slopes	2.8	0.2
Water	0.4	0.0

Viewer (2008) follow with more detail in Appendices N and O. Other potentially important soils information was gathered from the USDA NRCS soil characterization lab database (USDA NRCS 2009b).

Soil Acidity and Chemistry
Soil acidity is determined largely by soil composition and chemical reactions. The development or accumulation of soil acidity usually parallels the weathering sequence in which aluminum (Al) is released and accumulates in the soil, mainly as exchangeable Al^{3+} when soil pH <5.5. pH is a measure of the reaction of the soil. Since the availability of most plant-essential elements depend on soil pH, it is also an indicator of the relative availability of plant nutrients (McLean 1982) and provides necessary data to help determine liming needs and fertilizer responses.

Extractable acidity at pH 8.2 is a good measure of the "potential" acidity. High values of potential acidity indicate a possible lowering of the soil pH as weathering and leaching continue. The KCl-extractable Al is more related to the immediate lime requirement and existing cation exchange capacity (CEC) of the soil. Aluminum saturation increases at pH values of 4.5 or less, and is an indication of the percent of the effective CEC that is due to the presence of aluminum. Aluminum is not considered an essential nutrient. The primary concern with Al is the possible toxic effects at high concentrations, especially in strongly acid subsoils (below pH 5.0).

Plant sensitivity to Al is usually accentuated in soils low in Ca. Al toxicity reduces rooting depth and degree of root branching into the subsoil which is usually more apparent during stress periods, e.g., drought.

The effective CEC in acid soils is the measure of the total quantity of negative charges per unit weight of the material, measured as the sum of extractable bases plus KCl-extractable Al. The lower the effective CEC, the less able the soil is to adsorb added lime and nutrients. Base saturation is the ratio of the quantity of extractable Ca^{2+}, Mg^{2+}, and K^{+} ions attached to soil particles compared to the cation exchange capacity of the soil. Base saturation is expressed as a percentage of available exchange sites occupied (USDA NRCS 1995).

Soil characterization lab data for seven soils sampled as “Cullen” in Virginia were downloaded from the Soil Characterization Lab web (USDA NRCS 2009b). The data from the soil Pedon No. 78P0027 sampled in Appomattox, VA, was the closest soil to Appomattox Court House NHP. Soil acidity, pH, aluminum saturation, cation exchange capacity, and base saturation values were determined for this soil.

The exchange acidity in the soil sampled southeast of the park (about four miles) was very high below one meter, 41–91 times higher than the sum of the Ca^{2+}, Mg^{2+}, and K^{+}. There were almost no Ca^{2+}, Mg^{2+}, and K^{+} below 140 cm, causing the acidity to increase, the pH to decrease, and the base saturation to decrease dramatically for deep-rooted plants. The extractable Al^{3+} was high also, 13–40 times the sum of the Ca^{2+}, Mg^{2+}, and K^{+} in the lower subsoil and saprolite. The base saturation is extremely low (<5) in the lower subsoil (below one meter) with most of the bases being Al^{3+}. The high extractable Al^{3+} caused the Al saturation to be very high (93–98%) in the lower subsoil. To ameliorate the high Al^{3+} saturation and raise the pH below one meter, the soil would need to be limed. The low pH values (<4.5) in the lower subsoil indicate the need to raise the pH, base saturation, and CEC of the soil to decrease the Al saturation and potential toxicity.

Without actual values from the park, we cannot determine the needs or the hazards of the potential/actual acidity and liming needs. However, the MIDN has initiated collection of soil chemistry samples from forest vegetation plots as part of new protocols in 2010.

A recommendation for liming and fertilization accompanies the soil nutrient sample results obtained from the Virginia Cooperative Extension Nutrient Analysis Lab at Virginia Tech in Blacksburg, VA. Sampling can be conducted sequentially to follow the progress in raising the soil pH in the major rooting zone to between 5.5 and 5.8. A higher pH in this range indicates essential soil nutrients are soluble and most available to plants.

Potential Erosion Hazard (Off-road, Off-trail)

Ratings that indicate the hazard or risk of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface are based on slope and soil erodibility factor K. The soil loss is caused by sheet, rill, or gully erosion in off-road or off-trail areas where 50 to 75% of the surface has been exposed by logging, grazing, mining, or other kinds of disturbance. The hazard is described as “slight,” “moderate,” “severe,” or “very severe.” Ratings of soils found in the park of “slight” indicates that erosion is unlikely under ordinary climatic conditions; while soil rating of “moderate” indicates that some erosion is likely and that erosion-control measures may be needed (USDA NRCS 2008). As shown in Table 33, the majority of the park is rated as “slight” erosion hazard. Areas classified as “moderate” or “severe” are likely not in need of erosion control measures, as they are not near heavily visited areas of the park.

Another measure of the erosion potential of a soil is the hydrologic soil group (USDA NRCS 2008). Hydrologic soil groups are based on estimates of runoff potential. The dominant soils in each map unit are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The soils in the United States are assigned to four groups (A, B, C, and D). The groups found in the park are defined as follows: Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well-drained or well-drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission. Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission. This is a measure of how rapidly the upper 50 cm of the soil become saturated during extremely heavy rainfall events, causing accelerated erosion.

Table 33. Potential erosion hazard for Appomattox Court House National Historical Park soils.

Potential Erosion	APCO Acres	% of APCO
Not rated	0.4	0.0
Slight	1670.9	93.9
Moderate	94.5	5.3
Severe	14.5	0.8
Very Severe	0	0
Total	1780.3	100.0

Natural drainage class refers to the frequency and duration of wet periods under conditions similar to those under which the soil developed. Alteration of the water regime by man, either through drainage or irrigation, is not a consideration unless the alterations have significantly changed the morphology of the soil. The classes for soils found in the park or discussed under hydrologic soil groups B and C include:

Well-drained
Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of or deep to soil features that are related to wetness.

Moderately Well-drained
Water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory through permanent. They commonly have a moderately low or lower saturated hydraulic conductivity in a layer within the upper 1 m, periodically receive high rainfall, or both.

Hydric soils are soils found mostly in wetlands and former wetlands that show morphology formed under frequent, long-duration flooding, or long-term saturation and reduction conditions in the near surface, favoring the growth of hydrophytic vegetation. Hydric soils are explained in detail by the USDA NRCS (2008).

Soil types occurring within Appomattox Court House NHP are listed in Table 32 and displayed in Figure 42. The potential erosion hazards (Figure 43 and Table 33) and flooding frequencies (Figure 44 and Table 34) show that the majority of Appomattox Court House NHP is listed as having 'slight' erosion potential. The majority of the soil map units in the park are rated in hydrologic soil group B (49.6%) and C (26.8%). All areas with slopes of 15% or higher have moderate erosion potential as well, even with hydrologic soil group B.

Table 34. Flooding frequency for Appomattox Court House National Historical Park soils.

Flooding Frequency	APCO Acres	% of APCO
Not rated	0	0.0
None	1463.7	82.2
Rare	0.0	0.0
Occasional	14.5	0.8
Frequent	302.0	17.0
Total	1780.3	100.0

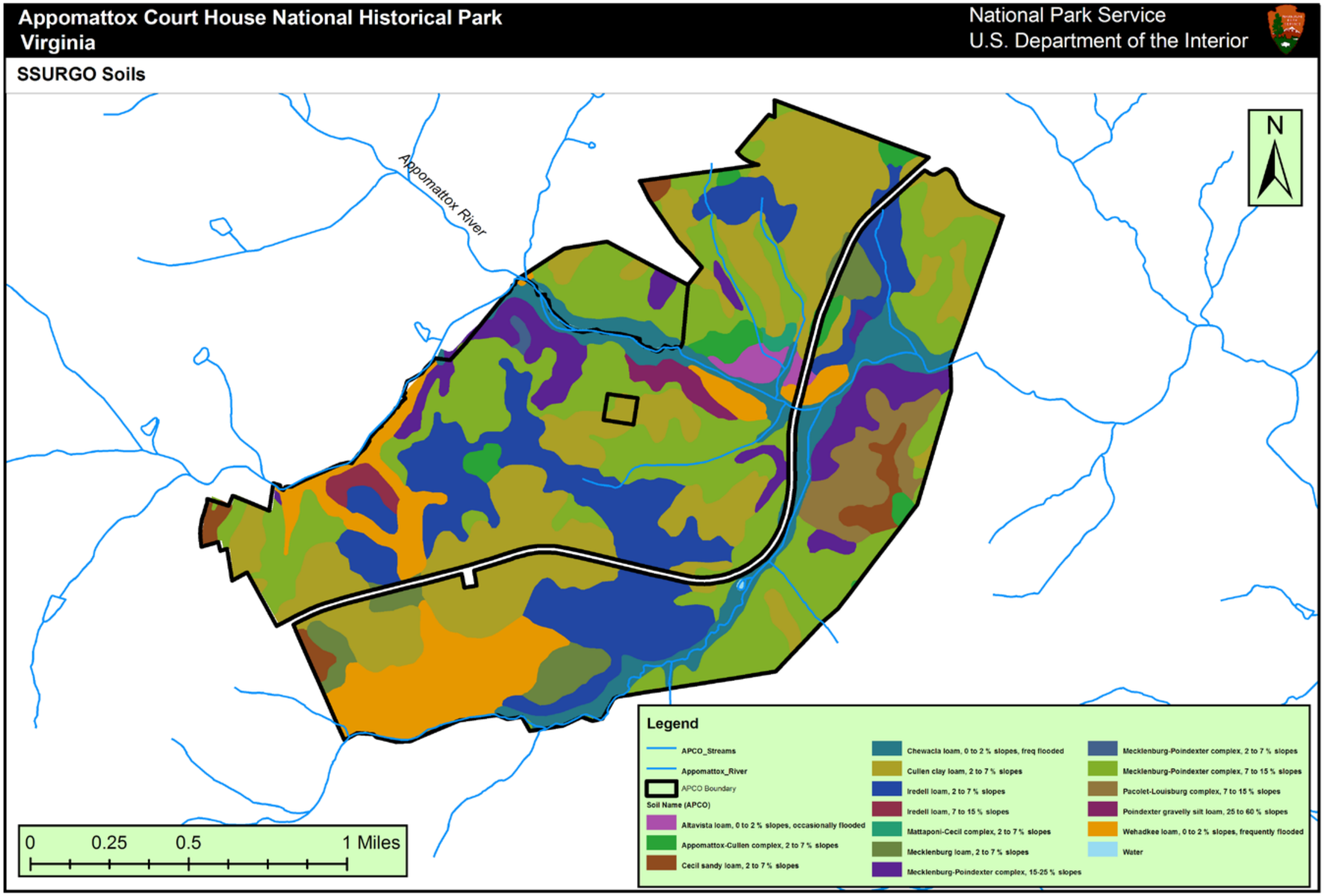

Figure 42. Soil types within Appomattox Court House National Historical Park (APCO).

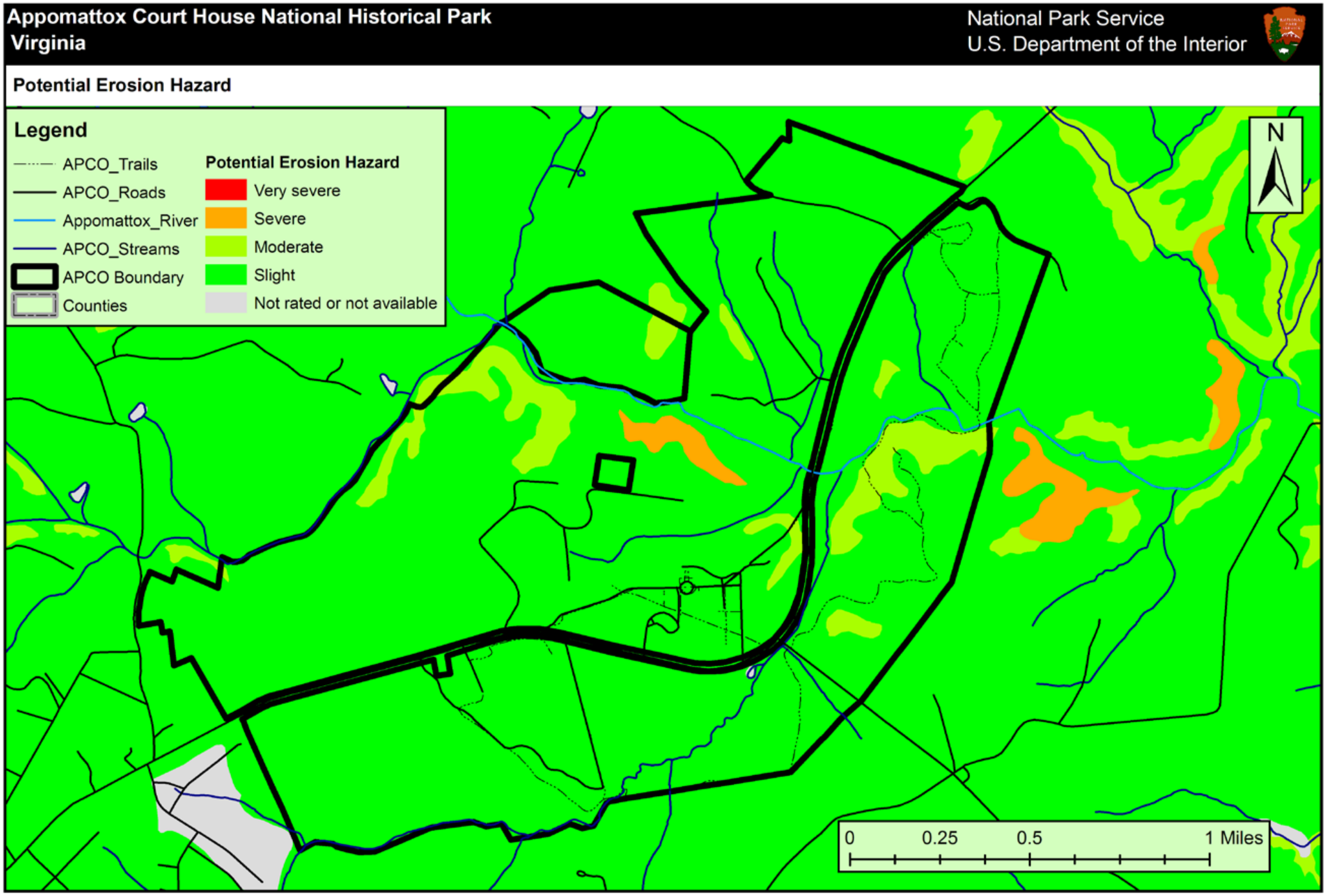

Figure 43. Potential erosion hazard (off-road, off-trial) according to soil characteristics at Appomattox Court House National Historic Park (APCO).

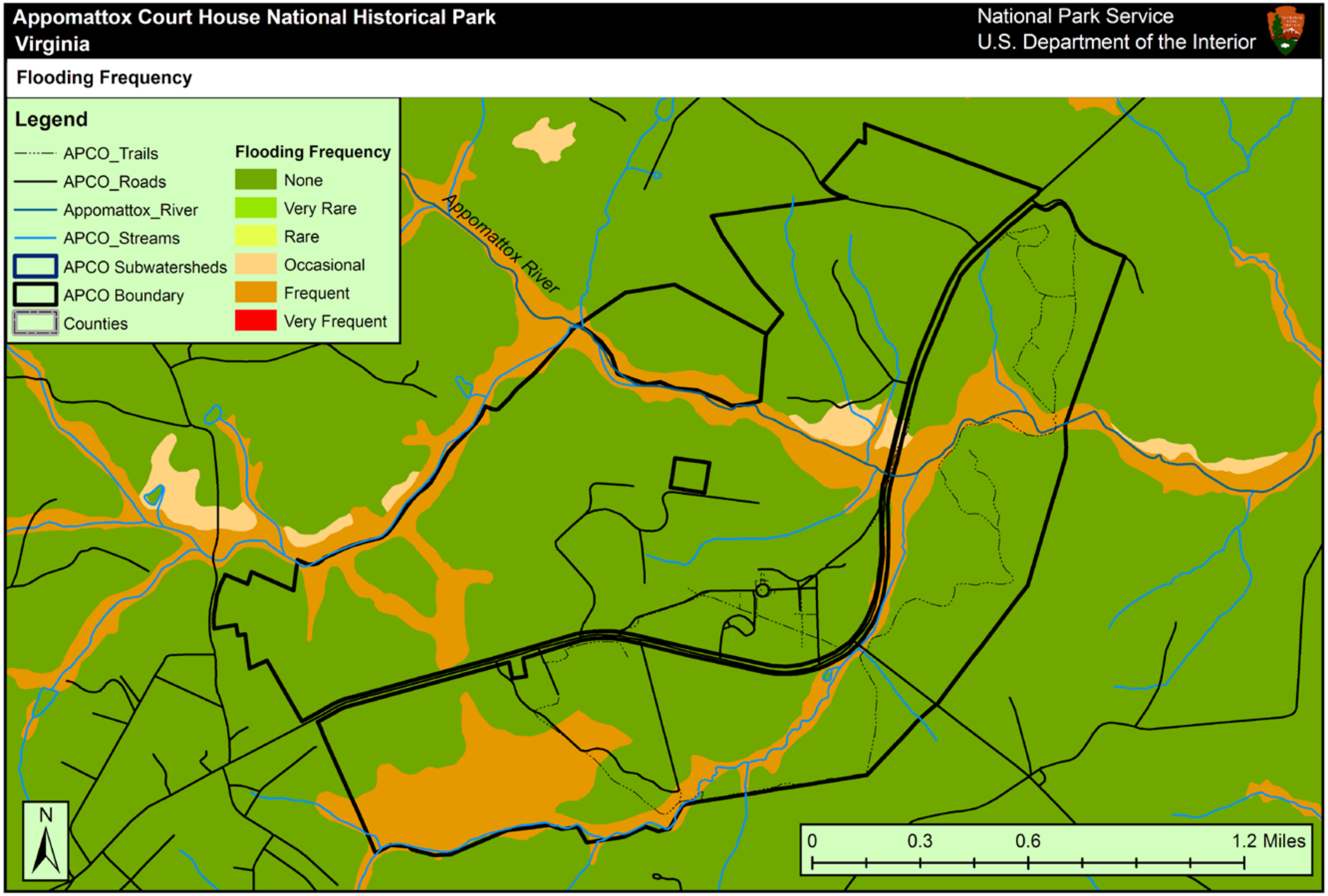

Figure 44. Flooding frequencies according to soil characteristics at Appomattox Court House National Historical Park (APCO).

Flooding Frequency Class

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding (Table 34).

Flooding frequency class is the number of times flooding occurs over a period of time and is expressed as a class. Flooding Frequency Classes are based on the interpretation of soil properties and other evidence gathered during soil survey fieldwork. The classes are "none," "very rare," "rare," "occasional," "frequent," and "very frequent" (USDA NRCS 2008). "Occasional" flooding is expected infrequently under usual weather conditions, with a 5–50% chance of flooding in any year, or 5–50 times in 100 years.

The majority of the park is rated as having a flooding frequency of 'none.' Only 17% of the park area is listed as having 'frequent' flooding frequency.

Air Quality

Air quality directly impacts health, visibility, vegetation, surface waters, soils, and wildlife. The risk of foliar injury on vegetation is increased with high levels of ozone (Kohut 2007). Threats to the park's air quality include point sources, such as power plants and large industrial facilities located upwind. Emissions from such sources can travel hundreds of kilometers and influence the park's air quality. Additionally, development near the park could lead to an increase in vehicle traffic and its associated emissions that could impact the park's air quality. Additional air quality data and information from the Air Resource Division (ARD) can be found in Appendix P of this report.

In addition to human health, air pollution has also been shown to impact ecological health at National Park Service sites (NPS 2004, 2007a). The NPS ARD has developed methods and reference values to evaluate air quality conditions important for natural resource planning and management (NPS 2007a). The ARD approach to air quality assessment includes standard reference values for ozone, atmospheric (wet) deposition in the form of nitrogen and sulfur, and visibility.

Based on certain criteria, these categories are given a score of "good," "moderate," or "significant concern." We added total mercury as a recommended measurement based on NPS Northeast Region findings (NPS 2004).

Although Appomattox Court House NHP does not have air quality monitoring stations on-site, the ARD interpolates data from all available monitors in the region into 5-year averages. This document utilizes the most recent data interpolations from the 2004–2008 period.

The NPS Inventory and Monitoring (I&M) Program is currently finalizing risk assessments to evaluate the threats from nitrogen deposition, acidic deposition, and mercury. These assessments will be available online in mid-2011 on the NPS ARD website (http://www.nature.nps.gov/air/) and will assist managers in determining what park resources are at risk from air pollution and what type of air quality monitoring might be needed.

Ozone (O_3)

The ARD criterion for ozone utilizes the newly revised 2008 national standard for ozone air quality as a baseline. The national standard requires that the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 75 parts per billion (ppb) (USEPA 2009). In assessing air quality within national parks, the ARD recommends that if the interpolated 5-year average of the fourth-highest daily maximum 8-hour average ozone concentrations is greater than or equal to 76 ppb, then ozone is classified as a "significant concern" in the park. If the interpolated 5-year average is between 61 ppb and 75 ppb, concentrations greater than 80% of the national standard, then the park is classified as "moderate." To receive a "good" ozone rating, a park must have a 5-year average ozone concentration less than 61 ppb (concentrations less than 80% of the national standard).

For Appomattox Court House NHP, the 5-year (2004–2008) average ozone concentrations were 73.2 ppb, earning the parks a "moderate" or "fair" ozone condition status rating (Table 35). The 2004 vegetation risk assessment indicated that the park is at moderate risk for plant injury, and the ARD consequently maintained the original ozone air quality condition status of "moderate."

Table 35. Air Resources Division ozone air quality condition classifications and corresponding condition status for this assessment.

Current Condition Ozone concentration (ppb)	Condition status
≥76	Poor
61–75	Fair
≤60	Good

[1]The Air Resources Division ozone air quality condition classifications are as follows: significant concern, moderate concern, and good condition.

Atmospheric Deposition

Atmospheric deposition is the process by which airborne pollutants are deposited to the earth. These pollutants include, but are not limited to, sulfur dioxide, nitrogen oxides, ammonia, and mercury. Total deposition consists of both wet and dry components. Wet deposition occurs when pollutants are deposited in combination with precipitation, predominantly by rain and snow, but also by clouds and fog.

Sulfur dioxide (SO_2) originates mostly from coal combustion and causes respiratory irritation. It also contributes to acid rain and particle formation. The national standard for acceptable SO_2 is set by the National Ambient Air Quality standards (NAAQS) at 0.033ppm for the annual arithmetic mean (USEPA 2008b).

Nitrogen dioxide (NO_2) is a brownish gas that is generated during high-temperature combustion. Major sources of NO_x include coal-fired power plants, industrial boilers, and motor vehicles. Like ozone, it causes respiratory irritation. It is also important because it can react to form ozone and particles, contribute to acid rain, deposit into water bodies and upset the nutrient balance, and degrade visibility. The national standard for acceptable NO_2 is set by the National Ambient

Air Quality standards (NAAQS) at 0.053ppm for an 8-hour average, not to be exceeded more than once per year (USEPA 2008b).

Using the guidance developed by the ARD for atmospheric nitrogen deposition, relative risk rankings for Appomattox Court House NHP were based on three factors: 1) nitrogen pollutant exposure; 2) inherent ecosystem sensitivity; and 3) level of park protection (Sullivan 2011). The ARD found that many of the smaller historical parks in the Mid-Atlantic Network are ranked very high in pollutant exposure; however, Appomattox Court House NHP is ranked high. Other ratings include ecosystem sensitivity (ranked low) and park protection (moderate). The summary risk score is low (Sullivan 2011).

Atmospheric deposition at Appomattox Court House NHP is classified as a "significant concern" or "poor" condition status rating (Table 36). The total wet nitrogen deposition at Appomattox Court House NHP is estimated at 4.2 kg/ha/yr and the total estimated wet sulfur deposition is 5.2 kg/ha/yr. There is no current information to indicate whether ecosystems at Appomattox Court House NHP are sensitive to nitrogen or sulfur deposition, but deposition is elevated. Nitrogen deposition, in particular, may affect the integrity of vegetation communities at Appomattox Court House NHP.

