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Fredericksburg and Spotsylvania National Military Park Natural Resource Condition Assessment

Natural Resource Report NPS/NERO/NRR—2015/1093

ON THE COVER
A trail at the Chancellorsville Battlefield Unit, Fredericksburg and Spotsylvania National Military Park.
Photograph credit: Mark J. Johnson

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Natural Resource Report NPS/NERO/NRR—2015/1093

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Introduction

Natural Resource Condition Assessments - What Are They?

Natural Resource Condition Assessments (NRCAs) evaluate natural resource conditions (e.g., state) and trends, identify resource threats, and evaluate data gaps in national parks. In general, the resources emphasized in a given project depend on the park's resource setting, status of resource stewardship planning, national park purpose, and available science and data. NRCAs represent a relatively new approach to assessing and reporting on park resource conditions and include the following characteristics:

- are multi-disciplinary in scope;
- use resource indicators where available and appropriate
- use reference conditions/values (where available) for comparison against current conditions;
- emphasize spatial evaluation of conditions and GIS (map) products;

Due to their modest funding, relatively quick timeframe for completion (~ 2 years), and reliance on existing data, analyses, and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources including published studies, technical reports, unpublished data sets, park staff, and resource experts.

NRCAs deliver science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities. NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) 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. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

This report details the findings of a NRCA conducted at Fredericksburg and Spotsylvania National Military Park from 2011 - 2014. This NRCA, in part, synthesizes cultural and natural resource data to provide a contextual resource assessment within the purpose and historical significance of the park setting. Our findings are summarized in a natural resource "report card" presented in the Appendix A.

Study Area

Fredericksburg and Spotsylvania National Military Park - Background and Purpose

Fredericksburg and Spotsylvania National Military Park (FRSP), located in Orange, Spotsylvania, Caroline, and Stafford counties and the City of Fredricksburg of Virginia was originally established in 1927 to commemorate four major engagements of the Civil War: the battles of 1) Fredericksburg, 2) Spotsylvania Court House, 3) Wilderness, and 4) Chancellorsville (NPS 1986). The original park boundary also included the Fredericksburg National Cemetery, created in 1869 to recognize the soldiers who fought in the four battles. The park was initially under the direction of the Secretary of War and it was the duty of the commissioners to survey and preserve the lines of opposing armies in each battle (NPS 1986). An Executive Order in 1933 transferred the park from the responsibility of the War Department to the Department of the Interior. Since 1933, the four battlefield units have grown by several thousand acres and additional park units have been added: Stonewall Jackson Shrine (1937), Salem Church (1965), and Chatham Manor (1977). Additional boundary legislation passed in 1989 further enlarged the park's boundaries.

Fredericksburg and Spotsylvania County Battlefields Memorial National Military Park was authorized by Congress on February 14, 1927. A general statement of the purpose reads as follows:

> *"... commemorate the Civil War battles of Fredericksburg, Spotsylvania Court House, Wilderness, and Chancellorsville.. and to mark and preserve for historical purposes the breastworks, earthworks, gun emplacements, walls, or other defenses or shelters... used by the armies...."*

The Historic Sites Act of 1935 directed that the National Park Service should help implement *"...a national policy to preserve for public use historic sites, buildings and objects of national significance..."*

The principal cultural resources of the park are the core areas of the battlefields where the Confederate Army of Northern Virginia and the Army of the Potomac fought between 1861 and 1865. These historic events are defined by structures like earthworks, archeological sites, farm buildings, property lines formed by fences, marking trees that identify fields and woodlot boundaries, and strategic military positions formed by swamps, hills, forests, and other physiographic features.

Today, the park serves as an important resource for public education and historic interpretation of the battles and the maneuvers employed by the Union and Confederate armies. It also preserves an important area of open space in the midst of increasing residential and commercial development. Facilities at the park include two visitor centers, self-guided tours of the battlefields and historic buildings, picnic areas, and a number of different walking trails that meander through the historic areas and many forested acres. The park also has an active farm program that currently manages over 364 hectares (900 ac) of the park historic scene. Another 142 hectares (350 ac) are managed as open fields.