Table 36. Air Resources Division wet deposition condition classifications and corresponding condition status for this assessment. The wet deposition values refer to either nitrogen or sulfur individually, not the sum of the two.

Current Condition Wet Deposition (kg/ha/yr)	Condition status[1]
>3	Poor
1–3	Fair
<1	Good

[1]Air Resources Division wet deposition condition classifications are as follows: significant concern, moderate concern, and good condition.

Visibility

The enjoyment and appreciation of the unique features of our national parks are linked to one's ability to see clearly through the atmosphere. Small particles suspended in the atmosphere, mostly as a result of human-caused air pollution, often create haze that lessens the visitor's national park experience. The visibility condition status rating at Appomattox Court House NHP is classified as a "significant concern" or "poor" because the current Group 50 visibility at the park is 12.8 dv above estimated Group 50 natural conditions.

As illustrated in Table 37, parks with a visibility condition estimate of less than two dv above estimated natural conditions receive a "good" visibility condition classification. Those parks with visibility condition estimates between two and eight dv above natural conditions are classified as "moderate," and parks with visibility condition estimates greater than eight dv above natural conditions are classified as a "significant concern." While the dv ranges for each category are somewhat subjective, they reflect as nearly as possible the variation in visibility conditions across the visibility monitoring network.

Table 37. Air Resources Division visibility condition classifications and corresponding condition status for this assessment.

Visibility Condition - Current Status Relative to Natural Background (dv)[1]	Condition Status[2]
>8	Poor
2–8	Fair
<2	Good

[1]This is based on the deviation of the current Group 50 visibility conditions from the estimated Group 50 natural background conditions, where Group 50 is defined as the mean of the visibility observations falling within the range from the 40th through the 60th percentiles.
[2]Air Resources Division visibility condition classifications are as follows: significant concern, moderate concern, and good condition.

Mercury

Mercury persists in the environment, accumulates in the food chain, and is a neurotoxin. This indicator is an especially important measurement of fish and wetland-feeding species (i.e. loons, pelicans, eagles, and otters) health. Due to the difficulty in rating mercury levels at the park level, mercury was not included in the overall rating of air quality in this assessment. There are a variety of factors that make it difficult to rate mercury concentrations or deposition in parks. It is much more difficult to set target values for mercury deposition rates, as deposition rates are highly influenced by precipitation amounts.

Concentrations in rainwater for the state of Virginia range from 8.0–8.9 ng/L (NADP 2009). A 2004 report (NPS 2004) found that wet mercury deposition is higher in the eastern U.S. than in the western U.S. No specific mercury data was reported for the closest MIDN site in Shenandoah NP, although it was stated that this site has been operating since 2002, so trends could not be calculated. Additionally, monitoring may not be adequate for Appomattox Court House NHP because the Shenandoah NP MIDN monitoring location is approximately 160 km away (NPS 2004). The locations of air quality monitoring stations for ozone, wet deposition, visibility, and mercury for Appomattox Court House NHP are displayed in Figure 45.

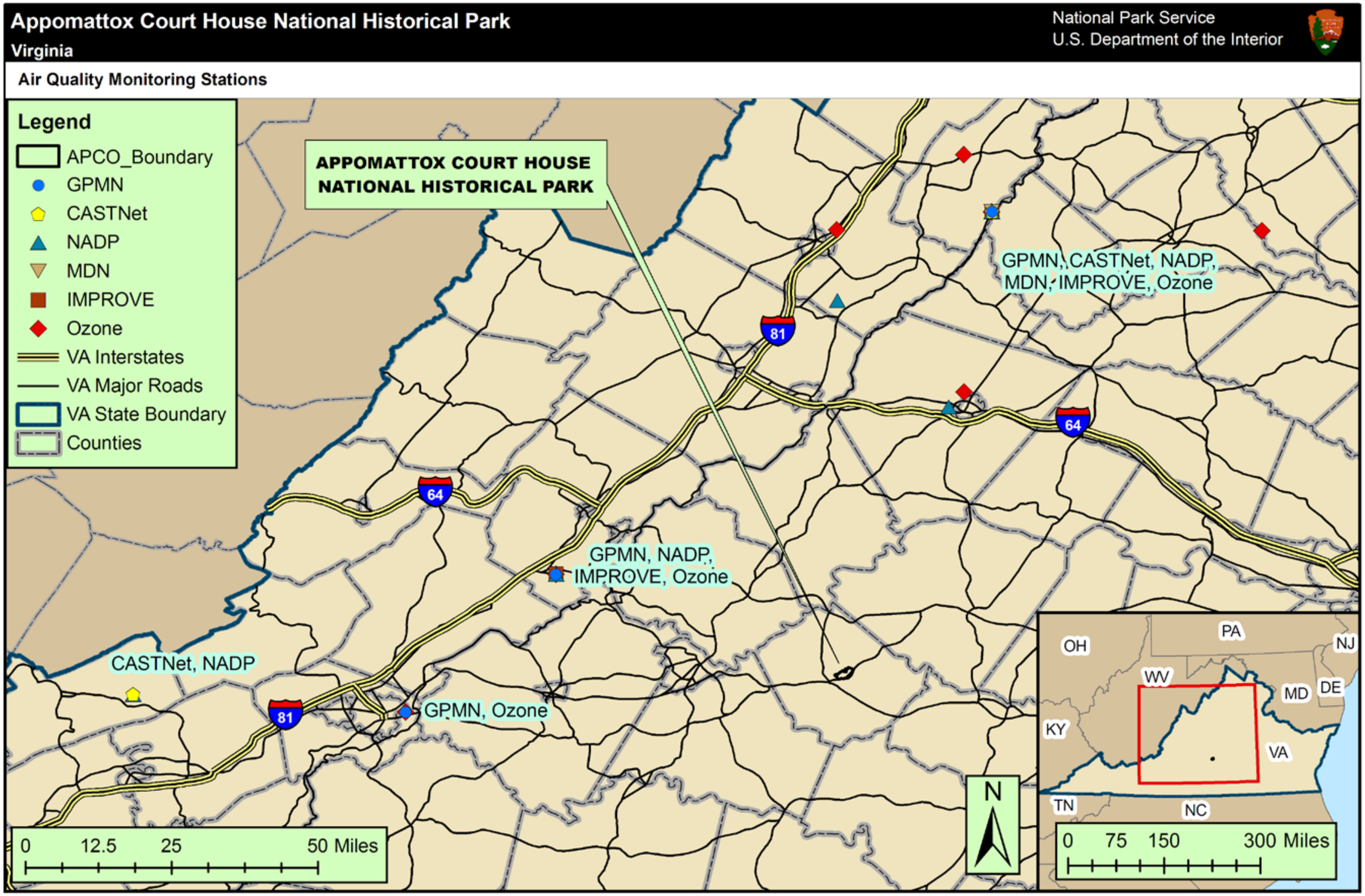

Figure 45. Air quality monitoring stations for Appomattox Court House National Historical Park (APCO). Gaseous Pollutant Monitoring Network (GPMN), Clean Air Status and Trends Network (CASTNet), National Atmospheric Deposition Program (NADP), Mercury Deposition Network (MDN), and Interagency Monitoring of Protected Visual Environments (IMPROVE) are all represented.

Summary of APCO Air Resources Condition

Table 38 contains a comprehensive summary of the current condition of the air resources at APCO. Overall air quality in the park is in poor condition for many of the individual vital signs metrics assessed as part of this report.

Visitor and Recreation Use

The National Park Service was established to provide for its visitors. The NPS mission is to "preserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations." In fact, the top guiding principle to accomplish this mission is excellent service for park visitors and partners (NPS 2008b). Visitors are no doubt the primary reason the NPS exists and continues to be an important part of this country.

Visitor and recreational use, however, has been shown to negatively affect the other half of the NPS mission, which is to protect natural and cultural resources. Several studies have shown a negative correlation between outdoor recreation and the various natural resources covered in this assessment (Taylor and Knight 2003, Wood et al. 2006, Park et al. 2008). As visitation to parks increases, these two parts of the mission often work against each other.

The number of visitors per year to Appomattox Court House NHP increased steadily from 1941 to 1989, where it peaked at approximately 402,947 visitors (NPS 2009b). For the past 20 years, however, visitor levels have been on an overall decline (Figure 46). Visitation to Appomattox Court House NHP appears to coincide with the seasons, with peaks occurring in the spring and summer months, particularly during May, June, and July (Figure 47). Appomattox Court House NHP ranked 186th out of 360 national parks, and 25th out of 43 national historical parks visited in 2008 (NPS 2009b).

Appomattox Court House NHP continues to have 150,000 park visitors each year, but it has been declining since it peaked in 1990 at over 400,000 visitors. It is unclear why the number of visitors has declined over the past twenty years, but the Appomattox Court House Strategic Plan 2007–2011 has put forth some long-term goals to improve the current condition of the park while increasing the amount of visitors. A few of the goals set forth are improving the condition of historical buildings, landscapes, and water quality, while having 95% visitor approval of facilities, services, and recreational opportunities (NPS 2007b). The park already has different educational programs and activities for visitors posted on the Appomattox Court House NHP Web site which may attract repeat visitors.

Table 38. Current air quality values compared to reference values at Appomattox Court House National Historical Park for natural resource management and planning.

MIDN Vital Sign/Indicator	Threshold Criteria	Current Condition	Comments
Ozone concentration (ppb)	<60ppb = Good 61–75ppb = Fair >76ppb = Poor	73.2 ppb (Fair)	For the period 1996–2005, ozone concentrations, nitrogen and sulfur deposition, and visibility in the Mid-Atlantic appear to remain relatively unchanged.
Wet deposition (kg/ha/yr)	<1 kg/ha/yr = Good 1–3 kg/ha/yr = Fair >3 kg/ha/yr = Poor	Sulfur: 5.2 kg/ha/yr (Poor) Nitrogen: 4.2 kg/ha/yr (Poor)	
Visibility condition – current status relative to natural background (dv)	<2= Good 2–8= Fair >8= Poor	12.8 dv (Poor)	
Mercury deposition	Mercury concentrations in rain and snow is 2-3 ng/L	Unknown	If Appomattox Court House NHP measures mercury levels in the future, a recommended reference value for mercury concentrations in rain and snow is 2–3 ng/L (Meili et al. 2003).

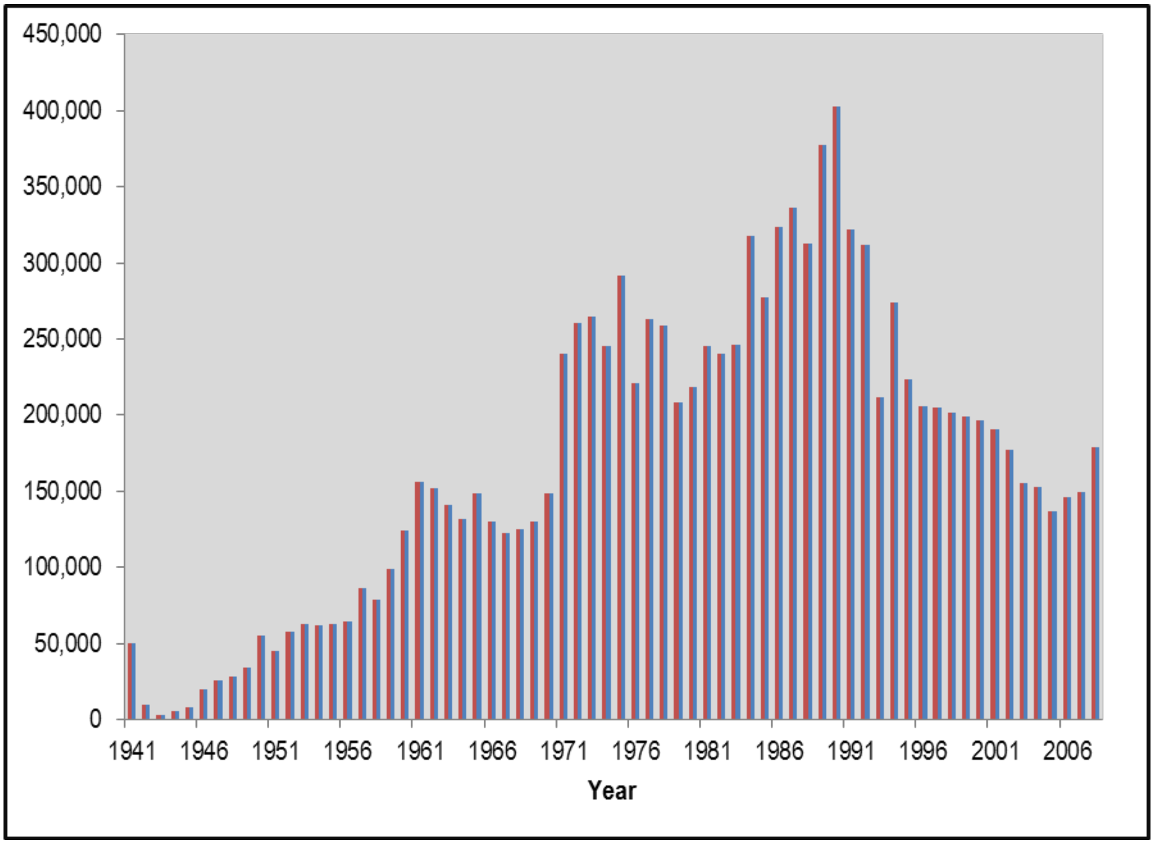

Figure 46. Number of visitors per year to Appomattox Court House National Historical Park from 1941 to 2008.

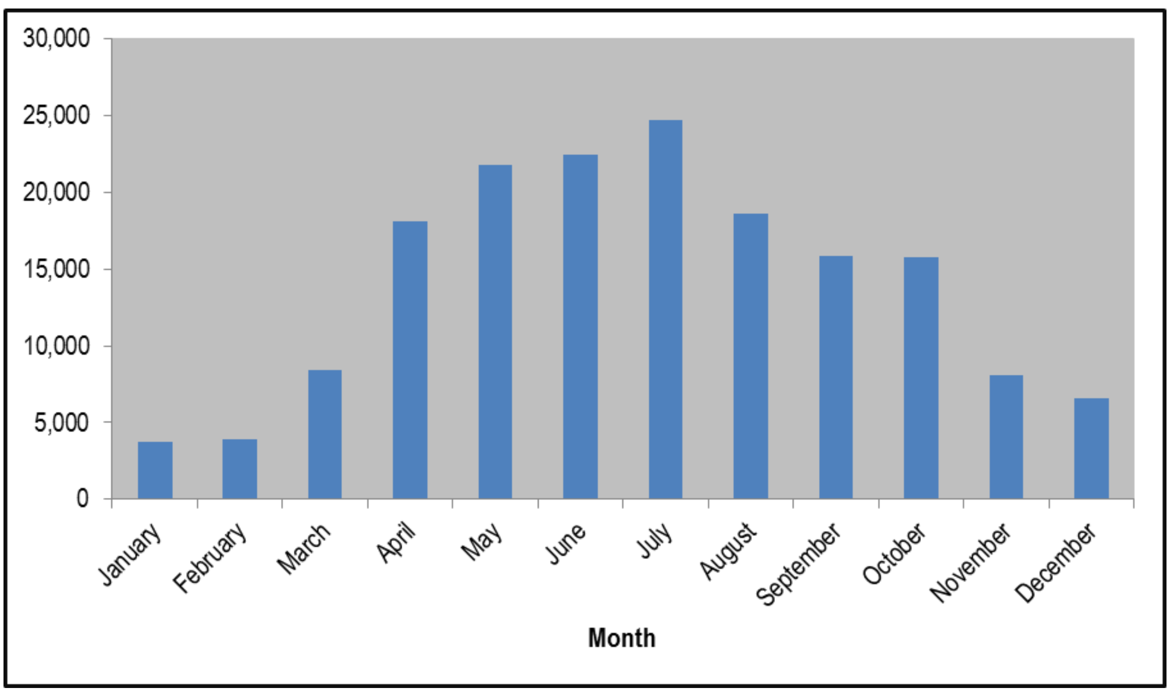

Figure 47. Average monthly visitors (from the past 10 years, 1999 – 2008) to Appomattox Court House National Historical Park.

The average length of stay for visitors to four of the most popular sites in Appomattox Court House NHP has been estimated for NPS Public Use Statistics (NPS 2009c). Table 39 shows how long the average visitor stays in four of the most frequented stops in Appomattox Court House NHP.

Table 39. Average time spent at different locations of Appomattox Court House National Historical Park. These averages have been used from 1995-present.

Location	Average Length of Stay
Visits to the Village	1.20 hours
Grant's Headquarters	0.05 hours
Confederate Cemetery	0.17 hours
Lee's Headquarters	0.08 hours

Viewscape

It is important for visitors to experience Appomattox Court House NHP in its historical context. Unobstructed views and concealing sounds of modern life are important factors for visitors to have an enjoyable experience. Specifically for cultural parks, open areas where historic battles took place are significant areas to protect. Many parks are facing expanding developments along park boundaries and/or in the viewshed. Appomattox Court House NHP is fortunate that the majority of the viewshed areas are contained within its boundary. Wooded communities along the park boundary act as buffers to conceal much of modern life. However, Route 24 is visible in some locations and traffic has increased in recent years. The southern ridge and northeastern boundaries are susceptible to land clearing activities that have occurred up to park property and could potentially, in the future, be viewed from key areas of the park.

A viewshed analysis was conducted in 2002 at Appomattox Court House NHP. Observation points were analyzed in a GIS and 360 degree views of the surrounding landscape were examined. The results of this study were used when considering boundary adjustments for planning in the GMP for the most heavily visited areas of the park.

Soundscape

The National Park Service aims to preserve and/or restore the natural resources within parks; this also includes the soundscape. Culturally appropriate sounds are important elements of the national park experience, especially in cultural parks. While, natural and culturally relevant sounds enhance visitors' experience, sounds associated with modern day life are usually unwanted, uncharacteristic, or inappropriate and can interfere with the visitors' experience and park's mission. Sounds effect visitors, wildlife, cultural, and historic resources. In recent years, the number of airplanes and helicopters flying over national park units has increased dramatically (http://www.nature.nps.gov/naturalsounds/). Visitors increasingly notice many noises such as aircraft, cell phones, vehicles, and park operations.

It is not documented whether the soundscape at Appomattox Court House NHP is adversely affected. Future acoustical monitoring for baseline conditions can be useful to park managers at Appomattox Court House NHP. Managers can identify specific issues related to their park and establish acceptable levels and impacts. Areas of the park where unnatural sound has a higher probability of impacting visitors should be noted. Frequencies, magnitudes, and durations will vary throughout the park and it is important to note if those areas are also popular visited areas. Visitors can be surveyed to determine if actions should be taken to minimize unnatural sounds in and around the park.

Condition Status Summary for Parkwide Resources

Air quality trends cannot be evaluated from the interpolated 5-year averages utilized by the ARD. However, the NPS ARD evaluates 10-year trends in air quality for parks with on-site or nearby monitoring (NPS 2010b). Maps in the most recently available progress report show trends in ozone, deposition, and visibility; these can be used to discern regional trends (NPS 2007a). For the period 1996–2005, ozone concentrations, nitrogen and sulfur deposition, and visibility in the Mid-Atlantic region appear to remain relatively unchanged. From the environmental and natural resource management perspective, air quality at Appomattox Court House NHP is poor, overall. Wet deposition and visibility both ranked as poor. A 2004 risk assessment determined that the ozone threat to vegetation at Appomattox Court House NHP is moderate. Risk of plant injury is moderate because the soil moisture values that prevail during periods of high ozone exposure are frequently not sufficient to limit stomatal uptake of ozone (NPS 2004).

Condition status for soils, soundscape, and visitor use (as it relates to natural resources) could not be evaluated due to lack of data relevant to natural resources; these metrics were assessed as "unknown."

Natural Resource Condition Assessment Summary

Based upon available data, most of the natural resources at Appomattox Court House appear to be in good condition (Table 40). The percent of unnatural vegetation within the park is low, 5.4%. The percent of forest cover (62.9%) is also rated as good. No forest pests have been detected at the park; however, exotic plant species have been found at the majority of forest monitoring plots. Managers are currently managing cold-season grasslands with prescribed fire to promote native, warm-season grasses. Three years of additional treatment and data are needed to determine if desired conditions for grasslands have been met.

All of the faunal groups assessed during initial Inventory and Monitoring surveys observed over 50% of the species expected to be observed. Currently, twenty-seven Species of Greatest Conservation Need (SGCN) have been observed at the park.

Wetland and riparian areas were rated as good. Water quality was rated good, but surrogate data had to be used for this assessment. This was the most significant data gap for this assessment. Irregular monitoring and reporting are the most significant impediments to a thorough assessment of water quality in and around Appomattox Court House NHP. The lack of data collected at the park prevented a useful rating for this assessment. However, the Mid-Atlantic Network is now collecting water quality data at three sites inside the park on a quarterly basis and surveys for macroinvertebrates are in process as of the date of this assessment.

Table 40. Summary of natural resource conditions for Appomattox Court House National Historical Park. Scores are overall average scores from each natural resource metric (if available).

Metric	Current Condition	Comments
MIDN Vital Sign/Indicator		
Landscape Dynamics	Good	One metric measured (Table 7).
Vegetation Communities	Good	3 out of 5 forest metrics rated "good." One grassland/meadow metric rated. Several data gaps exist (Table 12).
Wetland/Riparian Resources	Good	3 out of the 6 metrics rated "good" (Table 14).
Biological Integrity	Good	4 out of 5 metrics rated as "good" (Table 20). Future faunal surveys will be beneficial to monitor relative abundances and diversity over time. Insufficient data to evaluate trends.
Water Resources	Good	In park water data will better assess water quality at APCO in the future (3 metrics rated as "good"; 1 "poor"; and 1 data gap (Table 31).
Parkwide Resources	Poor (Air quality)	Air quality poor (3 metrics rated "poor"; 1 "fair"). Several data gaps including soils and visitor use (Table 38).
Data Quality		
Landscape Dynamics	Good	See Appendix A.
Vegetation Communities	Good	See Appendix A.
Wetland/Riparian Resources	Good	See Appendix A.
Biological Integrity	Fair	See Appendix A.
Water Resources	Poor	See Appendix A.
Parkwide Resources	Fair	See Appendix A.

Trend data was lacking for this assessment for the majority of metrics. Future NPS Inventory and Monitoring programs will focus on establishing trends for water quality, forest pests, exotic plant species, and faunal communities. Data quality was only rated good for three categories: landscape dynamics, vegetation communities, and wetland/riparian resources.

Suggested Research Areas

Data that can be collected to aid park managers in making management decisions at Appomattox Court House NHP include:

1. Monitor annual changes and long-term trends in faunal species composition and relative abundance.
2. Continue macroinvertebrate sampling to monitor water quality.
3. Improve understanding of the relationship between breeding birds, habitats, and park management.
4. Monitor other indicator species and/or species of concern.

To improve habitat quality at Appomattox Court House NHP:

1. Currently, cattle are being grazed to capacity on most fields at Appomattox Court House NHP. If possible, reevaluate the number of cows at the park and investigate impacts on soil erosion, sedimentation, reduction in water quality, and effects on stream and wetland/stream health and biodiversity (Bradshaw 2007). For cattle that remain at the park, fence off streams in areas where cattle graze.
2. Continue to manage for invasive species—in particular, those associated with stream and riparian habitats.
3. Continue replanting remaining fields with native, warm season grasses; these grasses are beneficial to many species of wildlife (Pagels et al. 2005, Wolter et al. 2008).
4. If haying continues at the park, avoid cutting during the nesting season for many bird species from mid-April through the end of July (Wolter et al. 2008).
5. Mitchell (2006) recommends maintaining Tibbs Ice Pond as a small breeding pond for amphibians, as well as keeping riparian and adjacent hardwood forest areas intact.
6. Reduce mowing frequency where possible, particularly along riparian areas.

Other recommendations include:

1. Determine the status and trends in soil Ca:Al and C:N ratios to assess the extent of base cation depletion, increased aluminum availability, and/or nitrogen saturation impacting MIDN forest soils.
2. When possible, evaluate the impact of vehicular traffic on U.S. Rt. 24 on faunal species crossing this road.
3. Poaching is a somewhat common occurrence at the park; as well as the presence of hunting dogs; when possible, increase enforcement to reduce incidences of poaching at the park.
4. If possible, estimate the rate of change for habitats within the park buffer area to track changes that could impact resources on park property.
5. Educational materials could be developed to educate park visitors about the natural resources and unique areas present at the park.

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Appendix A. Data Quality.

We provide a data quality rating based on three categories, *thematic*, *spatial*, and *temporal* (Table A-1). We gave *thematic* a 1 or 0 (yes or no) based on whether these data were from the best available source. Ratings for thematic data varied by each case and are explained in the corresponding section. *Spatial* received a 1 or 0 based on the spatial proximity of these data (in-park data or out-of-park data). We also gave *temporal* a 1 or 0 based on how recently these data were acquired. *Temporal* was somewhat dependent on data type, but generally, if the data were from the last five years, they received a 1. The data quality values were averaged, and an overall rating is given for the data quality (good = 2.67 to 3; fair = 1.34 to 2.66; and poor = 0 to 1.33).

These indicators and measures were selected among the recommendations made by Fancy et al. (2009), the MIDN vital signs (Comiskey and Callahan 2008), preliminary scoping meeting with NPS personnel, and follow-up communication.

Table A-1. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively.

Indicator	Measure	Data Quality		
		Thematic	Spatial	Temporal
Indicator A	Measure A	1	0	0
		1 out of 3		
Indicator B	Measure B	1	1	0
		2 out of 3		
Indicator C	Measure C	1	1	1
		3 out of 3		
Average		1	0.7	0.3
Sum of Average		2 out of 3		

Table A-2. Condition status scoring system for Appomattox Court House National Historical Park Natural Resource Assessment.

Condition Status	Range	Condition Score
Good	0.67 – 1.00	0.84
Fair	0.34 – 0.66	0.50
Poor	0.00 – 0.33	0.17

The following are data quality scores for measures assessed in the NRCA:

Table A-3. Landscape dynamics condition status summary for Appomattox Court House National Historical Park. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively.

Indicator	Measure	Data Quality		
		Thematic	Spatial	Temporal
Land Cover	Area covered by forest and grassland	1	1	1
		3 out of 3		
	Percent unnatural vegetation in the park	1	1	1
		3 out of 3		
Landscape Dynamics Average		1	1	1
		3 out of 3		

Table A-4. Vegetation communities condition status data summary for Appomattox Court House National Historical Park. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively.

Indicator	Measure	Data Quality		
		Thematic	Spatial	Temporal
Forest Health	Species Composition	1	1	1
		3 out of 3		
	Land cover	1	1	1
		3 out of 3		
	Key forest bird species	1	1	0
		2 out of 3		
	Native forest pests	1	1	1
		3 out of 3		
	Invasive exotic plants	1	1	1
		2 out of 3		
	Soil structure and composition	0	0	0
		Data gap		
	White-tailed deer density	0	0	0
		Data gap		
Grassland Integrity	Species Composition	1	1	1
		3 out of 3		
	Proportion of plot cover	1	1	1
		3 out of 3		
	Species count	1	1	1
		3 out of 3		
	Key grassland bird species	1	1	0
		2 out of 3		
	Soil structure and composition	0	0	0
		Data gap		
Vegetation Communities Total		1	1	0.78
		2.78 out of 3		

Table A-5. Biological integrity condition status data summary for Appomattox Court House National Historical Park. Data quality was rated based on thematic (1 = best source; 0 = not the best source), spatial (1 = inside park boundary; 0 = outside park boundary), and temporal (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively.

Indicator	Measure	Data Quality		
		Thematic	Spatial	Temporal
Fish	Jaccard's Index of Similarity	1	1	0
		2 out of 3		
Amphibians	Jaccard's Index of Similarity	1	1	0
		2 out of 3		
Reptiles	Jaccard's Index of Similarity	1	1	0
		2 out of 3		
Birds	Jaccard's Index of Similarity	1	1	0
		2 out of 3		
	BBS community trends	1	0	1
		2 out of 3		
Mammals	Jaccard's Index of Similarity	1	1	0
		2 out of 3		
	Biological Integrity Average	1	0.8	0.17
		1.97 out of 3		

Table A-6. Water resources condition status summary for Appomattox Court House National Historical Park. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), *spatial* (1 = within 5 miles of the park boundary; 0 = greater than 5 miles outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively.

Indicator	Measure	Data Quality		
		Thematic	Spatial	Temporal
Hydrology	Flow	0	1	0
		1 out of 3		
Stream Condition	Dissolved Oxygen	0	0	1
		1 out of 3		
	pH	1	0	0
		1 out of 3		
	Temperature	1	0	0
		1 out of 3		
	Bacterial Contamination (*E. coli*)	1	0	1
		2 out of 3		
	Conductivity	0	0	0
		0 out of 3		
	Water Resources Average	0.5	0.17	0.33
		1.0 out of 3		

Table A-7. Air quality condition status summary for Appomattox Court House National Historical Park. Data quality was rated based on *thematic* (1 = best source; 0 = not the best source), s*patial* (1 = inside park boundary; 0 = outside park boundary), and *temporal* (1 = recent; 0 = older than 5 years). The colors green, yellow, and red refer to good, fair, and poor scores respectively.

Indicator	**Data Quality**		
	Thematic	**Spatial**	**Temporal**
Ozone	1	0	1
		2 out of 3	
Atmospheric Deposition	1	0	1
		2 out of 3	
Visibility	1	0	1
		2 out of 3	
Air Quality Average	1	0	1
		2 out of 3	

Appendix B. Land cover calculation methods.

We used "Extract by Mask" in ArcToolbox (ESRI 2006) to clip each land cover dataset to the study area. In some cases we performed grid reclassification and relabeling of class name to simplify and to make the raster files that were produced more useable.

NOAA Coastal Change Analysis Program Classification Scheme (NOAA 2008):

Uplands
Consisting of areas above sea level where saturated soils and standing water are absent. Also, the Hydrologic regime is not sufficiently wet to support vegetation associated with wetlands. Upland features are divided into classes such as High, Medium, Low Intensity Development, Cultivated land, Grassland, Pasture/ Hay, Barren land, Scrub/Shrub, Dwarf Shrub, Deciduous, Evergreen and Mixed Forest.

2- *Developed*, *High Intensity* – Includes highly developed areas where people reside or work in high numbers. Impervious surfaces account for 80 to 100 percent of the total cover.
Characteristic land cover features: Large commercial/industrial complexes and associated parking, commercial strip development, large barns, hangars, interstate highways, and runways.

3- *Developed, Medium Intensity* – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover.
Characteristic land cover features: Small buildings such as single family housing units, farm outbuildings, and large sheds.

4- *Developed, Low Intensity* – Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 21 to 49 percent of total cover.
Characteristic land cover features: Same as Medium Intensity Developed with the addition of streets and roads with associated trees and grasses. If roads or portions of roads are present in the imagery they are represented as this class in the final land cover product.

5- *Developed, Open Space* – Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.
Characteristic land cover features: Parks, lawns, athletic fields, golf courses, and natural grasses occurring around airports and industrial sites.

6- *Cultivated Crops* – Areas used for the production of annual crops. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Characteristic land cover features: Crops (corn, soybeans, vegetables, tobacco, and cotton), orchards, nurseries, and vineyards.

7- *Pasture/Hay* – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle and not tilled. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Characteristic land cover features: Crops such as alfalfa, hay, and winter wheat.

8- *Grassland/Herbaceous* **–** Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Characteristic land cover features: Prairies, meadows, fallow fields, clear-cuts with natural grasses, and undeveloped lands with naturally occurring grasses.

9- *Deciduous Forest* **–** Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Characteristic species: Maples (*Acer*), Hickory (*Carya*), Oaks (*Quercus*), and Aspen (*Populus tremuloides*).

10- *Evergreen Forest* **–** Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Characteristic species: Longleaf pine (*Pinus palustris*), slash pine (*Pinus ellioti*), shortleaf pine (*Pinus echinta*), loblolly pine (*Pinus taeda*), and other southern yellow (*Picea*); various spruces and balsam fir (*Abies balsamea*); white pine (*Pinus strobus*), red pine (*Pinus resinosa*), and jack pine (*Pinus banksiana*); hemlock (*Tsuga canadensis*); and such western species as Douglas-fir (*Pseudotsuga menziesii*), redwood (*Sequoia sempervirens*), ponderosa pine (*Pinus monticola*), Sitka spruce (*Picea sitchensis*), Engelmann spruce (*Picea engelmanni*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*).

11- *Mixed Forest* **–** Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Characteristic species: Those listed in 9 and 10.

12- *Scrub/Shrub* **–** Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Characteristic species: Those listed in 9 and 10 as well as chaparral species such as chamise (*Adenostoma fasciculatum*), chaparral honeysuckle (*Lonicera interrupta*), scrub oak (*Quercus beberidifolia*), sagebrush (*artemisia tridentate*), and manzanita (*Arctostaphylos spp.*).

Wetlands

Areas dominated by saturated soils and often standing water. Wetlands vegetation is adapted to withstand long-term immersion and saturated, oxygen-depleted soils. These are divided into two salinity regimes: Palustrine for freshwater wetlands and Estuarine for saltwater wetlands. These are further divided into Forested, Shrub/Scrub, and Emergent wetlands. Unconsolidated Shores are also included as wetlands.

13- *Palustrine Forested Wetland* – Includes all tidal and nontidal wetlands dominated by woody vegetation greater than or equal to five meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.
Characteristic species: tupelo (*Nyssa*), cottonwoods (*Populus deltoids*), bald cypress (*Taxodium distichum*), American elm (*Ulmus Americana*), ash (*Fraxinus*), and tamarack.

14- *Palustrine Scrub/Shrub Wetland* – Includes all tidal and non tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions (Cowardin et al. 1979).
Characteristic species: alders (*Alnus spp*.), willows (*Salix spp*.), buttonbush (*Cephalanthus occidentalis*), red osier dogwood *(Cornus stolonifera*), honeycup (*Zenobia pulverenta*), spirea (*Spiraea douglassii*), bog birch (*Betula pumila*), and young trees such as red maple (*Acer rubrum*) and black spruce (*Picea mariana*).

15- *Palustrine Emergent Wetland (Persistent)* – Includes all tidal and nontidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Plants generally remain standing until the next growing season. Total vegetation cover is greater than 80 percent.
Characteristic species: cattails (*Typha spp*.), sedges (*Carex spp.*), bulrushes (*Scirpus spp.*), rushes (*Juncus spp*.), saw grass (*Cladium jamaicaense*), and reed (*Phragmites australis*).

16- *Estuarine Forested Wetland* – Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Characteristic species: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*) and white mangrove (*Languncularia racemosa*)

17- *Estuarine Scrub / Shrub Wetland* – Includes all tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Characteristic species: sea-myrtle (*Baccharis halimifolia*) and marsh elder (*Iva frutescens*).

18- *Estuarine Emergent Wetland* – Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens). Wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands. Total vegetation cover is greater than 80 percent.
Characteristic species: cordgrass (*Spartina spp.*), needlerush (*Juncus roemerianus*), narrow leaved cattail (*Typha angustifolia*), southern wild rice (*Zizaniopsis miliacea*), common pickleweed (*Salicornia virginica*), sea blite (*Suaeda californica*), and arrow grass (*Triglochin martimum*).

19- *Unconsolidated Shore* – Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
Characteristic land cover features: Beaches, bars, and flats.

20- *Barren Land* – (rock/sand/clay) Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover.
Characteristic land cover features: Quarries, strip mines, gravel pits, dunes, beaches above the high-water line, sandy areas other than beaches, deserts and arid riverbeds, and exposed rock.

21- *Open Water* – All areas of open water, generally with less than 25 percent cover of vegetation or soil.
Characteristic land cover features: Lakes, rivers, reservoirs, streams, ponds, and ocean.

NLCD Land Cover Codes and Descriptions

11. Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.

12. Perennial Ice/Snow - All areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.

21. Developed, Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes

22. Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

23. Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

24. Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

31. Barren Land (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

41. Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

52. Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

71. Grassland/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

82. Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

95. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Table B-1. Vegetation and land cover crosswalk (reclassifications) for C-CAP land cover and NPS vegetation map.

Vegetation Reclassification	C-CAP Class	Local Name (NPS Vegetation Map)	Ecological Community
Natural Vegetation	Deciduous Forest	Dense Hardwood Regeneration	Upland Forest
		Grazed Woodlot	Upland Forest
		Inner Piedmont / Lower Blue Ridge Basic Mesic Forest	Riparian Forest
		Mesic Mixed Hardwood Forest	Riparian Forest
		Oak - Hickory Forest	Upland Forest
		Piedmont / Low Elevation Mixed Oak / Heath Forest	Upland Forest
		Successional Black Walnut Forest	Upland Forest
		Successional Red-cedar Forest	Upland Forest
		Successional Tree-of-Heaven Forest	Upland Forest
		Successional Tuliptree Forest	Upland Forest
		Successional Virginia Pine Forest	Upland Forest
	Estuarine Emergent Wetland		
	Estuarine Forest Wetland		
	Estuarine Shrub/Scrub Wetland		
	Evergreen Forest	Loblolly Pine Plantation	Upland Forest
		Virginia Pine Plantation	Upland Forest
	Grassland		
	Mixed Forest		
	Palustrine Emergent Wetland	Beaver Wetland Complex	Wetlands
		Northern Piedmont / Lower New England Basic Seepage Swamp	Wetlands
		Upland Depression Swamp	Wetlands
	Palustrine Forested Wetland	Piedmont / Mountain Alluvial Forest	Riparian Forest
	Palustrine Shrub/Scrub Wetland		
	Shrub/Scrub		
Semi-natural Vegetation	Cultivated		
	Pasture/Hay	Cultural Meadow	Cultural Meadow (Field)
	Developed Open Space		
Unnatural Vegetation	High Intensity Developed		
	Low Intensity Developed	Transportation, Communications, and Utilities	Built-up Lands
	Medium Intensity Developed	Other Urban or Built-up Land	Built-up Lands
Other	Bare Land		
	Unconsolidated Shore		
	Water		

Appendix C. Climate Data.

The threat of changing climate is real, and much research points to the high likelihood of broad ecological impacts as a result. How these changes will impact specific park resources is yet unknown, but they are likely to be comprehensive. That is not to say that those changes will be catastrophic. While specific biota or processes will be impacted, climate change may not result in extinctions or degradations.

There is much interest in documenting the trends in climate over time, due to increasing temperatures and changing weather patterns across the globe (Blaustein et al. 2001, Walther et al. 2002, Corn 2005). Such changes have the potential to impact natural resources by shifting dominant vegetation communities, impacting animal species at the frontiers of their range, and impacting fundamental ecosystem processes. Invasive species, such as the hemlock woolly adelgid (*Adelges tsugae*), may be aided by warmer winter temperatures and spread further throughout the eastern coast (Paradis et al. 2007).

The Earth's climate has warmed by approximately 0.6 °C over the past 100 years. The main period of warming has occurred since 1976, and is greater than at any other time during the last 1,000 years (Walther et al. 2002). Average temperatures for January rose more than 5 °F in the continental U.S. over the past 40 years (Audubon 2009). Monitoring programs are important to track changes in species composition and abundance over time.

Analysis of four decades of data from the Audubon's Christmas Bird Count indicates a northward shift of birds seen in North America during the first weeks of winter. Movement occurred among 58% of the observed species (177 of 305) with an average northward movement of 35 miles, and 60 species moving in excess of 100 miles north (Audubon 2009). Climate change can have the largest impact on the survival of many long-distance migratory birds. Birds are removed from food sources and cannot predict changes to their breeding or overwintering grounds. Some species are therefore unable to advance their arrival date in spring breeding grounds to coincide with leaf-out and the changing availability of different prey sources such as insects.

Climate

We included some basic analysis on the climate of the landscape around Appomattox Court House NHP. Our analysis includes several weather events examined over the long term (>30 years). We attempted to narrow the suite of factors down to those metrics where data were available and long-term trends were established. These include temperature, precipitation, available moisture and phenology through growing degree days.

We used data provided by the Southeast Regional Climate Center (SERCC) to assess climate change for Appomattox Court House NHP. The SERCC is a regional climate center headquartered at the University of North Carolina at Chapel Hill and is directed and overseen by the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) and National Environmental Satellite, Data and Information Service (NESDIS). Appomattox, VA is one of the cities available for long-term climate information summaries provided through the SERCC Historical Climate Summaries product. This product allows access to annual, monthly, and daily climate information, including mean temperature (The Southeast Regional Climate Center 2009). It is important to note that we are simply reporting the available data; this analysis is not statistically significant given gaps in data availability and wide variations in the data.

Temperature

We used the monthly average temperature data to examine annual temperature trends as well as seasonally for winter (December – February), spring (March – May), summer (June – August), and fall (September – November) seasons. The range of dates for which data were available was 1962 to 2009; however, due to incomplete data for 2009, this assessment utilizes data from 1962 to 2008. In some years, data is incomplete or unavailable for a number of months. In assessing seasonal trends, those years with one or more months of incomplete data are not considered and are omitted from our analysis.

The mean annual temperature for Appomattox, Virginia has increased approximately 0.73 °F per decade (mean = 55.59 °F) from 1962 to 2008 based on data available (Figure C-1). This observed increasing trend was similar for all four seasons (Figure C-2 through C-5).

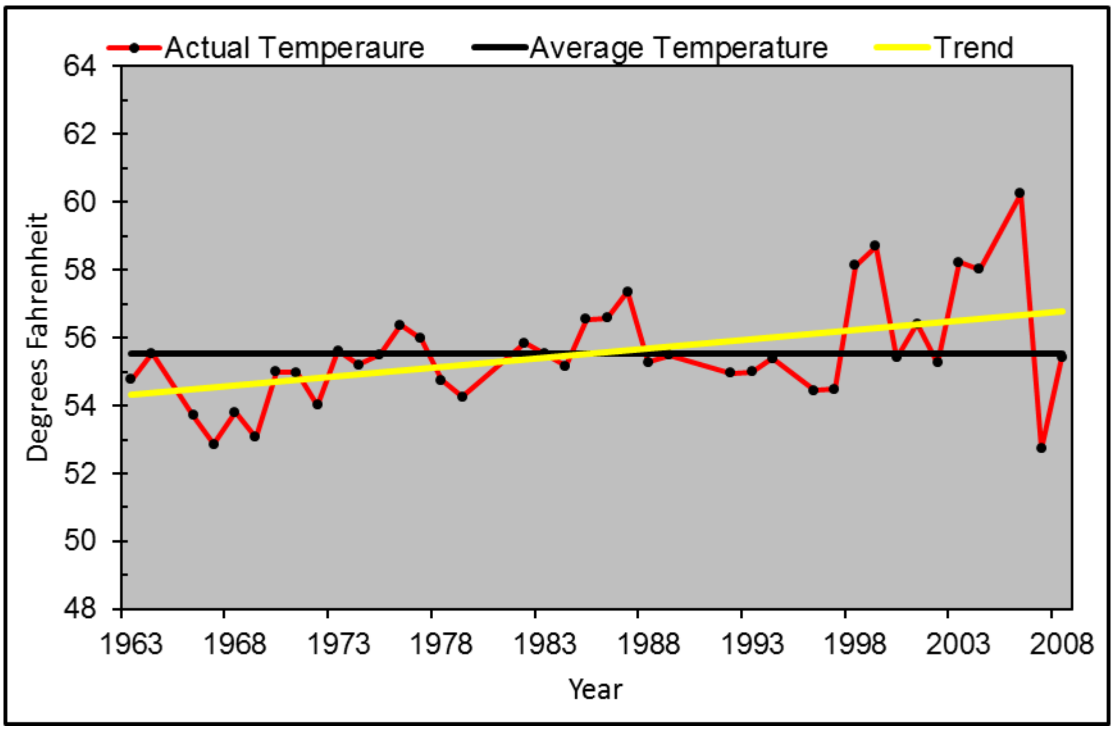

Figure C-1. Mean annual temperature for Appomattox, VA from 1963 to 2008. The mean annual temperature is 55.59 °F. The trend is 0.73 °F increase per decade. Eight years were omitted due to insufficient data (1965, 1980, 1981, 1984, 1990, 1991, 1995, and 2005).

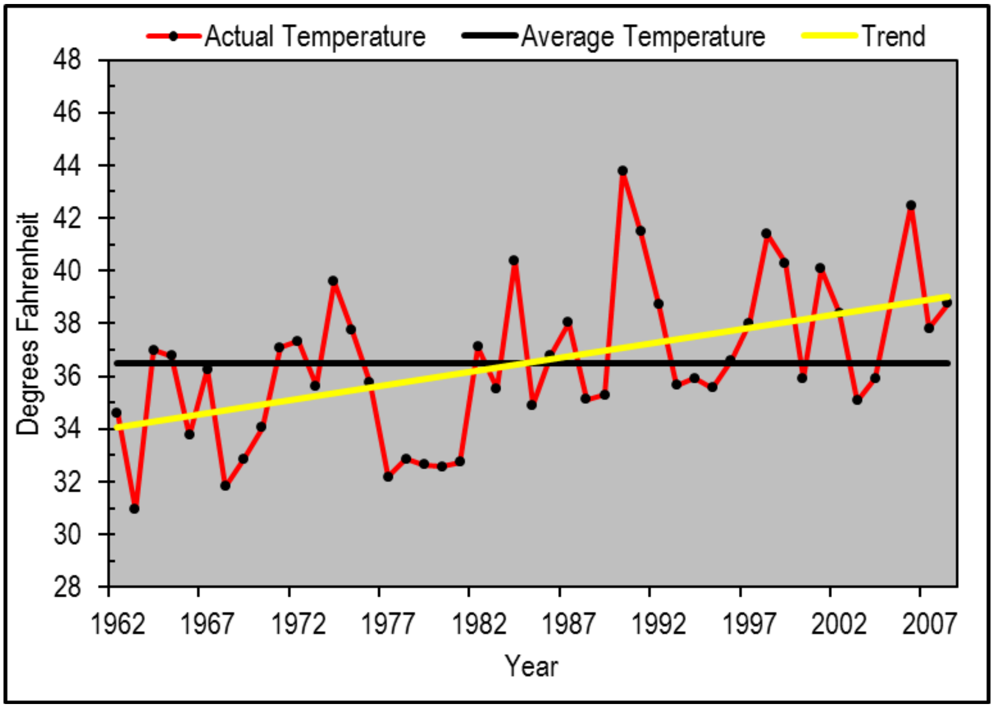

Figure C-2. Winter mean temperature for Appomattox, VA from 1962 to 2008. The mean temperature is 36.5 °F with an increasing trend of 1.1°F per decade. Year 2005 was omitted due to insufficient data.