Fredericksburg and Spotsylvania National Military Park Natural Resource Condition Assessment – General Approach and Topics of Interest

The NRCA for FRSP was initiated informally in March 2011 and officially in October 2011 (funding was secured in early 2012). At these initial meetings, we met with FRSP natural and cultural resources staff and resource experts to gather pertinent natural resource information in the form of raw data sets, inventory and monitoring reports, historic photographs, and current vegetation classification. In addition, we gathered information from outside historical sources (e.g., Scott 1985, Priest 1995, Rhea 2007) to provide a landscape context at the time of the Civil War. Following these initial data gathering meetings, we coarsely examined data provided and held a subsequent meeting in March 2012 and developed a project outline for the NRCA that focused on the following (5) topics and justification:

Topic 1: Forest habitats - largest, continuous patches and other significant forest elements should be identified and protected.

Justification:

- Based on historic photos, forest of varying ages (with interspersed agricultural fields) was the dominant land cover type at time of the battles, especially the battle of the Wilderness (1864).
- Forested habitats are threatened by development and fragmenting effects in and around Fredericksburg, VA. Maintaining and protecting connections between and among these forest patches will help ensure species persistence within the FRSP landscape.
- Several bird species found breeding in FRSP forests are significant from a natural resource perspective, especially Wood Thrush (*Hylocichla mustelina*), Kentucky Warbler (*Geothlypis formosa*), and Worm-eating Warbler (*Helmitheros vermivorum*).
- Small whorled pogonia (*Isotria medeoloides*) a federally-threatened plant found at FRSP is dependent on older (mature) hardwood forest stands.
- FRSP contains embedded forest wetland communities that are uncommon and are restricted in range within the mid-Atlantic. These communities include Floodplain Swamp forests, Acidic Seepage swamps, Depression wetlands, and Non-Riverine saturated forests.

Topic 2: Grassland and early successional habitats - these habitats should be maintained at current level or expanded (if culturally significant) in the park and early successional, transitional, shrubland habitats should be encouraged along forested/grassland edges.

Justification:

- Based on historic photographs, abandoned agricultural fields were present at the time of the battle (s) and were the location of culturally-significant events. Currently, many of these fields have been managed as historic artifacts and should be maintained as such.
- Coppice, early successional forests (a product of the local charcoal and mining industry in the mid-1800s) were a significant part of the landscape during the Battle of the Wilderness and contributed to the nature and outcome of that battle.
- Grassland and shrub habitats are threatened by development and succession throughout the mid-Atlantic and FRSP grasslands and shrublands support breeding bird species that are significant from a natural resource perspective - especially Blue Grosbeak (*Passerina caerulea*), Field Sparrow (*Spizella pusilla*), Prairie Warbler (*Setophaga discolor*), Eastern Towhee (*Pipilo erythrophthalmus*), Brown Thrasher (*Toxostoma rufum*), Yellow-billed Cuckoo (*Coccyzus americanus*), and Yellow-breasted Chat (*Icteria virens*).

Topic 3: Streams and riparian areas - water quality of streams, seeps, and wetlands should be examined and maintained and/or improved if necessary.

Justification:

- Waters in and around FRSP support a diverse fish assemblage. Significant and rare species include mottled sculpin (*Cottus bairdii*) and silverjaw minnow (*Ericymba buccata*), both of which rely on good water quality.
- Impervious surfaces are a result of rapid urbanization in the surrounding watersheds and threatens the health of aquatic systems within the park.

Topic 4: Wetland habitats and rare plant species should be identified, mapped, and protected.