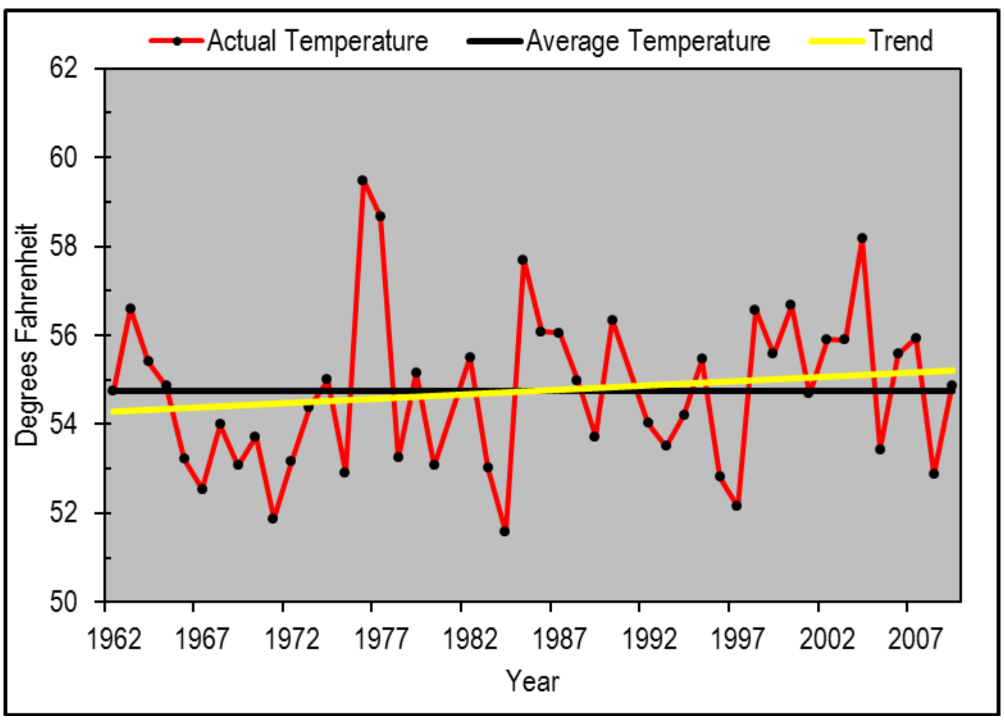

Figure C-3. Spring mean temperature for Appomattox, VA from 1962 to 2009. The mean temperature is 54.7°F with an increasing trend of 0.20 °F per decade. The years 1981 and 1991 were omitted due to insufficient data.

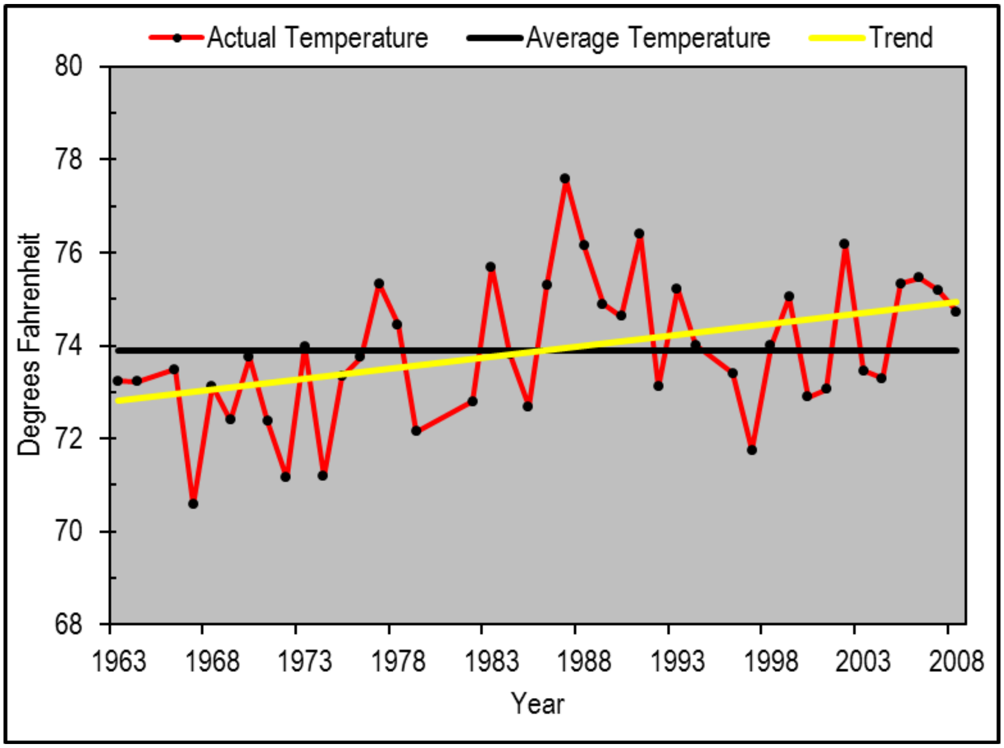

Figure C-4. Summer mean temperature for Appomattox, VA from 1963 to 2008. The mean temperature is 73.89°F with an increasing trend of 0.47 °F per decade. This figure omits 4 years with insufficient data (1965, 1980, 1981, and 1995).

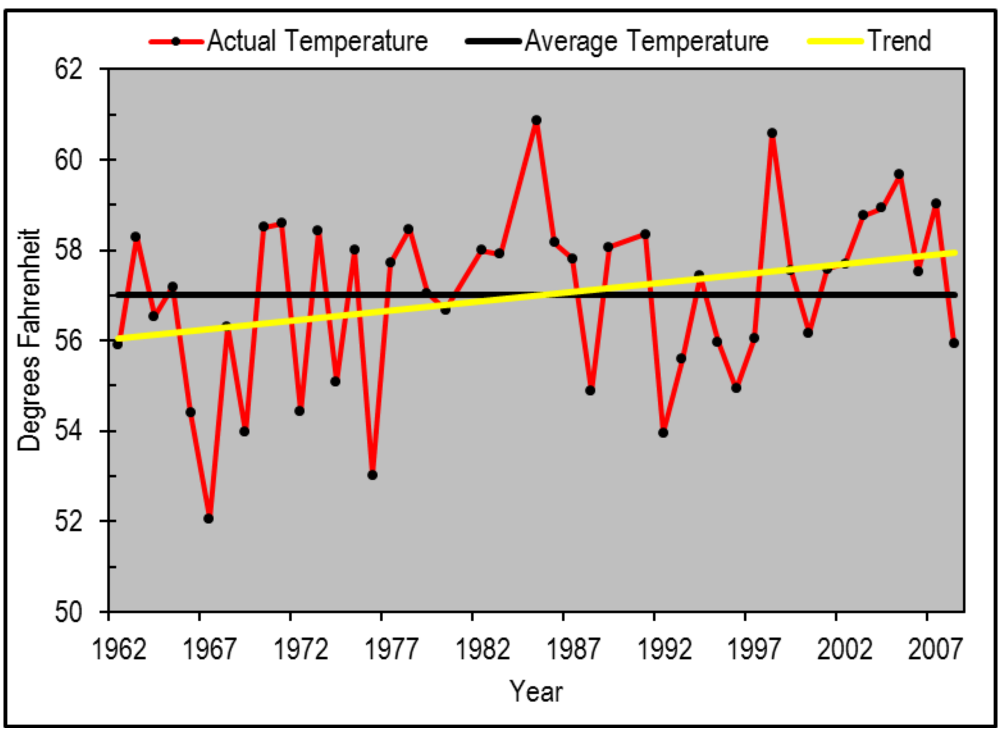

Figure C-5. Fall mean temperature for Appomattox, VA from 1962 to 2008. The mean temperature is 57.0 °F with an increasing trend of 0.41 °F per decade. This figure omits three years with insufficient data (1981, 1984, and 1990).

Precipitation and Snowfall

Annual values were compiled for precipitation using data collected at Appomattox, VA from 1938 to 2008. Data is incomplete or unavailable for a number of months in some years. In assessing seasonal trends, those years with one or more months of incomplete data are not considered and are omitted from our analysis. The annual precipitation at Appomattox has an average of 41.76 and an increasing trend of approximately 0.40 inches per decade (Figure C-6).

The average annual snowfall at Appomattox is 13.8 inches and has a decreasing trend of 0.45 inches per decade. Figures C-7 through C-10 display the seasonal trends for precipitation, and Figure C-11 displays annual snowfall trends.

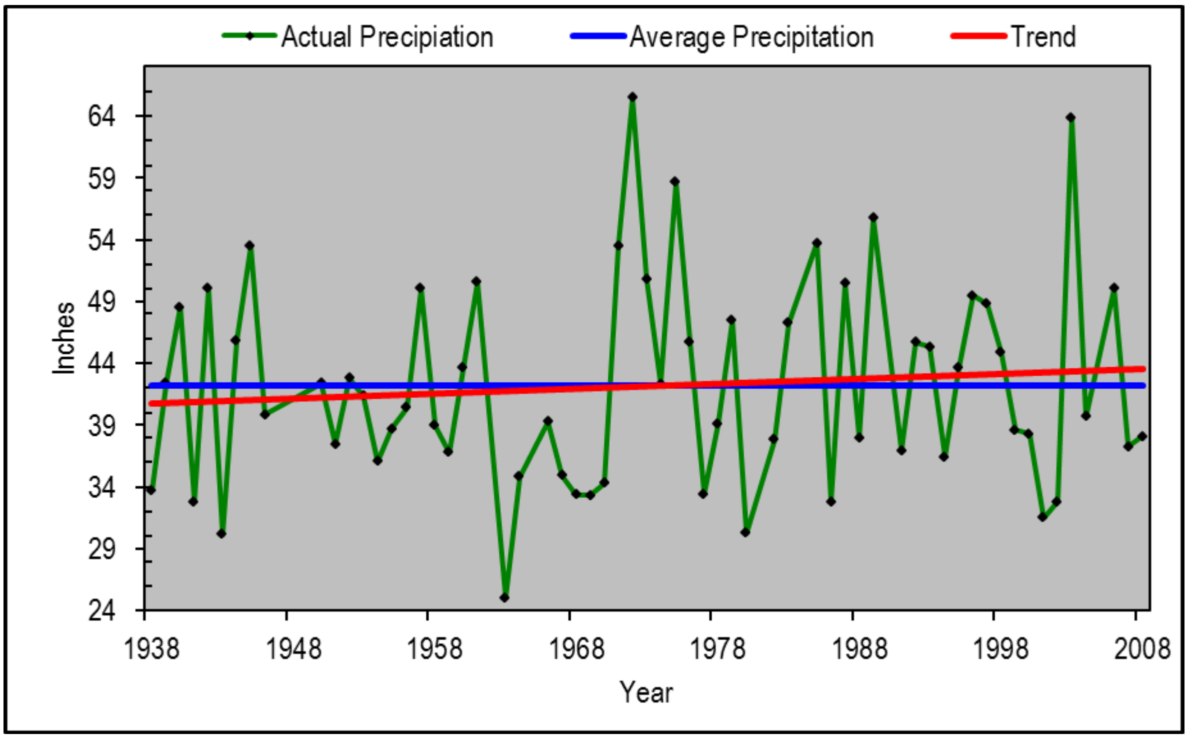

Figure C-6. Annual precipitation for Appomattox, VA from 1938 to 2008. The mean annual precipitation is 42.17 inches with an increasing trend of 0.40 inches per decade. Several years were omitted due to insufficient data (1947, 1948, 1949, 1962, 1965, 1981, 1984, 1990 and 2005).

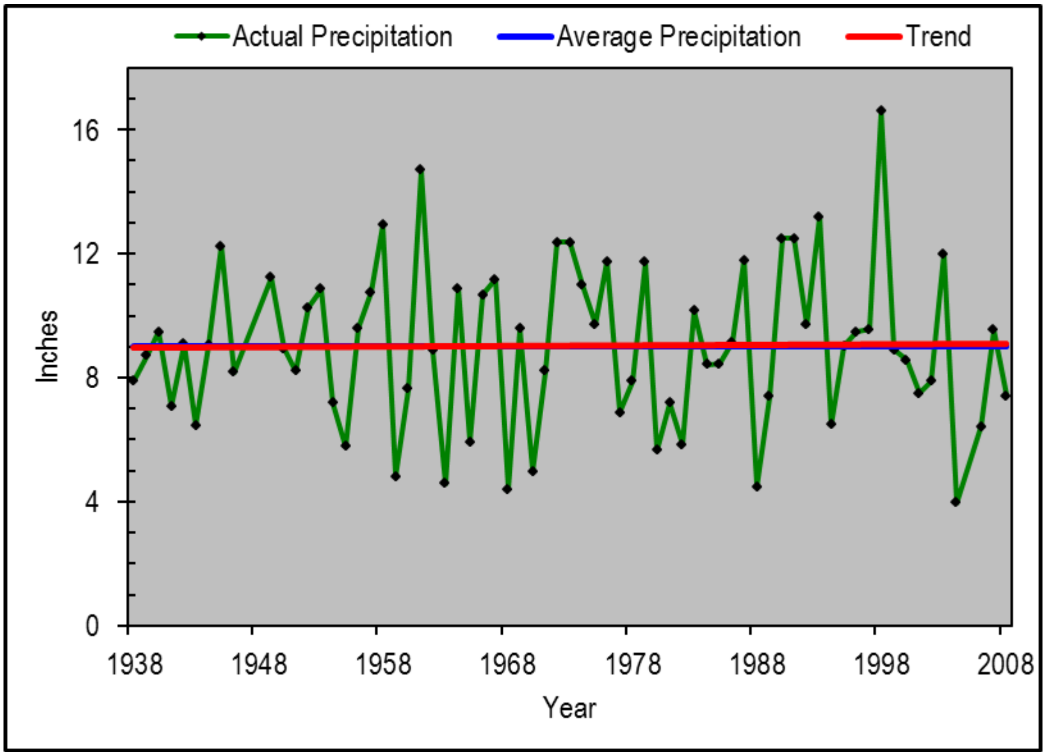

Figure C-7. Winter precipitation for Appomattox, VA from 1938 to 2008. The mean precipitation is 9.02 inches with an increasing trend of 0.02 inches per decade. The years 1947, 1948, and 2005 were omitted due to insufficient data.

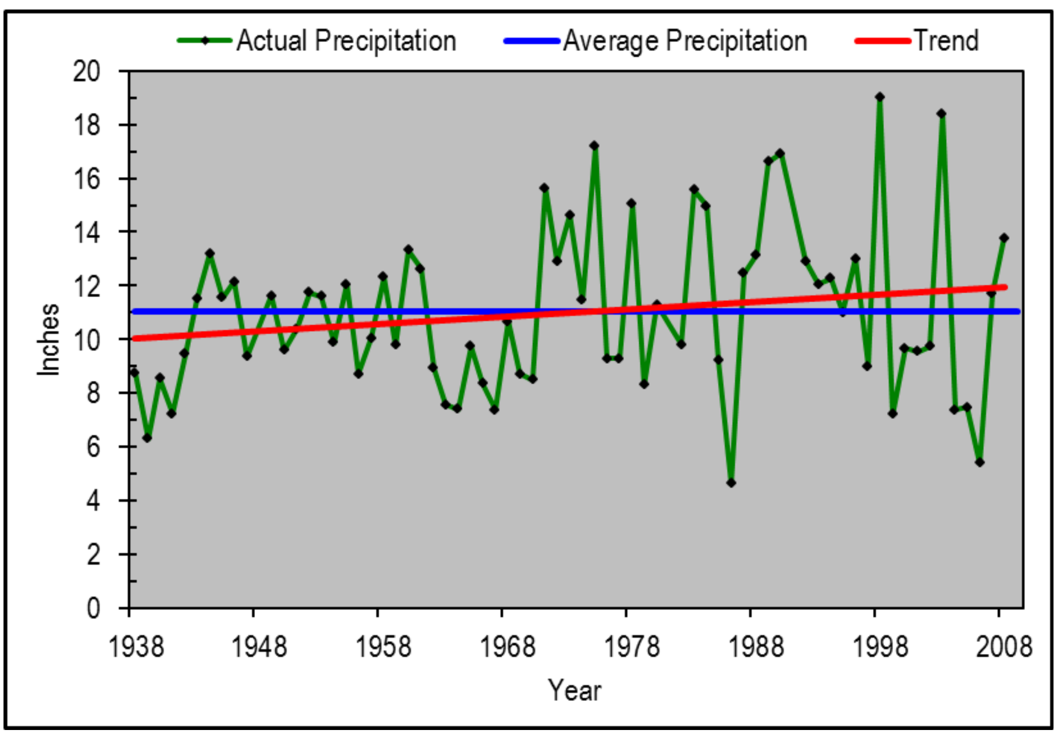

Figure C-8. Spring precipitation for Appomattox, VA from 1938 to 2008. The mean precipitation is 11.02 inches with an increasing trend of 0.28 inches per decade. The years 1948, 1981, and 1991 were omitted due to insufficient data.

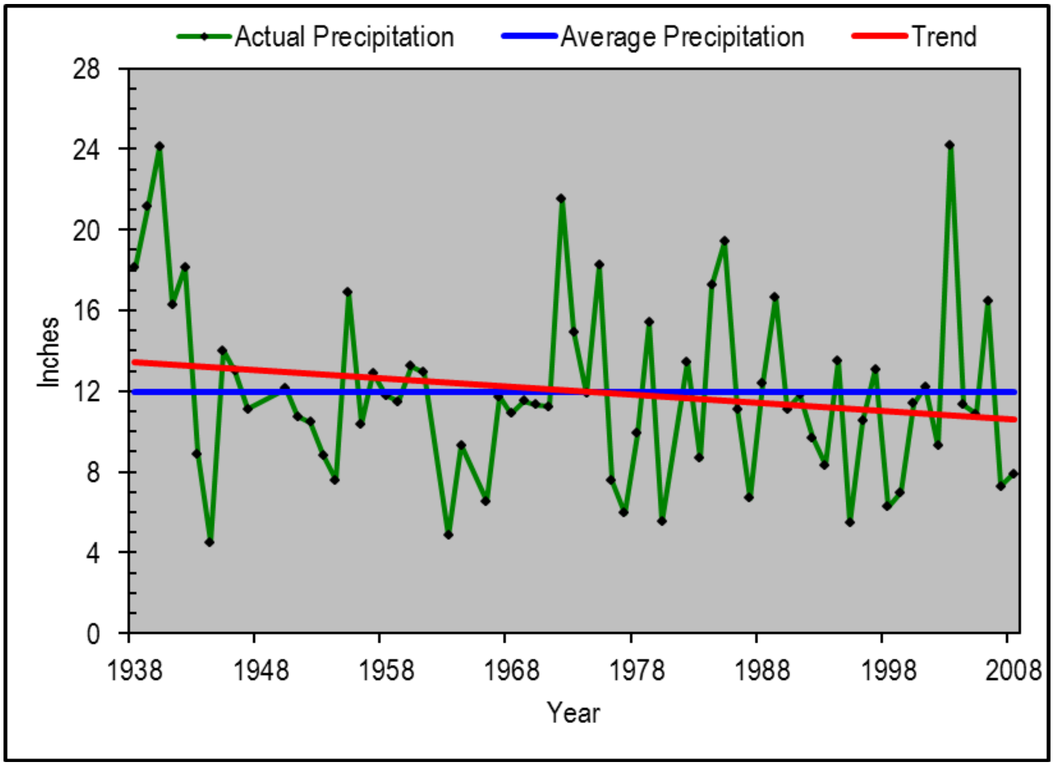

Figure C-9. Summer precipitation for Appomattox, VA from 1938 to 2008. The mean precipitation is 11.98 inches with a decreasing trend of 0.43 inches per decade. This figure omits 5 years with insufficient data (1948, 1949, 1962, 1965, and 1981).

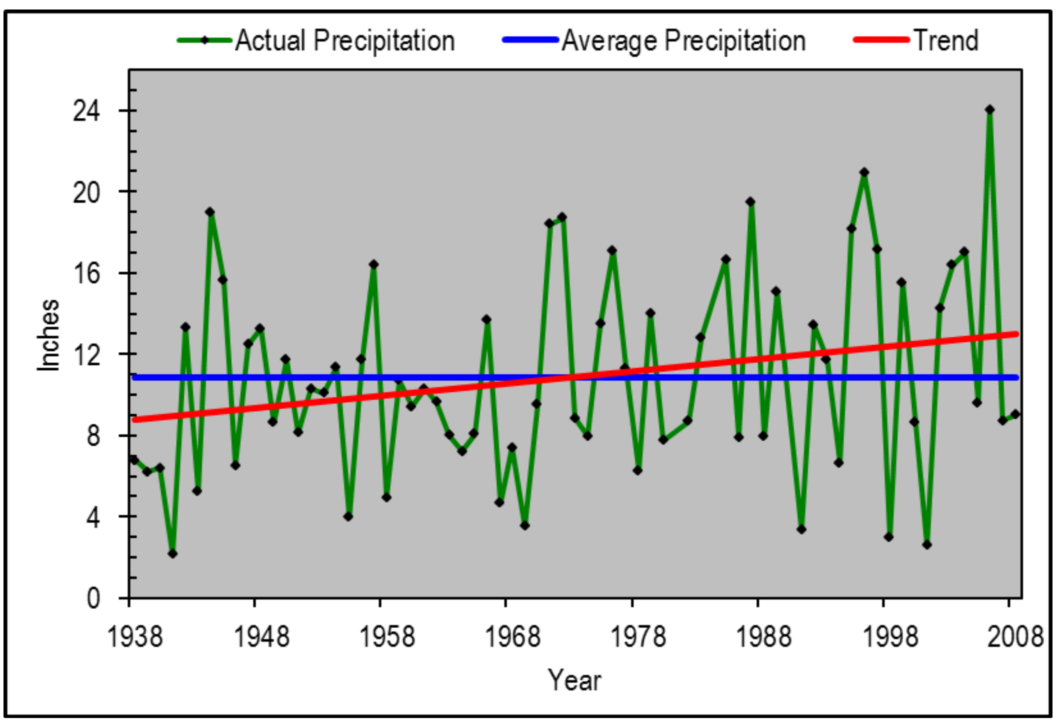

Figure C-10. Fall precipitation for Appomattox, VA from 1938 to 2008. The mean precipitation is 10.87 inches with an increasing trend of 0.60 inches per decade. The years 1981, 1984, and 1990 were omitted due to insufficient data.

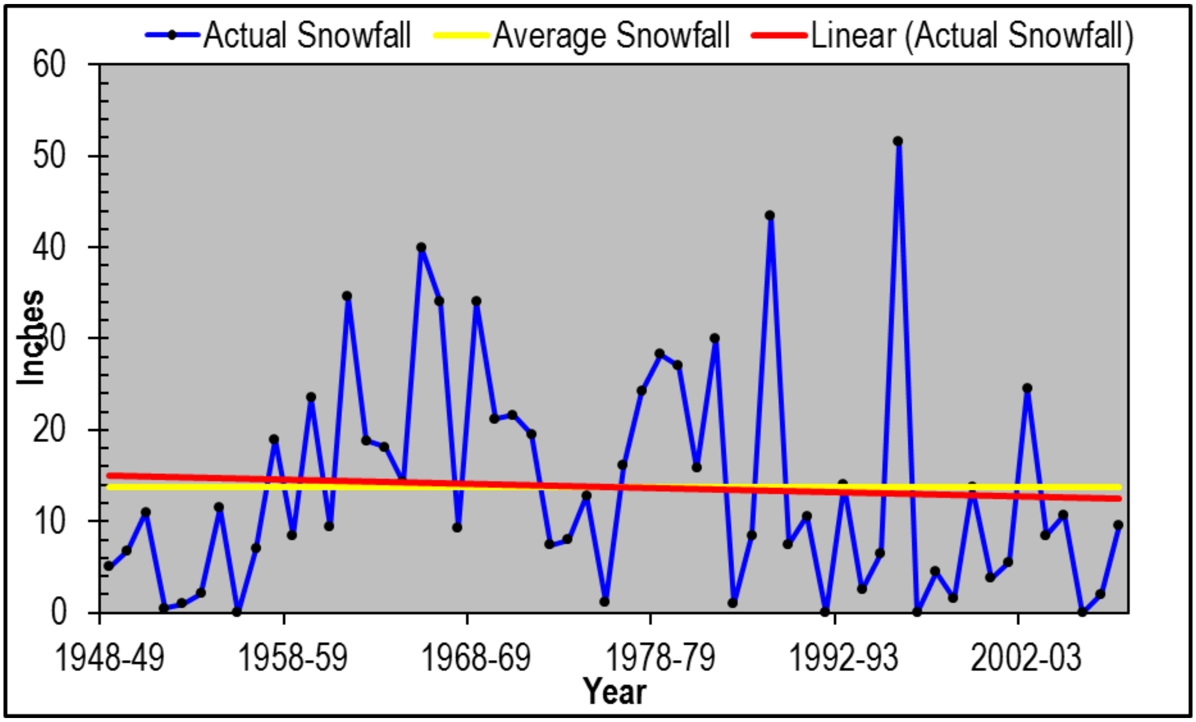

Figure C-11. Annual snowfall for Appomattox, VA from 1948 to 2008. The mean annual snowfall is 13.76 inches with a decreasing trend of 0.45 inches per decade. Five winters were omitted due to insufficient data (1980-81, 1984-85, 1987-88, 1990-91, and 2004-05.

Moisture

We also summarized information on drought severity using monthly data from NOAA for the Virginia Piedmont from 1895 to 2008. Drought severity was measured with the Palmer Drought Severity Index (PDSI, also as the Palmer Drought Index [PDI]). The PDSI attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months.

The PDSI values reflect the severity of drought and are classified into several levels (Table C-1). We used these classes for each monthly PDSI value from 1895 to 2008, and then determined the proportion of months in each class for each 9-year period for ease of comparison (Figure C-12).

Table C-1. Classification used for Palmer Drought Severity Index (PDSI) values.

PDSI Range	Class Description
-3 or less	Severely Dry
-2 to -3	Excessively Dry
-1 to -2	Abnormally Dry
-1 to 1	Slightly Dry/Favorably Moist
1 to 2	Abnormally Wet
2 to 3	Wet
3 or greater	Excessively Wet

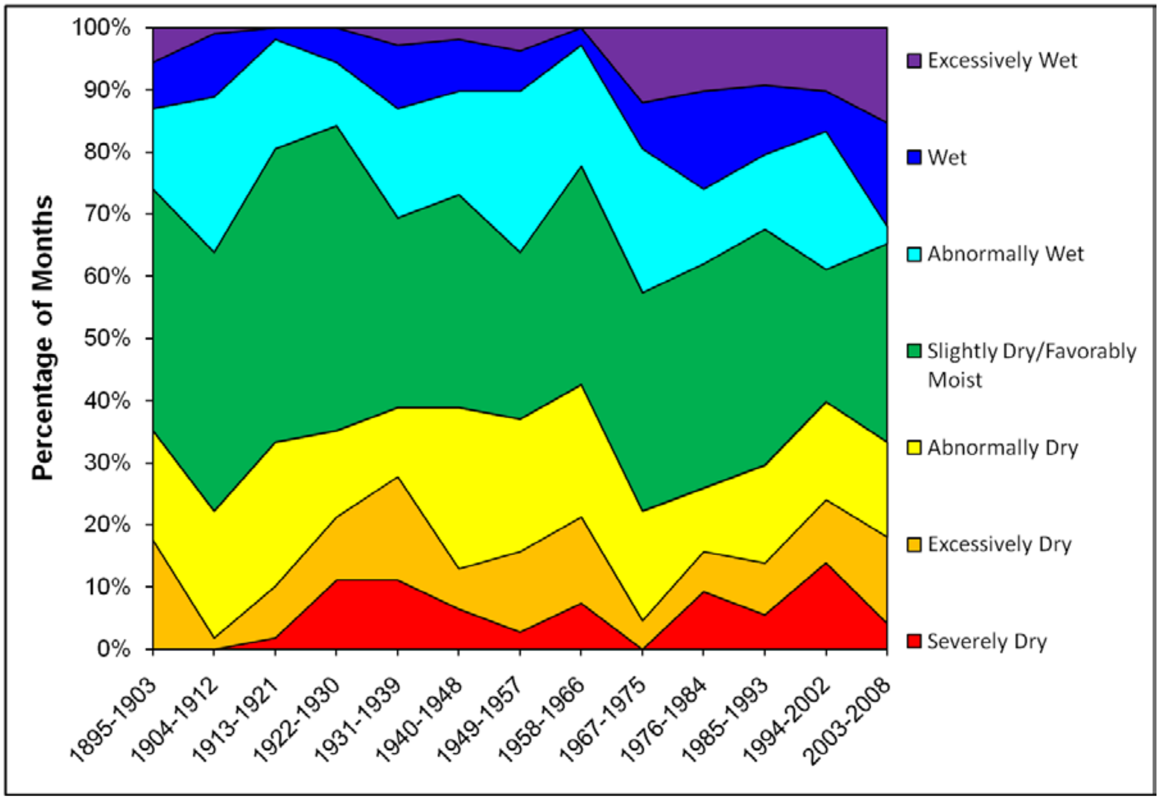

Figure C-12. PDSI value for the Western Piedmont region of VA for 9-year periods from 1895 to 2008.

Phenology (Growing Degree Days)

Patterns of seasonal variation in temperature and precipitation impact biological processes of all local biota. These cycles may alter the timing of many different behaviors like migration, flowering, and the birth of young. The study of such cycles and seasonal timing is termed "phenology" and changes in these annual cycles can provide information regarding important issues like the length of the growing season.

The best metric available for recording the passage of phenological time is "growing degree days." Growing degree days can be thought of as a measure of heat accumulation throughout a growing season. They can vary depending on the reference temperature corresponding to the species or process of interest. Therefore the reference temperature is often set to 40°F because at this temperature plants can photosynthesize, and it can be used as an indicator of the growing season. GDDs cannot be equated to calendar days as they are their own unit of measure. In this case, GDDs accumulate anytime the average temperature is more than 40 °F.

We calculated the approximate number of growing degree days per month for Appomattox Court House NHP by using monthly mean temperature data for weather collection stations in Appomattox, VA. Monthly temperature averages were available from 1963 to 2008 and were used to calculate the monthly growing degree day total with the formula:

$$GDD = (T_m - 40)\, D_m$$

Where GDD = Growing degree days

T_m = monthly mean temperature

D_m = number of days in month

The number of growing degrees days for each month were summed to determine the approximate number of growing degree days per year. These values were plotted against time (year) to illustrate the long-term trends in the numbers of growing degree days at Appomattox Court House NHP (Figure C-14).

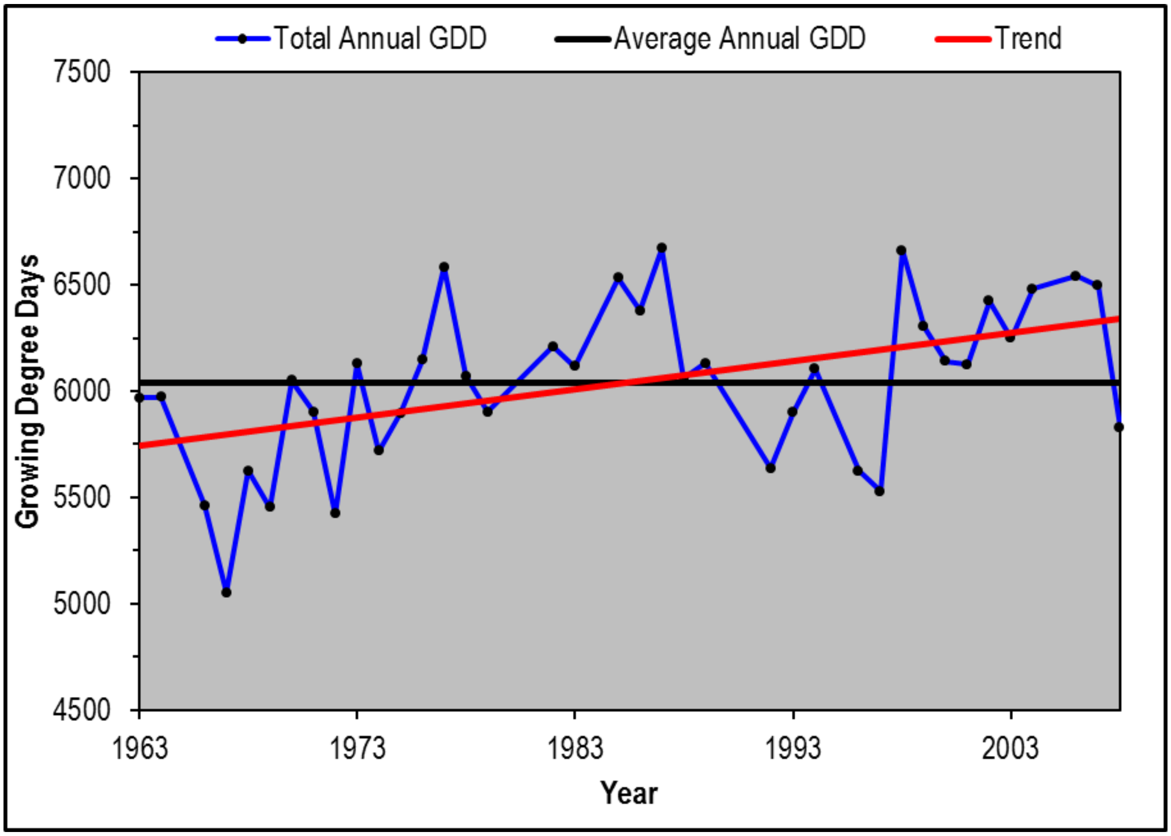

Figure C-14. The total annual growing degree days for Appomattox, VA from 1963 to 2008. The long-term average annual growing degree days (GDDs) is 6039. The trend line indicates an increasing amount of GDDs, approximately 132 per decade (R^2=0.23). This figure omits 10 years with incomplete data.

We observed an increasing trend in the annual number of growing degree days which may indicate an increase in the growing season through time. To better illustrate this, we elected to examine the same data in terms of phenology. Much research has been completed equating phenological events to growing degree days (McMaster and Wilhelm 1997, University of

Massachusetts Extension 2008, Virginia Tech FORSITE 2008). We attempted to put this in the context of a calendar year by selecting an arbitrary GDD reference value (1200 GDD) and estimating the date at which that number of growing degree days was achieved. This would be analogous to estimating the specific date a phenologic event was to occur (e.g., the blooming of dogwood trees).

Since our source data is a monthly mean daily temperature, we calculated the total monthly accumulated GDD by multiplying the mean daily temperature by the number of days in the month. We then set a reference number of GDDs at 1200 to approximate a springtime phenological event. Historically, this value was achieved during the month of May. We used the total GDD accumulated for the year through June 30th (sum of January, February, March, April, May, and June), then calculated the difference from 1200.

We estimated the number of days required to achieve the 1200 GDD by calculating the slope of the line for the appropriate month. If the difference was positive, we estimated the exact date where 1200 was achieved by determining the slope of the line between the total GDD for May and the total for June. If negative, the same procedure was used between April and May. This permitted us to use the most accurate daily rate in our estimation. Using this process we determined the calendar date that 1200 GDD was achieved for each year in the dataset and plotted it over time (Figure C-15).

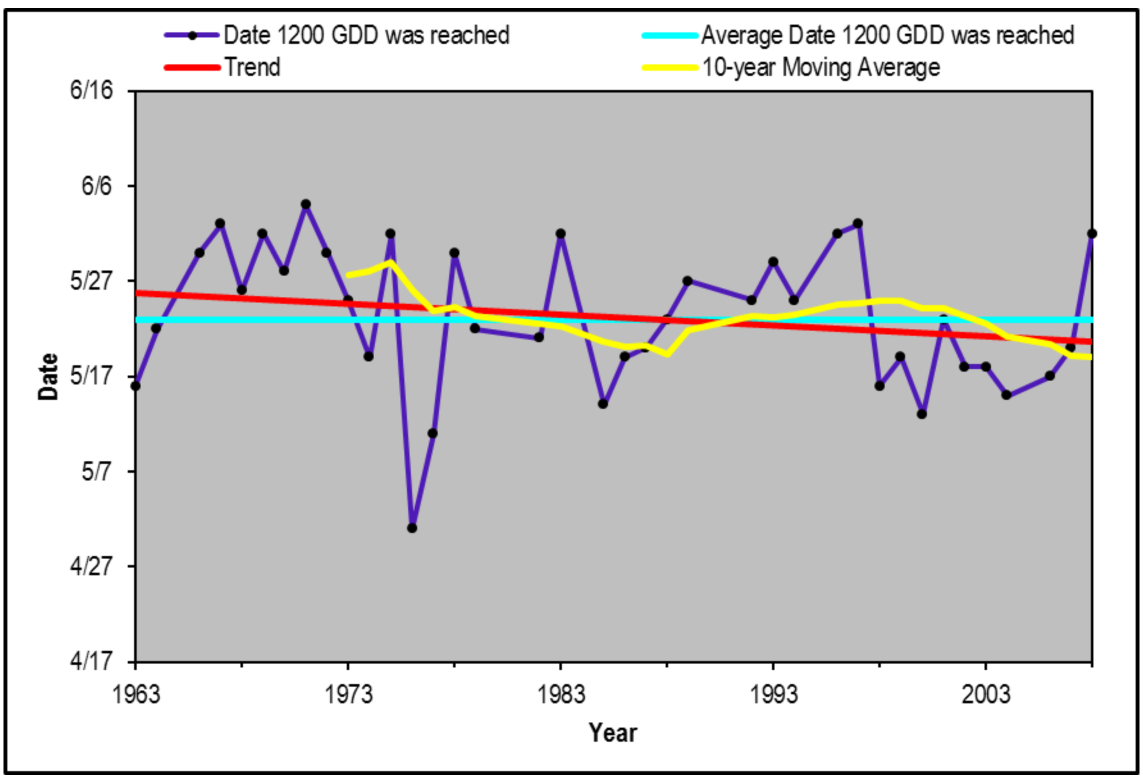

Figure C-15. The approximate date when 1200 GDD has been reached in Appomattox, VA during years 1963 – 2008. The mean annual date is 5/23. The decreasing trend indicates that this date is arriving earlier each year (1.1 days per decade.) This figure omits 10 years with incomplete data.

The decreasing trend suggests the growing season of Appomattox is lengthening over time since the date 1200 GDD is arriving earlier. However, the annual variation for this factor is high, making the correlation for this trend very weak (R^2 = 0.04).

Appendix D. Protected areas near Appomattox Court House National Historical Park.

Protected Area	Managed Area	Managing Agency	Acres
Woodlake Central Park	Local Park	Chesterfield County	15
Harrowgate Park	Local Park	Chesterfield County	30
Eppington Park	Local Park	Chesterfield County	43
Ettrick Park	Local Park	Chesterfield County	24
Breakthrough Battlefield	Non-Profit Fee Simple Holding	Civil War Preservation Trust	123
Lee Memorial Park	Local Park	City of Petersburg	375
Clover Hill Park	Local Park	Chesterfield County	94
Camp Baker	Local Park	Chesterfield County	21
Point of Rocks Park	Local Park	Chesterfield County	103
Matoaca Park	Local Park	Chesterfield County	30
Fort Lee Military Reservation	Military Installation	US Department of the Army	5350
Amelia Wildlife Management Area	State Wildlife Management Area	VA Dept of Game and Inland Fisheries	2233
Briery Creek Wildlife Management Area	State Wildlife Management Area	VA Dept of Game and Inland Fisheries	3131
Sandy River Reservoir	Reservoir	Prince Edward County	1452
Petersburg National Battlefield Park	National Park	US National Park Service	1376
Lake Amelia Public Fishing Lake	State Public Fishing Lake	VA Dept of Game and Inland Fisheries	98
Sailors Creek Battlefield State Park	State Park	VA Dept of Conservation and Recreation	314
Pocahontas State Park	State Park	VA Dept of Conservation and Recreation	7822
Lake Nottoway Public Fishing Lake	State Public Fishing Lake	VA Dept of Game and Inland Fisheries	163
Lake Nottoway Boat Access Area	Local Park	Nottoway County	152
Spring Creek Lake	Local Park	Prince Edward County	81
Prince Edward-Gallion State Forest	State Forest	VA Dept of Forestry	7030
Appomattox-Buckingham State Forest	State Forest	VA Dept of Forestry	20001
Featherfin Farm	State Wildlife Management Area	VA Dept of Game and Inland Fisheries	2749
Highbridge State Park	State Park	VA Dept of Conservation and Recreation	290

Appendix E. Regional Fire History.

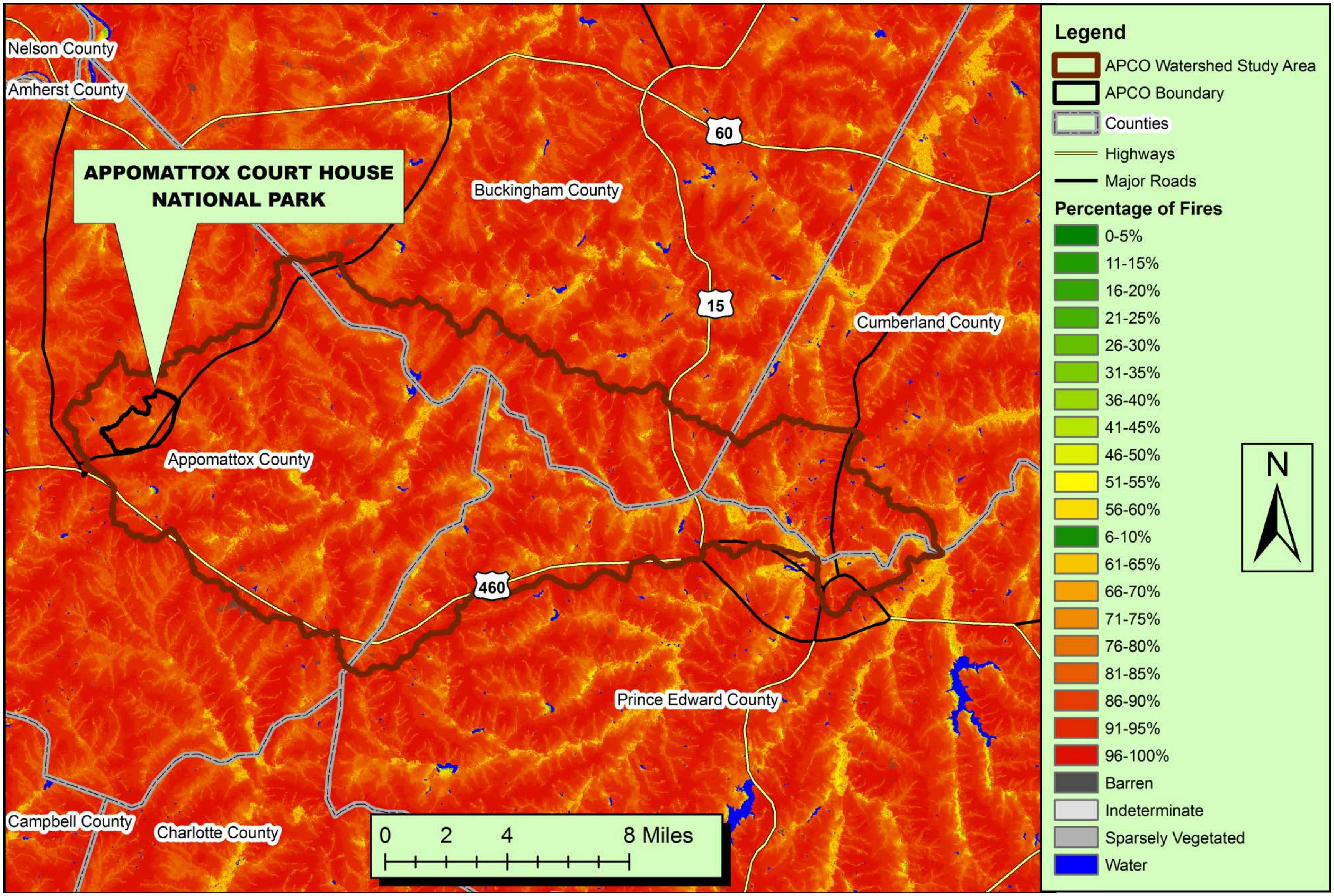

Figure E-1. Simulated historical percent of low severity fires according to LANDFIRE (USDA Forest Service 2006) in the region of Appomattox Court House National Historical Park (APCO).

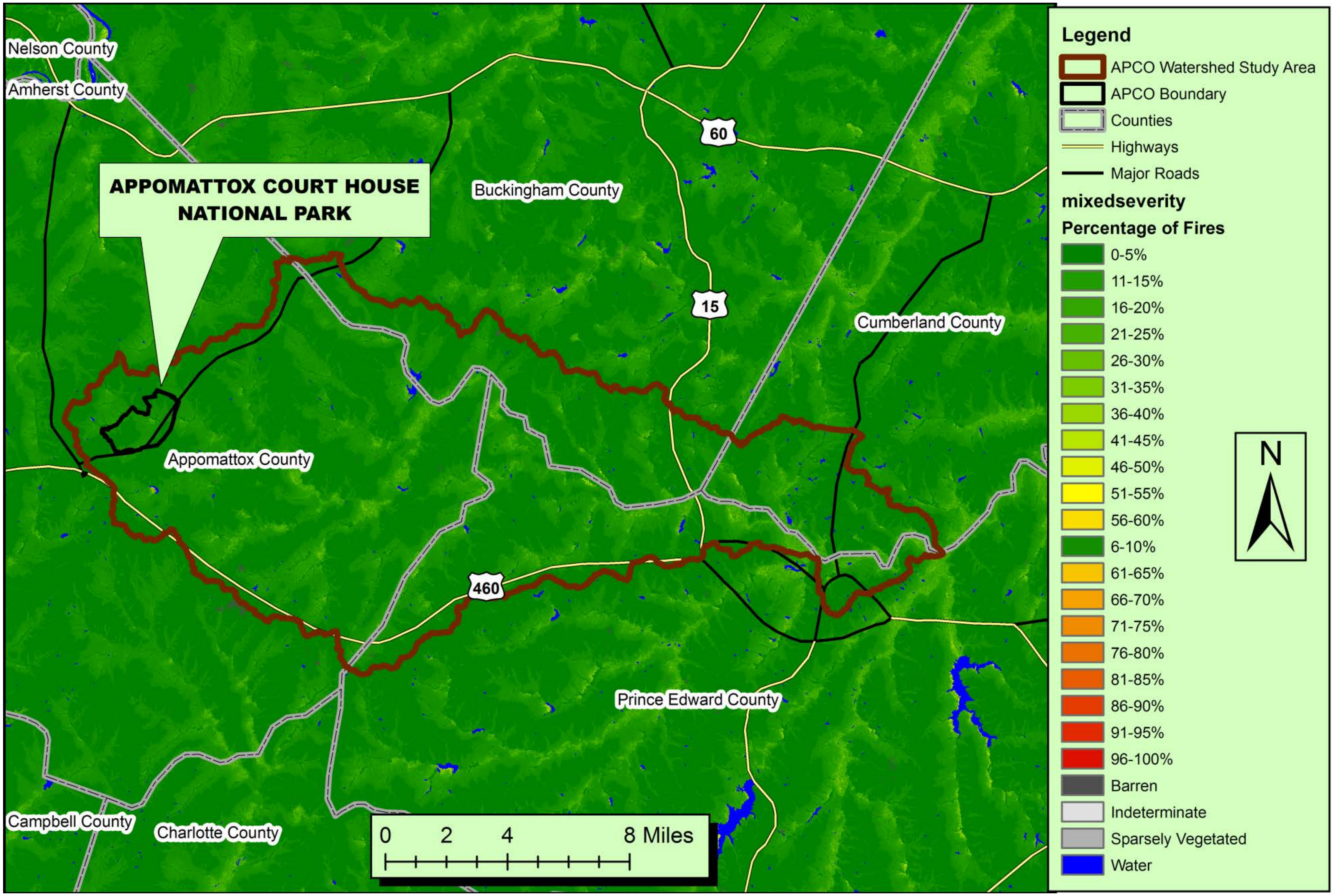

Figure E-2. Simulated historical percent of mixed severity fires according to LANDFIRE (USDA Forest Service 2006) in the region of Appomattox Court House National Historical Park (APCO).