Justification:

- Vernal pools in the park should be identified (mapped) as they provide critical breeding habitat for park amphibian species such as Ambystomid salamanders, treefrogs, and newts.
- Beaver ponds which provide wetland habitats in the park should be identified and protected where historically appropriate as they provide habitat for nesting waterfowl and breeding amphibians.
- Distribution and occurrence of two rare plant species, small whorled pogonia and red milkweed (*Asclepias rubra*), should be understood. Red milkweed was historically found in the park and a seed source could still persist in soil. Therefore, this rare species may be restored with proper management.

Topic 5: Cultural/landscape restoration areas

Justification:

- Cultural landscapes like abandoned agricultural fields and grasslands surrounding built environments can provide important habitat to grassland and early successional species.
- Current extent and condition of cultural landscapes may not reflect the time of the Civil War battles. Proper restoration of these landscapes could provide a better depiction of the battle and permit visitors to better interpret battlefield conditions.

In this document we examine the current state of these resource topics from a natural perspective and, if appropriate, a cultural perspective. In many cases, we also list potential threats to each resource and suggest management recommendations to protect or ensure their maintenance or restoration, if applicable, to the natural resource of interest. Information contained in this report has been synthesized from the aforementioned meetings, natural resource reports and publications, and unpublished data sets. As stated, this report is a contextual synthesis of information, therefore, it does not repeat findings of all natural resource studies conducted in the park, although references to those studies are provided.

Where appropriate, we used thresholds and reference conditions established in the scientific literature. However, many of our “conditions” are anecdotal in nature and provide a way to balance cultural resource management with significant natural resources found within the park.

Resource Setting

Location

Fredericksburg and Spotsylvania National Military Park (FRSP) is located in central Virginia, just south of the Rappahannock River within, west, and south of the city of Fredericksburg. The park contains seven geographically separated park units: Fredericksburg, Chatham, Stonewall Jackson Shrine, Spotsylvania Court House, Wilderness, Chancellorsville, and Salem Church. The park is primarily located in Spotsylvania County, but is also located in Orange, Stafford, and Caroline counties, as well as the independent city of Fredericksburg (Figure 1). The total acreage of park units held in fee is 7372 acres (2983 ha), with the smallest unit being the Battle of Salem Church (3.28 acres [1.33 ha]), and the largest being the Battle of Wilderness (2805.58 acres [1135.38 ha]) (Table 1). In addition to land held in fee, 2685.04 acres (1086.60 ha) of surrounding lands are authorized for future acquisition, and 1925.45 acres (779.20 ha) of adjoining land is in easement (with some overlap). Additionally, much of the riparian zone of the Rappahannock River to the north is in conservation easement, providing opportunities for future landscape connectivity.