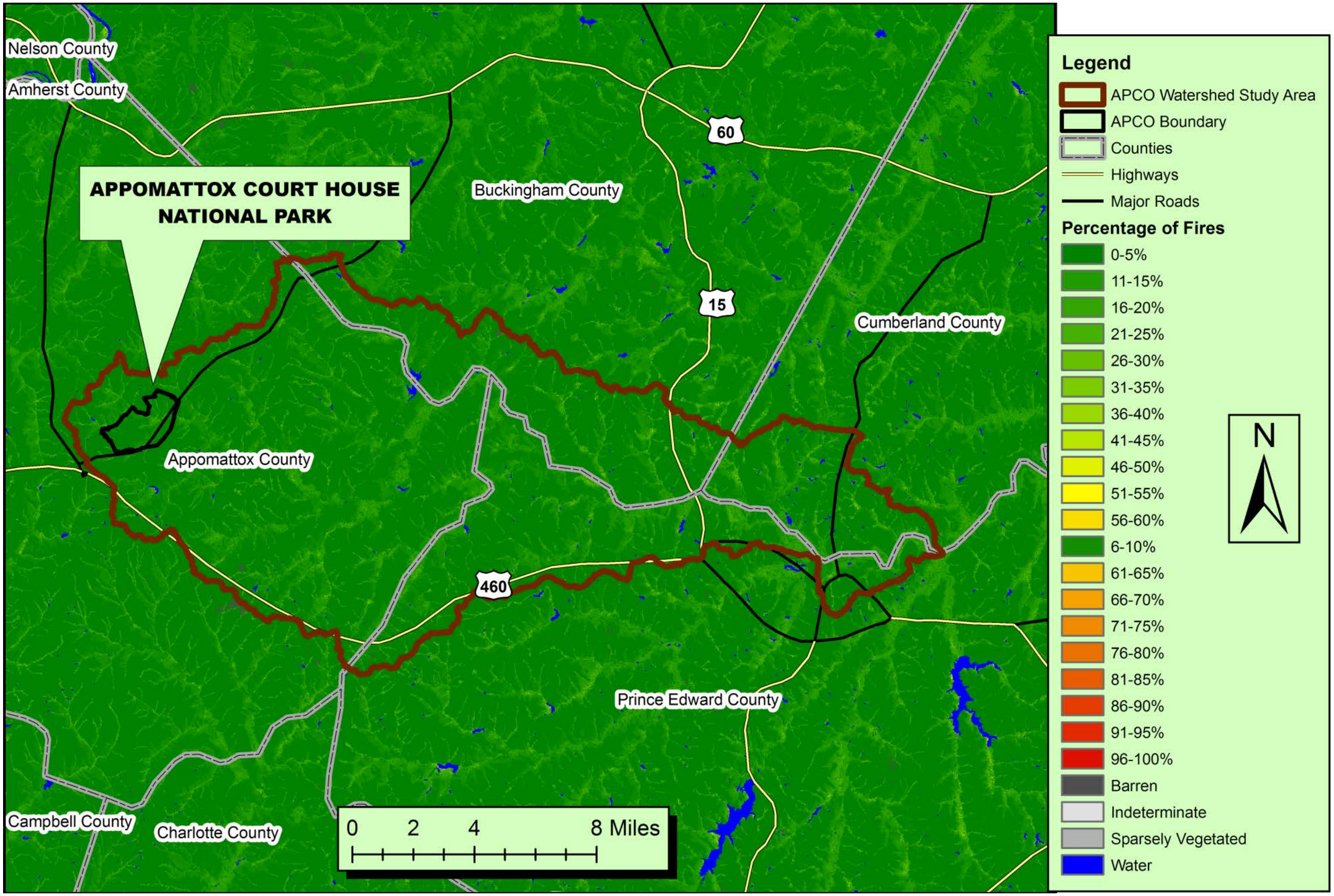

Figure E-3. Simulated historical percent of replacement severity fires according to LANDFIRE (USDA Forest Service 2006) in the region of Appomattox Court House National Historical Park (APCO).

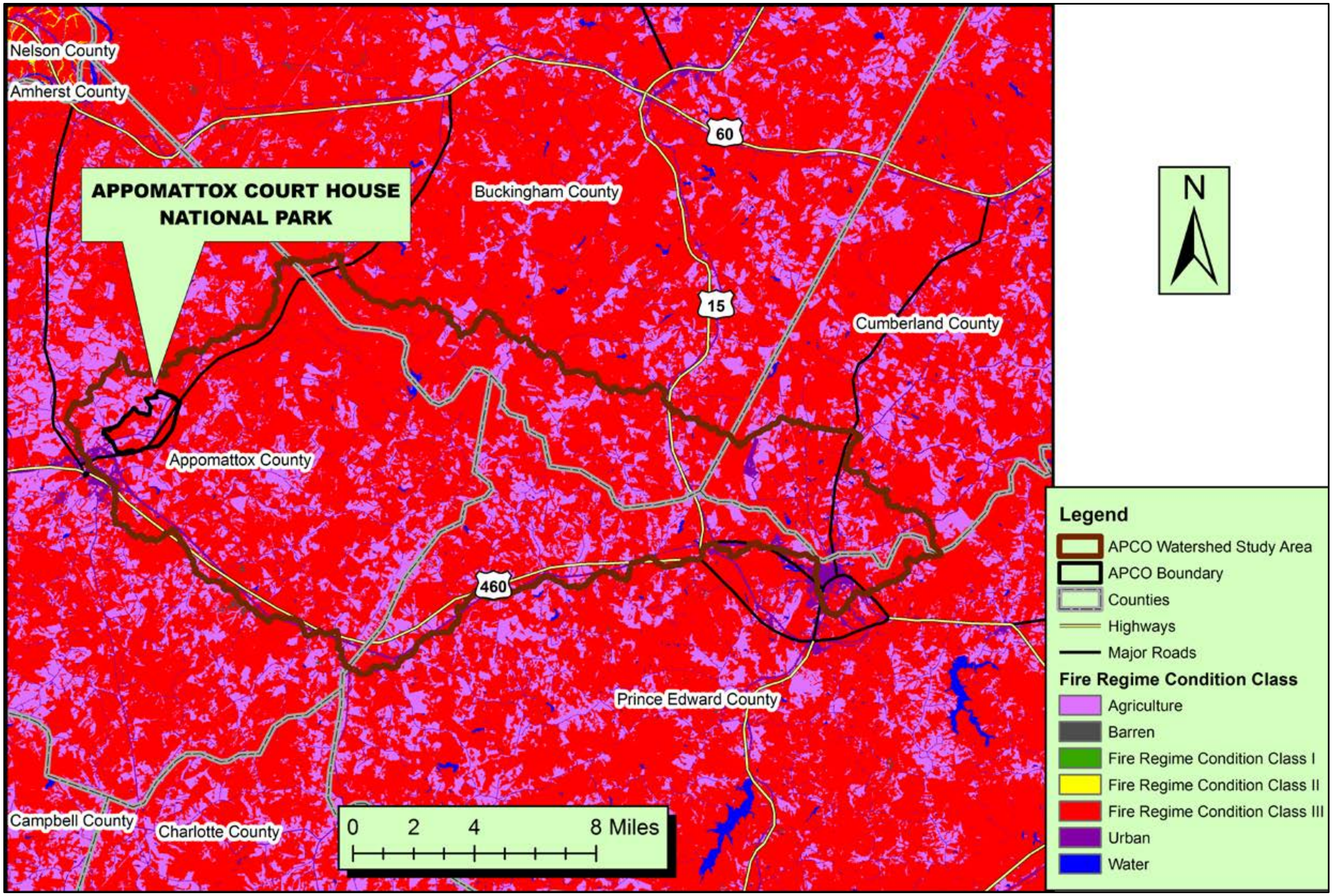

Figure E-4. Departure between current vegetation condition and reference vegetation condition according to LANDFIRE (USDA Forest Service 2006) in the region of Appomattox Court House National Historical Park (APCO). Fire Regime Condition Class I is low departure from historic vegetation; Condition Class II is moderate departure from historic vegetation; and Condition Class III is high departure from historic vegetation.

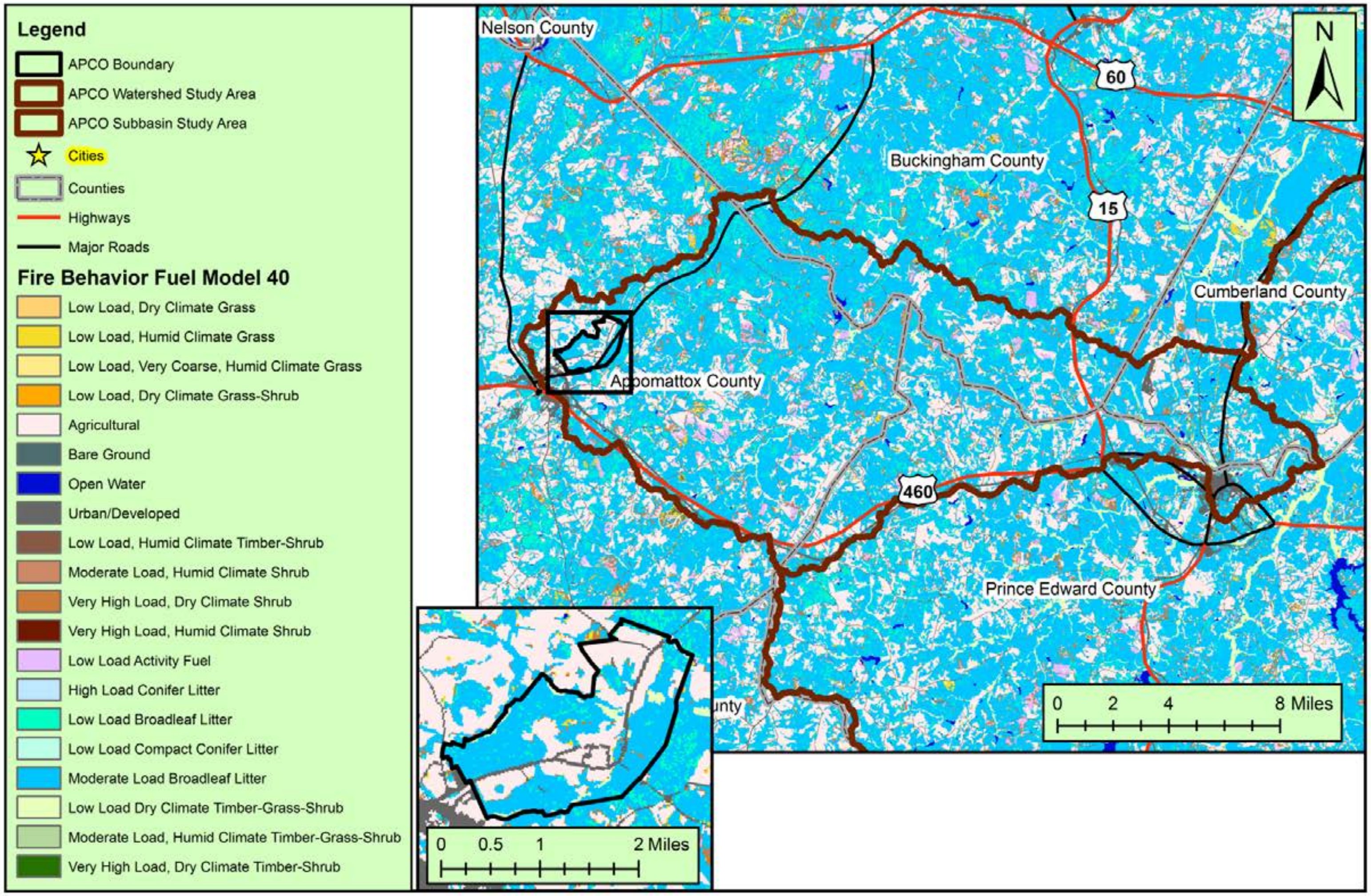

Figure E-5. Wildfire fuel types according to LANDFIRE (USDA Forest Service 2006) in the region of Appomattox Court House National Historical Park (APCO).

Appendix F. Wetland Integrity Methods.

Landscape Connectivity

Datasets

1. Park vegetation map provided by the National Park Service (NPS) (Appendix F-1).
2. National Land Cover Database (NLCD) (Appendix F-2).
3. Environmental Concern Inc. 2002.
4. National Hydrography Dataset (NHD).

Methodology

1. Export park wetlands in polygon format.
2. Reclass the park vegetation map to NLCD classifications (Table F-1).
3. Classify unfragmented/natural land cover types (Table F-2).
4. Merge the vegetation map with the surrounding NLCD.
5. Identify wetland polygons in the NWI adjacent to park wetlands.
6. Dissolve wetlands into contiguous groups (i.e., wetland complexes) in a GIS.
7. Define riverine and non-riverine wetland complexes utilizing the NHD.
8. Buffer non-riverine wetlands by 500 meters.
9. Buffer riverine wetlands 500 meters upstream and downstream, along the NHD, to a width of 100 feet.
10. Run spatial analysis in a GIS to determine percentage of unfragmented (non-riverine) or natural (riverine) landscape within the buffers.

Classification

1. Park vegetation reclassified to NLCD codes (Table F-1).
2. Unfragmented/Natural land cover (Table F-2).
3. Wetlands are defined by the park vegetation map. If these wetlands intersect the park boundary we will incorporate NWI wetlands that are adjacent to, and contiguous with, the park wetlands.

Analysis

Grades will quantify the percentage of unfragmented/natural landscape within each buffer based on the grading index provided by the NPS.

Table F-1. Park Service vegetation map crosswalk for NLCD classifications.

NLCD	Vegetation Map
11. Open Water	
12. Perennial Ice/Snow	
21. Developed, Open Space	Grazed Woodlot
22. Developed, Low Intensity	
23. Developed, Medium Intensity	Other Urban or Built-up Land
24. Developed, High Intensity	Transportation, Communications, and Utilities
31. Barren Land (Rock/Sand/Clay)	
41. Deciduous Forest	Dense Hardwood Regeneration, Oak - Hickory Forest, Piedmont / Low Elevation Mixed Oak / Heath Forest, Successional Black Walnut Forest, Successional Red-cedar Forest, Successional Tuliptree Forest, Successional Tree-of-Heaven Forest, Piedmont / Mountain Alluvial Forest, Inner Piedmont / Lower Blue Ridge Basic Mesic Forest, Mesic Mixed Hardwood Forest
42. Evergreen Forest	Successional Virginia Pine Forest, Virginia Pine Plantation, Loblolly Pine Plantation
43. Mixed Forest	
52. Shrub/Scrub	
71. Grassland/Herbaceous	
81. Pasture/Hay	Cultural Meadow
82. Cultivated Crops	
90. Woody Wetlands	
95. Emergent Herbaceous Wetlands	Beaver Wetland Complex, Northern Piedmont / Lower New England Basic Seepage Swamp, Upland Depression Swamp

Table F-2. Classification of natural systems.

Non-Anthropogenic	Anthropogenic Influence
11. Open Water	21. Developed, Open Space
12. Perennial Ice/Snow	22. Developed, Low Intensity
41. Deciduous Forest	23. Developed, Medium Intensity
42. Evergreen Forest	24. Developed, High Intensity
43. Mixed Forest	31. Barren Land (Rock/Sand/Clay)*
52. Shrub/Scrub	81. Pasture/Hay
71. Grassland/Herbaceous	82. Cultivated Crops
90. Woody Wetlands	
95. Emergent Herbaceous Wetlands	

* Applies to APCO but may not be true for parks with significant natural barren land cover (e.g. beaches).

Buffer Index

Datasets

1. Land cover dataset created under "Landscape Connectivity."
2. Wetland dataset created under "Landscape Connectivity."
3. National Elevation Dataset (NED).

Methodology

1. Identify and classify vegetated, non-anthropogenic land cover.
2. In a GIS determine the percentage of the wetland perimeter adjacent to buffer.
3. In a GIS determine the average width of identified buffer, corrected for slope.

Classification

1. Natural land cover defined as defined under "Landscape Connectivity"
2. Slope correction
    a) We assume that the length of the buffer should increase as slope increases. The simplest relationship to use would be the length of the slope which increases with any increase in rise (over a constant run). Using trigonometry, we know that the length of the slope is the square root of the rise squared plus the run squared. The run is constant at the threshold value provided (i.e., 200 m, 100m, 50m, 10m) and the increase in rise results in a lengthening run determined by this formula.
    b) The critical assumption is that the increased length provides the same "protection" as the 200m buffer does on flat ground. Or, the higher the slope the longer the slope length needed to provide equivalent protection. For example, if 200 m on flat ground provides protection, then the slope length (i.e., buffer width) on a 40% slope would be 215.4m. A percent slope of 40% is derived from a run of 200 m and a rise of 80 m (200 * 0.4). The slope distance is determined by taking the square root of 200 squared plus 80 squared. In other words, on a slope of 40% the minimum buffer width required to provide the same protection as 200 m on flat ground would be 215.4 m.

Analysis

Grades will be assigned for both the percent of natural land cover and average corrected buffer width based on the grading index provided by the NPS.

Surrounding Land Use Index

Datasets

1. Park boundary polygon.
2. Land cover as defined above.
3. 1:250,000 Hydrologic units from the U.S. Geological Survey (USGS).

Methodology

1. Buffer park boundary to landscape area as delineated by the 8-digit Hydrologic Unit Code (HUC).
2. Rank land cover by human impact.
3. In a GIS run analysis of land cover within the watershed.

Classification

Landcover classifications ranked by anthropogenic impact (Table F-3).

Analysis

Land cover index for the buffer area summed for each pixel divided by the total number of pixels in the area. The maximum value = 1 and minimum – 0. Grades will be assigned based on the grading index provided by the NPS.

Table F-3. Landcover ranking.

NLCD/Vegetation Class	Ranking
24. Developed, High Intensity	1
23. Developed, Medium Intensity	0.9
22. Developed, Low Intensity	0.8
21. Developed, Open Space	0.7
82. Cultivated Crops	0.6
31. Barren Land (Rock/Sand/Clay)	0.5
81. Pasture/Hay	0.3
11. Open Water, 12. Perennial Ice/Snow, 41. Deciduous Forest, 42. Evergreen Forest, 43. Mixed Forest, 52. Shrub/Scrub, 71. Grassland/Herbaceous, 90. Woody Wetlands, 95. Emergent Herbaceous Wetlands	0

Table F-4. Vegetation Types from the APCO Land Cover Map.

Local Name	NVCS Code
Beaver Wetland Complex	III.B.2.N.e
Cultural Meadow	V.A.5.N.c
Dense Hardwood Regeneration	Dense Hardwood Regeneration
Grazed Woodlot	Grazed Woodlot
Inner Piedmont / Lower Blue Ridge Basic Mesic Forest	I.B.2.N.a
Loblolly Pine Plantation	I.A.8.C.x
Mesic Mixed Hardwood Forest	I.B.2.N.a
Northern Piedmont / Lower New England Basic Seepage Swamp	I.B.2.N.g
Oak - Hickory Forest	I.B.2.N.a
Other Urban or Built-up Land	Other Urban or Built-up Land
Piedmont / Low Elevation Mixed Oak / Heath Forest	I.B.2.N.a
Piedmont / Mountain Alluvial Forest	I.B.2.N.d
Successional Black Walnut Forest	I.B.2.N.a
Successional Red-cedar Forest	I.A.8.N.c
Successional Tree-of-Heaven Forest	I.B.2.N.a
Successional Tuliptree Forest	I.B.2.N.a
Successional Virginia Pine Forest	I.A.8.N.b
Transportation, Communications, and Utilities	Transportation, Communications, and Utilities
Upland Depression Swamp	I.B.2.N.e
Virginia Pine Plantation	I.A.8.C.x

Appendix G. Description of abbreviations used in species tables.

NatureServe Ranks (NatureServe 2009):
Global Ranks:
G#G#: NatureServe Global Conservation Status Rank, Range Rank - A numeric range rank (e.g., G2G3) is used to indicate the rank of uncertainty in the status of a species or community. Ranges cannot skip more than one rank (e.g., GU should be used rather than G1G4).

G1: Critically Imperiled
At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.

G2: Imperiled
At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.

G3: Vulnerable
At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.

G4: Apparently Secure
Uncommon but not rare; some cause for long-term concern due to declines or other factors.
G5: Secure
Common; widespread, and abundant.

State Ranks:
S#S#: NatureServe Subnational Conservation Status Rank - Range Rank-A numeric range rank (e.g., S2S3) is used to indicate the range of uncertainty about the status of the species or community. Ranges cannot skip more than one rank (e.g., SU should be used rather than S1S4).

S?: Unranked
State/Province conservation status not yet assessed.

S1: Critically Imperiled
Critically imperiled in the state or province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state or province.

S2: Imperiled
Imperiled in the state or province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state or province.

S3: Vulnerable
Vulnerable in the state or province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4: Apparently Secure
Uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5: Secure
Common, widespread, and abundant in the state or province.

VDGIF listings for endangered, threatened, or rare species (Virginia Department of Game and Inland Fisheries 2009):
SS=State Special Concern
FS=Federal Species of Concern

Species of Greatest Conservation Need:
I=VA Wildlife Action Plan - Tier I - Critical Conservation Need
II=VA Wildlife Action Plan - Tier II - Very High Conservation Need
III=VA Wildlife Action Plan - Tier III - High Conservation Need
IV=VA Wildlife Action Plan - Tier IV - Moderate Conservation Need

Appendix H. Native (n=251) and nonnative (n=93) plant species documented at Appomattox Court House National Historical Park (Patterson 2008, NPS 2009). These species have been cross referenced to the Virginia Department of Conservation and Recreation's Division of Natural Heritage rare plant list (Virginia Department of Conservation and Recreation Division of Natural Heritage 2007).

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Alisma subcordatum	mud plantain water plantain	present	unknown	native					
Daucus carota	Queen Anne's lace	present	unknown	nonnative					
Sanicula canadensis	sanicle snakeroot	present	unknown	native					
Thaspium trifoliatum	meadow parsnip	present	unknown	native					
Arisaema triphyllum	jack-in-the-pulpit	present	unknown	native					
Aristolochia serpentaria	Virginia snakeroot	present	unknown	native					
Achillea millefolium	milfoil yarrow	present	unknown	nonnative					
Ageratina altissima	white snakeroot	present	unknown	native					
Ambrosia artemisiifolia	bitter-weed common ragweed roman wormwood	present	unknown	native					
Ambrosia trifida	giant ragweed	present	unknown	native					
Aster dumosus	rice button aster	present	unknown	native					
Aster pilosus	frost aster	present	unknown	native					
Bidens bipinnata	Spanish needles	present	unknown	native					
Bidens frondosa	beggar ticks stick tight	present	unknown	native					
Brickellia eupatorioides	false boneset	present	unknown	native					
Centaurea biebersteinii	spotted knapweed	present	unknown	nonnative					
Chrysopsis mariana	Maryland golden aster	present	unknown	native					
Cichorium intybus	chicory	present	unknown	nonnative					
Cirsium arvense	Canada thistle	present	unknown	nonnative					
Cirsium discolor	field thistle	present	unknown	native					
Cirsium vulgare	bull thistle	present	unknown	nonnative					
Conoclinium coelestinum	blue mistflower	present	unknown	native					
Coreopsis verticillata	whorled tickseed	present	unknown	native					
Eclipta prostrata	eclipta false daisy yerba de tago	present	unknown	native					
Elephantopus carolinianus	elephant's-foot	present	unknown	native					
Erigeron annuus	daisy fleabane	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Erigeron canadensis	butterweed hogweed horseweed	present	unknown	native					
Erigeron philadelphicus	daisy fleabane	present	unknown	native					
Erigeron strigosus	daisy fleabane	present	unknown	native					
Eupatorium fistulosum	Joe-pye-weed Queen-of-the-meadow	present	unknown	native					
Eupatorium godfreyanum	Godfrey's thoroughwort	present	unknown	native					
Eupatorium hyssopifolium	hyssopleaf thoroughwort	present	unknown	native					
Eurybia divaricata	white wood aster	present	unknown	native					
Gamochaeta purpurea	spoonleaf purple everlasting spoon-leaf purple everlasting	present	unknown	nonnative					
Gnaphalium obtusifolium	catfoot	present	unknown	native					
Helianthus strumosus	paleleaf woodland sunflower	present	unknown	native					
Hieracium gronovii	gronovis hawkweed queendevil	present	unknown	native					
Hieracium pilosella	hawkweed	present	unknown	nonnative					
Hieracium scabrum	hawkweed	present	unknown	native					
Hieracium venosum	poor robin's plantain rattlesnake weed	present	unknown	native					
Krigia virginica	dwarf dandelion	present	unknown	native					
Lactuca saligna	willow-leaved lettuce	present	unknown	nonnative					
Leucanthemum vulgare	oxeye daisy	present	unknown	nonnative					
Liatris squarrosa	scaly blazing star scaly gayfeather	present	unknown	native					
Mikania scandens	climbing hempvine climbing hempweed	present	unknown	native					
Packera anonyma	small's ragwort	present	unknown	native					
Parthenium integrifolium	wild quinine	present	unknown	native					
Pyrrhopappus carolinianus	false dandelion	present	unknown	native					
Rudbeckia hirta	black-eyed susan	present	unknown	native					
Sericocarpus asteroides	white-topped aster	present	unknown	native					
Silphium trifoliatum	rosinweed	present	unknown	native					
Solidago canadensis	goldenrod	present	unknown	native					
Solidago juncea	early goldenrod	present	unknown	native					
Solidago nemoralis	dyersweed goldenrod gray goldenrod	present	unknown	native					
Solidago rugosa	goldenrod	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Solidago speciosa	noble goldenrod showy goldenrod	present	unknown	native					
Symphyotrichum dumosum	rice button aster	present	unknown	native					
Symphyotrichum pilosum	hairy white oldfield aster	present	unknown	native					
Taraxacum laevigatum	red-seed dandelion rock dandelion, rock dandylion	present	unknown	nonnative					
Verbesina alternifolia	wingstem	present	unknown	native					
Verbesina occidentalis	yellow crownbeard	present	unknown	native					
Vernonia glauca	ironweed	present	unknown	native					
Vernonia noveboracensis	ironweed New York ironweed	present	unknown	native					
Lobelia inflata	Indian-tobacco	present	unknown	native					
Lobelia siphilitica	great lobelia	present	unknown	native					
Specularia perfoliata	Venus' looking glass	present	unknown	native					
Barbarea vulgaris	common winter-cress yellow rocket	present	unknown	nonnative					
Brassica rapa	rape, turnip	present	unknown	nonnative					
Cardamine hirsuta	bitter cress	present	unknown	nonnative					
Lepidium campestre	cow cress field cress	present	unknown	nonnative					
Teesdalia nudicaulis	shepard vress	present	unknown	nonnative					
Cerastium fontanum	mouse-ear chickweed	present	unknown	nonnative					
Cerastium glomeratum	mouse-ear chickweed	present	unknown	nonnative					
Dianthus armeria	deptford pink	present	unknown	nonnative					
Silene antirrhina	sleepy catchfly	present	unknown	native					
Stellaria media	chickweed	present	unknown	nonnative					
Phytolacca americana	pigeonberry poke pokeweed	present	unknown	native					
Ilex opaca	American holly	present	unknown	native					
Euonymus americana	bursting heart strawberry bush	present	unknown	native					
Commelina communis	dayflower	present	unknown	nonnative					
Cornus florida	flowering dogwood	present	unknown	native					
Nyssa sylvatica	black gum, black tupelo	present	unknown	native					
Carex caroliniana	Carolina sedge	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Carex cephalophora	ovalleaf sedge oval-leaf sedge, oval-leaved sedge	present	unknown	native					
Carex crinita	fringed sedge	present	unknown	native					
Carex frankii	Frank's sedge	present	unknown	native					
Carex laevivaginata	smoothsheath sedge wooly sedge	present	unknown	native					
Carex laxiflora	broad looseflower sedge	present	unknown	native					
Carex lurida	shallow sedge	present	unknown	native					
Carex pensylvanica	Penn sedge Pennsylvania sedge	present	unknown	native					
Carex scoparia	broom sedge pointed broom sedge	present	unknown	native					
Carex squarrosa	squarrose sedge	present	unknown	native					
Carex swanii	swan sedge swan's sedge	present	unknown	native					
Cyperus echinatus	globe flatsedge	present	unknown	native					
Cyperus pseudovegetus	marsh flatsedge	present	unknown	native					
Cyperus retrofractus	rough flatsedge	present	unknown	native					
Schoenoplectus tabernaemontani	great bulrush softstem bulrush soft-stem bulrush	present	unknown	native					
Scirpus atrovirens	dark-green bulrush green bulrush	present	unknown	native					
Scleria pauciflora	fewflower nutrush	present	unknown	native					
Andropogon virginicus	broom sedge	present	unknown	native					
Aristida dichotoma	poverty grass	present	unknown	native					
Arthraxon hispidus	hairy jointgrass	present	unknown	nonnative					
Avena sativa	oats	present	unknown	nonnative					
Bromus japonicus	Japanese brome Japanese bromegrass Japanese chess	present	unknown	nonnative					
Dichanthelium boscii	Bosc's panicgrass	present	unknown	native					
Dichanthelium clandestinum	deer tongue grass	present	unknown	native					
Dichanthelium commutatum	variable panicgrass	present	unknown	native					
Dichanthelium dichotomum	cypress panicgrass	present	unknown	native					
Elymus riparius	river wild-rye riverbank wildrye	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Eragrostis spectabilis	purple lovegrass	present	unknown	native					
Glyceria striata	fowl-meadow grass	present	unknown	native					
Hystrix patula	bottlebrush grass	present	unknown	native					
Lolium pratense	meadow fescue meadow ryegrass	present	unknown	nonnative					
Microstegium vimineum	Japanese stiltgrass	present	unknown	nonnative					
Panicum anceps	beaked panicgrass beaked panicum	present	unknown	native					
Paspalum floridanum	Florida paspalum	present	unknown	native					
Paspalum laeve	field paspalum	present	unknown	native					
Pennisetum glaucum	pearl millet pearl-millet yellow bristlegrass	present	unknown	nonnative					
Phleum pratense	timothy	present	unknown	nonnative					
Setaria faberi	nodding foxtail	present	unknown	nonnative					
Sorghastrum nutans	Indian grass wood grass	present	unknown	native					
Sorghum halepense	johnson grass	present	unknown	nonnative					
Tripsacum dactyloides	gama grass sesame grass	present	unknown	native					
Lonicera japonica	Japanese honeysuckle	present	unknown	nonnative					
Sambucus nigra ssp. canadensis	blue elder common elderberry elder	present	unknown	native					
Symphoricarpos orbiculatus	buck bush coralberry Indian current	present	unknown	native					
Diospyros virginiana	persimmon	present	unknown	native					
Vaccinium pallidum	lowbush blueberry	present	unknown	native					
Vaccinium stamineum	deerberry	present	unknown	native					
Chimaphila maculata	pipsissewa spotted wintergreen	present	unknown	native					
Buxus sempervirens	English boxwood	present	unknown	nonnative					
Acalypha rhomboidea	three-seeded mercury	present	unknown	native					
Chamaesyce maculata	large spurge spotted sandmat spotted spurge	present	unknown	native					
Euphorbia corollata	flowering spurge tramp spurge	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Euphorbia cyparissias	cypress spurge	present	unknown	nonnative					
Albizia julibrissin	mimosa	present	unknown	nonnative					
Amphicarpa bracteata	hog peanut	present	unknown	native					
Baptisia tinctoria	wild false indigo	present	unknown	native					
Cassia fasciculata	partridge pea	present	unknown	native					
Cassia nictitans	wild sensitive plant	present	unknown	native					
Cercis canadensis	judas tree, redbud	present	unknown	native					
Coronilla varia	crowned vetch	present	unknown	nonnative					
Desmodium canescens	beggar lice	present	unknown	native					
Desmodium glutinosum	largeflower tickclover pointedleaf ticktrefoil trefoil tickclover	present	unknown	native					
Desmodium laevigatum	smooth tickclover smooth ticktrefoil	present	unknown	native					
Desmodium marilandicum	Maryland tickclover smooth small-leaf ticktrefoil	present	unknown	native					
Desmodium nudiflorum	beggar lice beggar's ticks	present	unknown	native					
Desmodium obtusum	stiff tickclover stiff ticktrefoil	present	unknown	native					
Desmodium paniculatum	narrow-leaf tick-trefoil panicled tickclover, panicledleaf ticktrefoil	present	unknown	native					
Desmodium rotundifolium	prostrate ticktrefoil roundhead tickclover	present	unknown	native					
Desmodium viridiflorum	beggar lice beggar's ticks	present	unknown	native					
Gleditsia triacanthos	honey-locust honey-shuck	present	unknown	native					
Kummerowia stipulacea	Korean clover Korean lespedeza	present	unknown	nonnative					
Lespedeza cuneata	Sericea	present	unknown	nonnative					
Lespedeza intermedia	intermediate lespedeza	present	unknown	native					
Lespedeza procumbens	trailing lespedeza	present	unknown	native					
Lespedeza repens	creeping lespedeza	present	unknown	native					
Lespedeza virginica	slender lespedeza	present	unknown	native					
Melilotus alba	white sweet clover	present	unknown	nonnative					
Robinia pseudoacacia	black locust	present	unknown	native					
Strophostyles umbellata	wild bean	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Stylosanthes biflora	pencil flower	present	unknown	native					
Tephrosia virginiana	Virginia tephrosia	present	unknown	native					
Trifolium arvense	rabbit foot clover	present	unknown	nonnative					
Trifolium campestre	low hop clover	present	unknown	nonnative					
Trifolium dubium	low hop clover	present	unknown	nonnative					
Trifolium pratense	red clover	present	unknown	nonnative					
Trifolium repens	white clover	present	unknown	nonnative					
Vicia caroliniana	wood vetch	present	unknown	native					
Vicia dasycarpa	smooth vetch	present	unknown	nonnative					
Vicia sativa	vetch	present	unknown	nonnative					
Vicia villosa	hairy vetch winter vetch	present	unknown	nonnative					
Wisteria sinensis	Chinese wisteria	present	unknown	nonnative					
Alnus serrulata	hazel alder	present	unknown	native					
Carpinus caroliniana	hornbeam	present	unknown	native					
Fagus grandifolia	American beech beech	present	unknown	native					
Quercus alba	white oak	present	unknown	native					
Quercus coccinea	scarlet oak	present	unknown	native					
Quercus falcata	southern red oak spanish oak	present	unknown	native					
Quercus marilandica	black jack oak	present	unknown	native					
Quercus phellos	willow oak	present	unknown	native					
Quercus prinus	chestnut oak	present	unknown	native					
Quercus rubra	northern red oak	present	unknown	native					
Quercus stellata	post oak	present	unknown	native					
Quercus velutina	black oak	present	unknown	native					
Apocynum cannabinum	Indian hemp	present	unknown	native					
Vinca major	periwinkle	present	unknown	nonnative					
Vinca minor	periwinkle	present	unknown	nonnative					
Asclepias purpurascens	purple milkweed	present	unknown	native	Yes	G5?	S2		
Asclepias syriaca	common milkweed	present	unknown	native					
Asclepias tuberosa	butterfly-weed pleurisy-root	present	unknown	native					
Asclepias viridiflora	green antelopehorn milkweed green comet milkweed green milkweed	present	unknown	native					
Cynanchum laeve	blue vine, sand vine	present	unknown	native					
Sabatia angularis	bitter-bloom, rose pink	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Impatiens capensis	jewel-weed spotted-touch-me-not	present	unknown	native					
Geranium dissectum	cranesbill	present	unknown	nonnative					
Oxalis stricta	wood sorrel	present	unknown	native					
Platanus occidentalis	sycamore	present	unknown	native					
Carya alba	mockernut hickory	present	unknown	native					
Carya glabra	pignut hickory	present	unknown	native					
Carya ovalis	sweet pignut hickory	present	unknown	native					
Carya ovata	shagbark hickory	present	unknown	native					
Juglans nigra	black walnut	present	unknown	native					
Juncus dichotomus	forked rush	present	unknown	native					
Juncus tenuis	path rush	present	unknown	native					
Buglossoides arvensis	corn gromwell	present	unknown	nonnative					
Clinopodium vulgare	wild basil	present	unknown	native					
Hedeoma pulegioides	pennyroyal pudding-grass	present	unknown	native					
Lamium amplexicaule	henbit deadnettle	present	unknown	nonnative					
Lycopus americanus	bugleweed	present	unknown	native					
Lycopus virginicus	Virginia bugleweed Virginia water horehound	present	unknown	native					
Perilla frutescens	beefsteak beefsteak mint beefsteakplant	present	unknown	nonnative					
Prunella vulgaris	heal-all	present	unknown	native					
Pycnanthemum incanum	hoary mountainmint	present	unknown	native					
Pycnanthemum tenuifolium	narrowleaf mountainmint narrowleaf mountianmint	present	unknown	native					
Salvia lyrata	cancer-weed lyre-leaved salvia	present	unknown	native					
Scutellaria elliptica	hairy skullcap	present	unknown	native					
Scutellaria integrifolia	helmet flower	present	unknown	native					
Phryma leptostachya	lop-seed	present	unknown	native					
Verbena simplex	narrowleaf vervain narrow-leaved vervain simple verbena	present	unknown	native					
Verbena urticifolia	white verbena white vervain	present	unknown	native					
Sassafras albidum	sassafras	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Hypoxis hirsuta	common goldstar eastern yellow star-grass	present	unknown	native					
Sisyrinchium angustifolium	blue-eyed grass	present	unknown	native					
Allium vineale	field garlic	present	unknown	nonnative					
Hemerocallis fulva	common orange day lily	present	unknown	nonnative					
Muscari neglectum	grape hyacinth	present	unknown	nonnative					
Polygonatum biflorum	solomon's seal	present	unknown	native					
Smilacina racemosa		present	unknown	native					
Uvularia perfoliata	perfoliate bellwort	present	unknown	native					
Smilax glauca	sarsaparilla sawbrier	present	unknown	native					
Smilax rotundifolia	bullbrier china-brier tramp's trouble	present	unknown	native					
Linum virginianum	flax	present	unknown	native					
Lycopodium digitatum	fan clubmoss	present	unknown	native					
Liriodendron tulipifera	tulip poplar	present	unknown	native					
Hibiscus syriacus	rose of sharon	present	unknown	nonnative					
Cuphea viscosissima	waxweed	present	unknown	native					
Lagerstroemia indica	crepe myrtle	present	unknown	nonnative					
Ludwigia alternifolia	seedbox	present	unknown	native					
Oenothera fruticosa ssp. glauca	narrowleaf evening primrose	present	unknown	native					
Botrychium virginianum	rattlesnake fern	present	unknown	native					
Goodyera pubescens	downy rattlesnake plantain	present	unknown	native					
Spiranthes gracilis	southern slender ladies-tresses	present	unknown	native					
Spiranthes tuberosa	little ladiestresses little ladies'-tresses	present	unknown	native					
Juniperus virginiana	eastern redcedar red cedar	present	unknown	native					
Pinus echinata	long-tag pine shortleaf pine yellow pine	present	unknown	native					
Pinus taeda	loblolly pine	present	unknown	nonnative					
Pinus virginiana	scrub pine Virginia pine	present	unknown	native					
Tsuga canadensis	Canadian hemlock eastern hemlock	present	unknown	native					
Plantago aristata	bottlebrush Indianwheat argebracted plantain	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Plantago lanceolata	English plantain ribgrass	present	unknown	nonnative					
Plantago rugelii	blackseed plantain black-seed plantain Rugel's plantain	present	unknown	native					
Polygala verticillata	whorled milkwort	present	unknown	native					
Polygonum caespitosum var. longisetum	oriental ladysthumb	present	unknown	nonnative					
Polygonum persicaria	lady's thumb	present	unknown	nonnative					
Polygonum sagittatum	arrow-leaved tearthumb	present	unknown	native					
Rumex acetosella	sheep-sorrel sour-grass	present	unknown	nonnative					
Rumex crispus	dock	present	unknown	nonnative					
Rumex patientia	patience dock	present	unknown	nonnative					
Athyrium asplenioides	southern lady fern	present	unknown	native					
Onoclea sensibilis	sensitive fern	present	unknown	native					
Polystichum acrostichoides	Christmas fern	present	unknown	native					
Anagallis arvensis	poor man's weather-glass scarlet pimpernel	present	unknown	nonnative					
Lysimachia ciliata	fringed loosestrife fringed yellow-loosestrife	present	unknown	native					
Berberis thunbergii	Japanese barberry	present	unknown	nonnative					
Nandina domestica	heavenly bamboo	present	unknown	nonnative					
Podophyllum peltatum	mandrake may-apple	present	unknown	native					
Anemone virginiana	thimbleweed	present	unknown	native					
Clematis ochroleuca	curly heads	present	unknown	native					
Ranunculus bulbosus	buttercup	present	unknown	nonnative					
Thalictrum pubescens	muskrat-weed tall meadow-rue	present	unknown	native					
Ceanothus americanus	New Jersey tea	present	unknown	native					
Parthenocissus quinquefolia	Virginia creeper	present	unknown	native					
Vitis labrusca	fox grape	present	unknown	native					
Vitis rotundifolia	muscadine muscadine grape	present	unknown	native					
Agrimonia parviflora	agrimony cocklebur harvest lice	present	unknown	native					
Amelanchier arborea	downy serviceberry	present	unknown	native					
Chaenomeles japonica	flowering quince	present	unknown	nonnative					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Duchesnea indica	Indian strawberry	present	unknown	nonnative					
Fragaria virginiana	strawberry	present	unknown	native					
Geum canadense	white avens	present	unknown	native					
Potentilla canadensis	five fingers	present	unknown	native					
Potentilla recta	roughfruit cinquefoil sulfur (or erect) cinquefoil sulfur cinquefoil	present	unknown	nonnative					
Prunus domestica	plum	present	unknown	nonnative					
Prunus persica	peach	present	unknown	nonnative					
Prunus serotina	black cherry	present	unknown	native					
Pyracantha coccinea	firethorn 'leylandii' variety	present	unknown	nonnative					
Rosa carolina	wild rose	present	unknown	native					
Rosa multiflora	multiflora rosa	present	unknown	nonnative					
Rosa palustris	swamp rose	present	unknown	native					
Rubus allegheniensis	Allegheny blackberry	present	unknown	native					
Rubus occidentalis	black raspberry	present	unknown	native					
Spiraea vanhouttei	spiraea vanhouttei	present	unknown	nonnative					
Cephalanthus occidentalis	buttonbush	present	unknown	native					
Diodia virginiana	buttonweed	present	unknown	native					
Galium circaezans	bedstraw wild licorice	present	unknown	native					
Galium parisiense	bedstraw	present	unknown	nonnative					
Galium pilosum	bedstraw	present	unknown	native					
Galium tinctorium	dye bedstraw stiff marsh bedstraw	present	unknown	native					
Galium triflorum	sweet-scented bedstraw	present	unknown	native					
Houstonia purpurea	purple bluets venus' pride	present	unknown	native					
Houstonia pusilla	tiny bluet	present	unknown	native					
Acer negundo	box elder	present	unknown	native					
Acer rubrum	red maple	present	unknown	native					
Acer saccharinum	silver maple	present	unknown	native					
Acer saccharum	sugar maple	present	unknown	native					
Rhus copallina	dwarf sumac winged sumac	present	unknown	native					
Rhus glabra	common sumac smooth sumac	present	unknown	native					
Ailanthus altissima	copal-tree tree of heaven	present	unknown	nonnative					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Ruellia caroliniensis	Carolina wild petunia	present	unknown	native					
Forsythia suspensa	forsythia	present	unknown	nonnative					
Fraxinus americana	white ash	present	unknown	native					
Fraxinus pennsylvanica	green ash	present	unknown	native					
Syringa vulgaris	lilac	present	unknown	nonnative					
Agalinis fasciculata	purple gerardia	present	unknown	native					
Agalinis tenuifolia	slenderleaf false foxglove slender-leaf false foxglove	present	unknown	native					
Aureolaria virginica	false foxglove	present	unknown	native					
Mimulus ringens	monkey-flower	present	unknown	native					
Paulownia tomentosa	princess tree	present	unknown	nonnative					
Verbascum blattaria	moth mullein white moth mullein	present	unknown	nonnative					
Veronica hederifolia	ivyleaf speedwell	present	unknown	nonnative					
Veronica officinalis	common speedwell gypsyweed	present	unknown	native					
Calystegia sepium	hedge bindweed	present	unknown	nonnative					
Convolvulus arvensis	bindweed	present	unknown	nonnative					
Ipomoea hederacea	ivy-leaved morning glory	present	unknown	nonnative					
Ipomoea pandurata	man-of-the-earth man-root wild potato-vine	present	unknown	native					
Ipomoea purpurea	common morning glory	present	unknown	nonnative					
Solanum carolinense	horse nettle	present	unknown	native					
Hypericum gentianoides	orange grass pineweed	present	unknown	native					
Hypericum hypericoides	St. Andrew's cross	present	unknown	native					
Hypericum mutilum	dwarf st. johnswort	present	unknown	native					
Hypericum punctatum	St. John's-wort	present	unknown	native					
Broussonetia papyrifera	paper mulberry	present	unknown	nonnative					
Morus alba	white mulberry	present	unknown	nonnative					
Morus rubra	paper mulberry red mulberry	present	unknown	native					
Celtis occidentalis	hackberry	present	unknown	native					
Ulmus americana	American elm white elm	present	unknown	native					
Ulmus pumila	Siberian elm	present	unknown	nonnative					
Boehmeria cylindrica	bog hemp false nettle	present	unknown	native					

Scientific Name	Common Name	Occurrence	Abundance	Nativity	DCR-DNH Rare Species	Global Rank	State Rank	Federal Status	State Status
Urtica dioica	stinging nettle	present	unknown	nonnative					
Helianthemum canadense	frostweed rockrose	present	unknown	native					
Viola bicolor	field pansy	present	unknown	native					
Viola palmata	violet	present	unknown	nonnative					
Viola sororia	common blue violet hooded blue violet	present	unknown	native					

Appendix I. Fish species documented for Appomattox Court House National Historical Park (Atkinson 2008, NPS 2009). These species have been cross referenced to the VA Wildlife Action Plan (Virginia Department of Game and Inland Fisheries 2005) Species of Greatest Conservation Need; the VA listings for endangered, threatened, or rare species (Virginia Department of Game and Inland Fisheries 2009); and NatureServe's global and state rankings.

Scientific Name	Common Name	Occurrence	Abundance	Residency	Nativity	VA SGCN	Global Rank	State Rank	Federal Status	State Status
Anguilla rostrata	American eel	present	uncommon	resident	native	Tier IV	G4	S5		
Rhinichthys atratulus	blacknose dace	present	common	breeder	native					
Lepomis macrochirus	bluegill	present	common	breeder	nonnative					
Nocomis leptocephalus	bluehead chub	present	abundant	breeder	native					
Pimephales notatus	bluntnose minnow	present	rare	vagrant	nonnative					
Campostoma anomalum	central stoneroller	present	abundant	breeder	native					
Esox niger	chain pickerel	present	uncommon	breeder	native					
Luxilus cornutus	common shiner	present	abundant	breeder	native					
Semotilus atromaculatus	creek chub	present	common	breeder	native					
Erimyzon oblongus	creek chubsucker	present	abundant	breeder	native					
Exoglossum maxillingua	cutlips minnow	present	uncommon	breeder	native					
Semotilus corporalis	fallfish	present	uncommon	breeder	native					
Etheostoma flabellare	fantail darter	present	common	breeder	native					
Etheostoma nigrum	johnny darter	present	abundant	breeder	native					
Micropterus salmoides	largemouth bass	present	uncommon	breeder	nonnative					
Etheostoma longimanum	longfin darter	present	uncommon	breeder	native					
Rhinichthys cataractae	longnose dace	present	uncommon	breeder	native					
Noturus insignis	margined madtom	present	uncommon	breeder	native					
Phoxinus oreas	mountain redbelly dace	present	abundant	breeder	native					
Hypentelium nigricans	northern hogsucker	present	uncommon	breeder	native					
Aphredoderus sayanus	pirate perch	present	common	breeder	native					
Lepomis gibbosus	pumpkinseed	present	common	breeder	native					
Lepomis auritus	redbreast sunfish	present	abundant	breeder	native					
Nocomis micropogon	river chub	unconfirmed	n/a	n/a	native					
Lythrurus ardens	rosefin shiner	present	abundant	breeder	native					
Clinostomus funduloides	rosyside dace	present	common	breeder	native					
Micropterus dolomieui	smallmouth bass	present	uncommon	breeder	nonnative					
Percina notogramma	stripeback darter	present	uncommon	breeder	native					
Notropis procne	swallowtail shiner	present	abundant	breeder	native					
Thoburnia rhothoeca	torrent sucker	present	abundant	breeder	native					
Catostomus commersoni	white sucker	present	abundant	breeder	native					

Appendix J. Amphibian species documented for Appomattox Court House National Historical Park (Mitchell 2006, NPS 2009). These species have been cross referenced to the VA Wildlife Action Plan (VDGIF 2005) Species of Greatest Conservation Need; the VA listings for endangered, threatened, or rare species (VDGIF 2009); and NatureServe's global and state rankings (NatureServe 2009).

Scientific Name	Common Name	Occurrence	Abundance	Residency	Nativity	VA SGCN	Global Rank	State Rank	Federal Status	State Status
Rana catesbeiana	American bullfrog	present	uncommon	breeder	native					
Hyla chrysoscelis	Cope's gray tree frog	present	uncommon	breeder	native					
Bufo americanus americanus	eastern American toad	present	common	breeder	native					
Plethodon cinereus	eastern red-backed salamander	present	unknown	breeder	native					
Hemidactylium scutatum	four-toed salamander	present	unknown	breeder	native					
Hyla versicolor	gray tree frog	present	common	breeder	native					
Ambystoma opacum	marbled salamander	present	common	breeder	native					
Ambystoma talpoideum	mole salamander	present	common	breeder	native	Tier II	G5	S2		SS
Desmognathus fuscus fuscus	northern dusky salamander	present	common	breeder	native					
Rana clamitans melanota	northern green frog	present	uncommon	breeder	native					
Pseudotriton ruber ruber	northern red salamander	unconfirmed	n/a	n/a	native					
Pseudacris crucifer crucifer	northern spring peeper	present	common	breeder	native					
Rana palustris	pickerel frog	present	common	breeder	native					
Notophthalmus viridescens viridescens	red-spotted newt	present	uncommon	breeder	native					
Eurycea cirrigera	southern two-lined salamander	present	common	breeder	native					
Ambystoma maculatum	spotted salamander	present	common	breeder	native					
Eurycea guttolineata	three-lined salamander	present	unknown	breeder	native					
Pseudacris feriarum feriarum	upland chorus frog	present	uncommon	breeder	native					
Plethodon cylindraceus	white-spotted slimy salamander	present	unknown	breeder	native					
Rana sylvatica	wood frog	present	common	breeder	native					

Appendix K. Reptile species documented for Appomattox Court House National Historical Park (Mitchell 2006, NPS 2009). These species have been cross referenced to the VA Wildlife Action Plan (VDGIF 2005) Species of Greatest Conservation Need; the VA listings for endangered, threatened, or rare species (VDGIF 2009); and NatureServe's global and state rankings (NatureServe 2009).

Scientific Name	Common Name	Occurrence	Abundance	Residency	Nativity	VA SGCN	Global Rank	State Rank	Federal Status	State Status
Elaphe obsoleta obsoleta	black rat snake	present	common	breeder	native					
Eumeces fasciatus	common five-lined skink	present	common	breeder	native					
Nerodia sipedon sipedon	common water snake	present	uncommon	breeder	native					
Terrapene carolina carolina	eastern box turtle	present	common	breeder	native	Tier III	G5	S4		
Thamnophis sirtalis sirtalis	eastern garter snake	present	uncommon	breeder	native					
Kinosternon subrubrum subrubrum	eastern mud turtle	present	common	breeder	native					
Chrysemys picta picta	eastern painted turtle	present	common	breeder	native					
Chelydra serpentina serpentina	eastern snapping turtle	present	common	breeder	native					
Carphophis amoenus amoenus	eastern worm snake	present	common	breeder	native					
Coluber constrictor constrictor	northern black racer	present	common	breeder	native					
Storeria dekayi dekayi	northern brown snake	present	rare	breeder	native					
Sceloporus undulatus hyacinthinus	northern fence lizard	present	common	breeder	native					
Diadophis punctatus edwardsii	northern ring-necked snake	present	common	breeder	native					
Regina septemvittata	queen snake	present	uncommon	breeder	native	Tier IV	G5	S5		

Appendix L. Bird species documented for Appomattox Court House National Historical Park (Bradshaw 2007, NPS 2009). These species have been cross referenced to the VA Wildlife Action Plan (Virginia Department of Game and Inland Fisheries 2005) Species of Greatest Conservation Need; the VA listings for endangered, threatened, or rare species (VDGIF 2009); and NatureServe's global and state rankings (NatureServe 2009). Bird species were also cross referenced to the Partners in Flight Priority Species (Partners in Flight 2005) and Audubon WatchList (Audubon 2007).

Scientific Name	Common Name	Occurrence	Abundance	Residency	Nativity	VA SGCN	PIF Priority Species	Audubon WatchList	Global Rank	State Rank	Federal Status	State Status
Empidonax virescens	Acadian flycatcher	present	common	breeder	native		Yes					
Corvus brachyrhynchos	American crow	present	common	breeder	native							
Carduelis tristis	American goldfinch	present	abundant	breeder	native							
Falco sparverius	American kestrel	present	uncommon	breeder	native							
Setophaga ruticilla	American redstart	present	uncommon	unknown	native							
Turdus migratorius	American robin	present	abundant	breeder	native							
Scolopax minor	American woodcock	present	unknown	breeder	native	Tier IV						
Haliaeetus leucocephalus	bald eagle	present	occasional	unknown	native	Tier II			G5	S2S3B,S3N	FS	ST
Icterus galbula	Baltimore oriole	present	unknown	breeder	native							
Hirundo rustica	barn swallow	present	uncommon	unknown	native							
Strix varia	barred owl	present	rare	unknown	native							
Coragyps atratus	black vulture	present	uncommon	unknown	native							
Mniotilta varia	black-and-white warbler	present	uncommon	unknown	native	Tier IV			G5	S5		
Dendroica caerulescens	black-throated blue warbler	present	rare	migratory	native							
Dendroica virens	black-throated green warbler	present	uncommon	unknown	native							
Guiraca caerulea	blue grosbeak	present	common	breeder	native							
Cyanocitta cristata	blue jay	present	abundant	breeder	native							
Polioptila caerulea	blue-gray gnatcatcher	present	abundant	breeder	native							
Certhia americana	brown creeper	present	uncommon	resident	native	Tier IV	Yes		G5	S3B,S5N		
Toxostoma rufum	brown thrasher	present	uncommon	breeder	native	Tier IV			G5	S5		
Molothrus ater	brown-headed cowbird	present	common	breeder	native							
Dendroica tigrina	Cape May warbler	present	rare	migratory	native							
Poecile carolinensis	Carolina chickadee	present	abundant	breeder	native							
Thryothorus ludovicianus	Carolina wren	present	abundant	breeder	native							
Bombycilla cedrorum	cedar waxwing	present	common	unknown	native							
Dendroica pensylvanica	chestnut-sided warbler	present	rare	migratory	native							
Chaetura pelagica	chimney swift	present	common	breeder	native	Tier IV	Yes		G5	S5		
Spizella passerina	chipping sparrow	present	common	breeder	native							
Quiscalus quiscula	common grackle	present	abundant	breeder	native							
Geothlypis trichas	common yellowthroat	present	common	breeder	native							
Accipiter cooperii	Cooper's hawk	present	rare	unknown	native							
Junco hyemalis	dark-eyed junco	present	abundant	resident	native							

Scientific Name	Common Name	Occurrence	Abundance	Residency	Nativity	VA SGCN	PIF Priority Species	Audubon WatchList	Global Rank	State Rank	Federal Status	State Status
Picoides pubescens	downy woodpecker	present	common	breeder	native							
Sialia sialis	eastern bluebird	present	common	breeder	native							
Tyrannus tyrannus	eastern kingbird	present	unknown	breeder	native	Tier IV						
Sturnella magna	eastern meadowlark	present	common	breeder	native	Tier IV	Yes		G5	S5		
Sayornis phoebe	eastern phoebe	present	uncommon	breeder	native							
Megascops asio	eastern screech-owl	present	rare	breeder	native							
Pipilo erythrophthalmus	eastern towhee	present	common	breeder	native	Tier IV	Yes		G5	S5		
Contopus virens	eastern wood-pewee	present	common	breeder	native	Tier IV			G5	S5		
Sturnus vulgaris	European starling	present	abundant	breeder	nonnative							
Spizella pusilla	field sparrow	present	common	breeder	native	Tier IV	Yes		G5	S5		
Regulus satrapa	golden-crowned kinglet	present	uncommon	resident	native							
Ammodramus savannarum	grasshopper sparrow	present	common	breeder	native	Tier IV	Yes		G5	S4		
Dumetella carolinensis	gray catbird	present	rare	unknown	native							
Ardea herodias	great blue heron	present	unknown	breeder	native							
Myiarchus crinitus	great crested flycatcher	present	uncommon	breeder	native							
Bubo virginianus	great horned owl	present	rare	breeder	native							
Butorides virescens	green heron	present	unknown	breeder	native	Tier IV						
Picoides villosus	hairy woodpecker	present	uncommon	breeder	native							
Catharus guttatus	hermit thrush	present	uncommon	resident	native							
Wilsonia citrina	hooded warbler	present	uncommon	breeder	native							
Carpodacus mexicanus	house finch	present	common	breeder	nonnative							
Passerina cyanea	indigo bunting	present	abundant	breeder	native							
Oporornis formosus	Kentucky warbler	present	rare	breeder	native							
Charadrius vociferus	killdeer	present	rare	unknown	native							
Seiurus motacilla	Louisiana waterthrush	present	uncommon	breeder	native	Tier IV	Yes		G5	S5		
Zenaida macroura	mourning dove	present	common	breeder	native							
Colinus virginianus	northern bobwhite	present	uncommon	breeder	native	Tier IV	Yes		G5	S5		
Cardinalis cardinalis	northern cardinal	present	abundant	breeder	native							
Colaptes auratus	northern flicker	present	common	breeder	native							
Circus cyaneus	northern harrier	present	rare	resident	native							
Mimus polyglottos	northern mockingbird	present	common	breeder	native							
Parula americana	northern parula	present	uncommon	breeder	native	Tier IV	Yes		G5	S5		
Stelgidopteryx serripennis	northern rough-winged swallow	present	unknown	breeder	native	Tier IV						
Icterus spurius	orchard oriole	present	uncommon	breeder	native							
Seiurus aurocapillus	ovenbird	present	common	breeder	native	Tier IV			G5	S5		
Dryocopus pileatus	pileated woodpecker	present	common	breeder	native							
Dendroica pinus	pine warbler	present	rare	unknown	native							
Dendroica discolor	prairie warbler	present	uncommon	breeder	native							
Melanerpes carolinus	red-bellied woodpecker	present	abundant	breeder	native							

Scientific Name	Common Name	Occurrence	Abundance	Residency	Nativity	VA SGCN	PIF Priority Species	Audubon WatchList	Global Rank	State Rank	Federal Status	State Status
Vireo olivaceus	red-eyed vireo	present	abundant	breeder	native							
Buteo lineatus	red-shouldered hawk	present	rare	unknown	native							
Buteo jamaicensis	red-tailed hawk	present	uncommon	unknown	native							
Agelaius phoeniceus	red-winged blackbird	present	rare	unknown	native							
Pheucticus ludovicianus	rose-breasted grosbeak	present	rare	migratory	native							
Regulus calendula	ruby-crowned kinglet	present	common	resident	native							
Archilochus colubris	ruby-throated hummingbird	present	uncommon	breeder	native							
Passerculus sandwichensis	savannah sparrow	present	uncommon	resident	native							
Piranga olivacea	scarlet tanager	present	common	breeder	native	Tier IV	Yes		G5	S5B		
Melospiza melodia	song sparrrow	present	abundant	breeder	native							
Piranga rubra	summer tanager	present	common	breeder	native							
Baeolophus bicolor	tufted titmouse	present	abundant	breeder	native							
Cathartes aura	turkey vulture	present	common	unknown	native							
Sitta carolinensis	white-breasted nuthatch	present	common	breeder	native							
Vireo griseus	white-eyed vireo	present	common	breeder	native							
Zonotrichia albicollis	white-throated sparrow	present	abundant	resident	native							
Meleagris gallopavo	wild turkey	present	rare	breeder	native							
Troglodytes troglodytes	winter wren	present	uncommon	resident	native							
Aix sponsa	wood duck	present	uncommon	breeder	native							
Hylocichla mustelina	wood thrush	present	abundant	breeder	native	Tier IV	Yes	Yes	G5	S5		
Helmitheros vermivorus	worm-eating warbler	present	rare	unknown	native							
Dendroica petechia	yellow warbler	present	uncommon	breeder	native							
Sphyrapicus varius	yellow-bellied sapsucker	present	rare	resident	native							
Coccyzus americanus	yellow-billed cuckoo	present	common	breeder	native	Tier IV			G5	S5B		
Icteria virens	yellow-breasted chat	present	rare	unknown	native	Tier IV	Yes		G5	S5		
Dendroica coronata	yellow-rumped warbler	present	abundant	resident	native							
Vireo flavifrons	yellow-throated vireo	present	uncommon	breeder	native	Tier IV			G5	S4		
Dendroica dominica	yellow-throated warbler	present	common	breeder	native							

Appendix M. Mammal species documented for Appomattox Court House National Historical Park (Pagels et al. 2005, NPS 2009). These species have been cross referenced to the VA Wildlife Action Plan (VDGIF 2005) Species of Greatest Conservation Need; the VA listings for endangered, threatened, or rare species (VDGIF 2009); and NatureServe's global and state rankings (NatureServe 2009).

Scientific Name	Common Name	Occurrence	Abundance	Residency	Nativity	VA SGCN	Global Rank	State Rank	Federal Status	State Status
Odocoileus virginianus	white-tailed deer	present	unknown	breeder	native					
Urocyon cinereoargenteus	gray fox	present	rare	unknown	native					
Vulpes vulpes	red fox	present	rare	unknown	native					
Mephitis mephitis	striped skunk	present	rare	breeder	native					
Procyon lotor	raccoon	present	common	breeder	native					
Ursus americanus	black bear	present	occasional	unknown	native		G5	S4		
Didelphis virginiana	Virginia opossum	present	common	breeder	native					
Sylvilagus floridanus	eastern cottontail	present	unknown	breeder	native					
Castor canadensis	American beaver	present	occasional	unknown	native					
Microtus pinetorum	woodland (pine) vole	present	uncommon	breeder	native					
Ochrotomys nuttalli	golden mouse	present	common	breeder	native		G5	S4		
Peromyscus leucopus	white-footed mouse	present	abundant	breeder	native					
Reithrodontomys humulis	eastern harvest mouse	present	rare	breeder	native					
Sigmodon hispidus	hispid cotton rat	present	common	breeder	native					
Glaucomys volans	southern flying squirrel	present	rare	breeder	native					
Marmota monax	woodchuck	present	unknown	breeder	native					
Sciurus carolinensis	eastern gray squirrel	present	uncommon	breeder	native					
Tamias striatus	eastern chipmunk	present	uncommon	breeder	native					
Blarina brevicauda	northern short-tailed shrew	present	common	breeder	native					
Sorex hoyi	pygmy shrew	present	rare	breeder	native		G5	S4		
Sorex longirostris	southeastern shrew	present	uncommon	breeder	native					

Appendix N. SSURGO definition of 'Erosion Hazard (Off-Road, Off-Trail).'

The ratings in this interpretation indicate the hazard of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface. The ratings are based on slope and soil erosion factor K. The soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been exposed by logging, grazing, mining, or other types of disturbance.

The ratings are both verbal and numerical. The hazard is described as "slight," "moderate," "severe," or "very severe." A rating of "slight" indicates that erosion is unlikely under ordinary climatic conditions; "moderate" indicates that some erosion is likely and that erosion-control measures may be needed; "severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and "very severe" indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value to represent the map unit as a whole.

A map unit is typically composed of one or more "components." A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. The components in the map unit name represent the major soils within a map unit delineation. Minor components make up the balance of the map unit. Great differences in soil properties can occur between map unit components and within short distances. Minor components may be very different from the major components. Such differences could significantly affect use and management of the map unit. Minor components may or may not be documented in the database. The results of aggregation do not reflect the presence or absence of limitations of the components which are not listed in the database. An on-site investigation is required to identify the location of individual map unit components.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be generated. Aggregation must be done because, on any soil map, map units are delineated but components are not. The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie.

The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Tie-break Rule: Higher
The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Appendix O. SSURGO definition of 'Flooding Frequency.'

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent.

"None" means that flooding is not probable. The chance of flooding is nearly 0 percent in any year. Flooding occurs less than once in 500 years.

"Very rare" means that flooding is very unlikely but possible under extremely unusual weather conditions. The chance of flooding is less than 1 percent in any year.

"Rare" means that flooding is unlikely but possible under unusual weather conditions. The chance of flooding is 1 to 5 percent in any year.

"Occasional" means that flooding occurs infrequently under normal weather conditions. The chance of flooding is 5 to 50 percent in any year.

"Frequent" means that flooding is likely to occur often under normal weather conditions. The chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year.

"Very frequent" means that flooding is likely to occur very often under normal weather conditions. The chance of flooding is more than 50 percent in all months of any year.

Appendix P. Air quality standards and explanations.

Air Quality Context – National Standards
The Clean Air Act established both primary and secondary National Ambient Air Quality Standards (NAAQS) for six criteria pollutants. The primary standards are established to protect public health; the secondary standards are set to protect public welfare, including natural resources. Currently, the secondary standards are set to the same limits as the primary standards. However, the NPS along with other entities have documented that specific park Air Quality Related Values (AQRV) can be adversely affected at levels well below the NAAQS, or by pollutants for which no NAAQS exist. This suggests that the current NAAQS are not protective of ecosystems, and consequently the U.S. Environmental Protection Agency (EPA) is considering revising the secondary standards for ozone and nitrogen and sulfur oxides (U.S. Environmental Protection Agency 2008a). For this reason, the NPS recommends AQRV target values that are below the NAAQS established to protect human health.

The EPA requires monitoring of six pollutants considered harmful to human health that can also negatively affect the environment. The six “criteria” pollutants are listed and described below (U.S. Environmental Protection Agency 2008c). The first two are considered problematic in hundreds of counties across the U.S., and the last four are of concern only in a handful of locations at most. Currently, Appomattox Court House NHP is not designated as nonattainment area for any criteria pollutant listed below.

Ozone (O_3)

Ozone high in the atmosphere protects us from ultraviolet (UV) radiation, but ozone at ground-level can negatively affect plant populations and can cause respiratory irritation when humans or animals breathe it. Ozone is formed when other pollutants, primarily nitrogen oxides and volatile organic compounds, react in the atmosphere in the presence of sunlight, usually during the warm summer months. Ozone causes considerable damage to vegetation throughout the world, including agricultural crops and native plants in natural ecosystems.

Vegetation sensitivity to ozone is also taken into consideration when conducting air quality assessments in national parks. A 2004 vegetation risk assessment identified 18 plant species present at Appomattox Court House NHP that are sensitive to ozone (NPS 2004). This risk assessment indicated that the risk of injury to plants is moderate at Appomattox Court House NHP due to occasionally elevated levels of ozone exposure coupled with soil moisture values which fail to significantly inhibit the uptake of ozone. The 2004 report also identifies 11 bioindicator species that can be monitored at Appomattox Court House NHP to indicate increased ozone injury to vegetation.

Particulate matter (PM) is subdivided into two categories by size:
Fine particulate matter ($PM_{2.5}$)
Fine particles can be inhaled deeply into the lungs and can cause respiratory irritation and, over the long term, are associated with elevated levels of cardiovascular disease and mortality. Particles also obscure visibility and affect global climate. Fine particles are generated by combustion; major sources include industry and motor vehicles. Such particles can also be formed in the atmosphere through reactions involving gases. The reference value for acceptable

$PM_{2.5}$ is set by the National Ambient Air Quality standards (NAAQS) at 35 μg/m^3 for a 24-hour average (U.S. Environmental Protection Agency 2008b).

Coarse particulate matter (PM_{10}) consists of particles smaller than 10 micrometers. They may cause respiratory irritation. Coarse particles stem from grinding and other mechanical processes and include wind-blown dust. The reference value for acceptable PM_{10} is set by the National Ambient Air Quality standards (NAAQS) at 150 μg/m^3 for a 24-hour average (U.S. Environmental Protection Agency 2008b).

Sulfur dioxide (SO_2) originates mostly from coal combustion and causes respiratory irritation. It also contributes to acid rain and particle formation. The reference value for acceptable SO_2 is set by the National Ambient Air Quality standards (NAAQS) at 0.033ppm for the annual arithmetic mean (U.S. Environmental Protection Agency 2008b).

Carbon monoxide (CO) is a colorless, odorless gas that is formed during incomplete combustion of fuels. Its major sources include vehicles and fires. Exposure to high levels of carbon monoxide can cause dizziness, headaches, confusion, blurred vision, and ultimately coma and death. The reference value for acceptable CO is set by the National Ambient Air Quality standards (NAAQS) at 9 ppm for the annual arithmetic mean (U.S. Environmental Protection Agency 2008b).

Lead (Pb) is a metal found in particles and can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. In children, it has been found to lower IQ. Lead originates mainly from the processing of metals in industry.

Nitrogen dioxide (NO_2) is a brownish gas that is generated during high-temperature combustion. It is a member of a family of chemicals called nitrogen oxides, or NO_x. Major sources of NO_x include coal-fired power plants, industrial boilers, and motor vehicles. Like ozone, it causes respiratory irritation. It is also important because it can react to form ozone and particles, contribute to acid rain, deposit into water bodies and upset the nutrient balance, and degrade visibility. The reference value for acceptable NO_2 is set by the National Ambient Air Quality standards (NAAQS) at 0.053ppm for an 8-hour average, not to be exceeded more than once per year (U.S. Environmental Protection Agency 2008b).

The National Ambient Air Quality Standards (NAAQS) are public health-based levels not to be exceeded for each pollutant (U.S. Environmental Protection Agency 2008b). Air quality is summarized for the public in terms of the Air Quality Index (AQI Table F-1), a scale that runs from 0 to 500, where any number over 100 is considered to be unhealthy (AirNow 2008). Based on measurements or predicted levels of pollutants, an AQI is calculated for each of the criteria pollutants, and the highest value is reported to the public. The breakpoints and calculations used for the AQI are shown in Table F-1 (U.S. Environmental Protection Agency 1999). These public-health-based measures and reference values give us a good starting point in which to discuss air quality. Several of the NAAQS reference values can be further refined to 80% of their current level for a more appropriate natural resource-based target.

Table P-1. The Air Quality Index (AQI) is a cross-agency U.S. Government venture whose purpose is to explain air quality health implications to the public.

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 – 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 – 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 – 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 – 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 – 300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

Table P-2. Breakpoint values of the AQI (US EPA 1999, 2008c).

Category	Value	O_3 (ppm), 8/hr	CO (ppm), 8/hr	SO_2 (ppm), 24/hr	$PM_{2.5}$, (µg/m^3)	PM_{10}, (µg/m^3)	NO_2
Good	0-50	0.000–0.059	0.0–4.4	0.000–0.034	0.0–15.4	0–54	([1])
Moderate	51-100	0.060–0.075	4.5–9.4	0.035–0.144	15.5–40.4	55–154	([1])
Unhealthy for Sensitive Groups	101-150	0.076–0.095	9.5–12.4	0.145–0.224	40.5–65.4	155–254	([1])
Unhealthy	151-200	0.096–0.115	12.5–15.4	0.225–0.304	[3] 65.5–150.4	255–354	([1])
Very Unhealthy	201-300	0.116–0.374	15.5–30.4	0.305–0.604	[3] 150.5–250.4	355–424	0.65–1.24
Hazardous	301-400	([2])	30.5–40.4	0.605–0.804	[3] 250.5–350.4	425–504	1.25–1.64
	401-500	([2])	40.5–50.4	0.805–1.004	[4] 350.5–500.4	505–604	1.65–2.04

[1] NO_2 has no short-term NAAQS and can generate an AQI only above an AQI value of 200.
[2] 8-hour O_3 values do not define higher AQI values ([2] 301). AQI values of 301 or higher are calculated with 1-hour O_3 concentrations.
[3] If a different SHL for $PM_{2.5}$ is promulgated, these numbers will change accordingly.

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