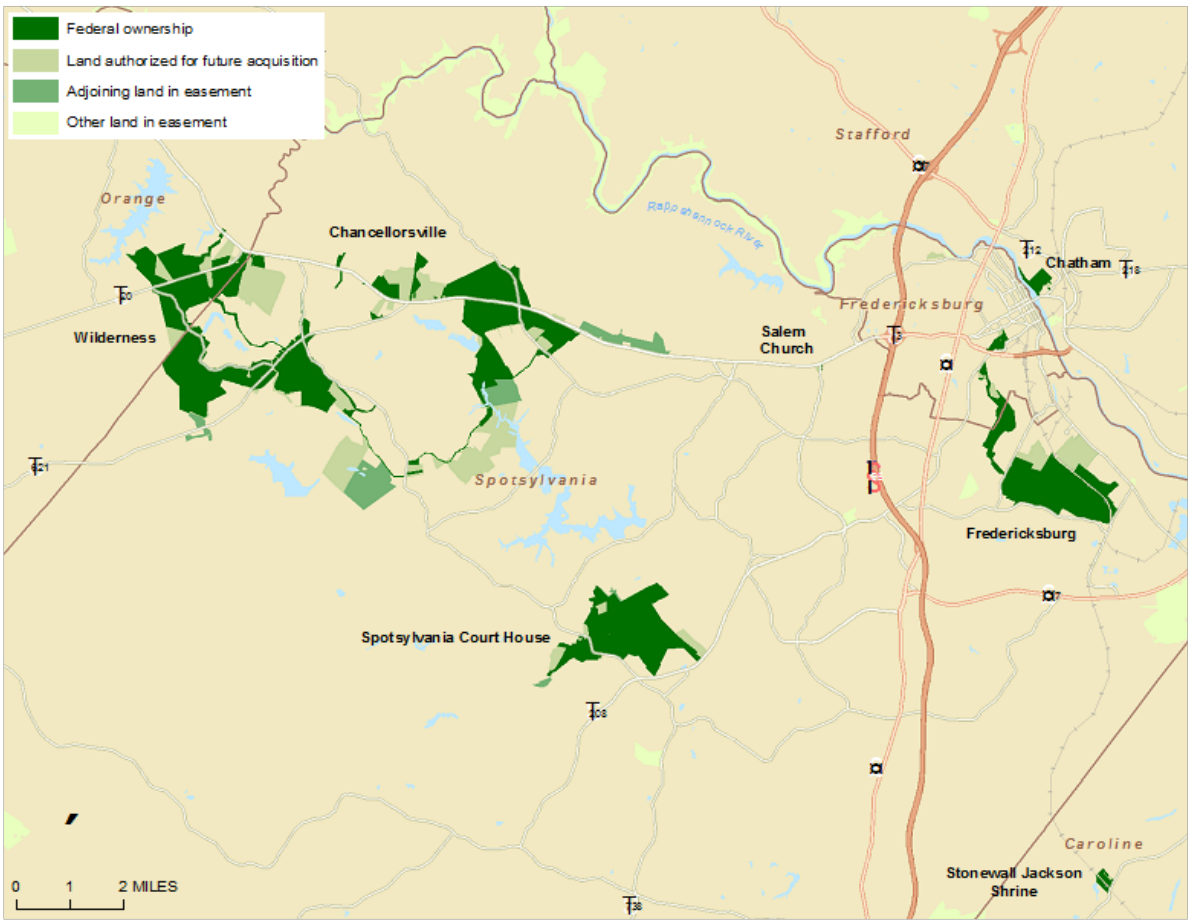


Figure 1. Federal ownership (land held in fee), land authorized for future acquisition, and adjoining land in easement, Fredericksburg and Spotsylvania national Military Park. [Data sources: NPS, National Conservation Easement Database, ESRI, Inc.]

Table 1. Area by Park Unit in Federal land ownership held in fee at Fredericksburg and Spotsylvania National Military Park, at time of writing, 2013.

Park Unit	Acres (Hectares)
Wilderness	2805.59 (1135.38)
Chancellorsville	1729.19 (699.78)
Chatham	86.34 (34.94)
Spotsylvania Court House	1328.32 (537.55)
Fredericksburg	1372.03 (555.24)
Salem Church	3.28 (1.33)
Stonewall Jackson Shrine	47.51 (19.26)
Total Area	7372.26 (2983.45)

Landscape Setting

The FRSP park units are situated along the heavily populated Interstate-95 corridor, between the population centers of Richmond and Washington, D.C. Night lights imagery available from NOAA (Figure 2) graphically demonstrates the rural-urban setting in this heavily populated region.

Land use and landscape pattern metrics developed by the National Park Service NPScape program (Monahan et al. 2012) provide a useful guide for assessing the landscape setting for all of the National Park units, including those at FRSP. The 2006 NPScape analysis considers the parks and their landscape setting in reference to a 30-km “Area of Analysis” or AOA (e.g. a buffer zone) surrounding the park (Figure 3). By comparing land use data within the park boundaries to land uses outside the park boundaries within the 30-km AOA, a contrast can be drawn between the park’s landscape and that of its surroundings (Table 2). As might be expected, a larger proportion of the FRSP unit area (58%) is in deciduous forest as compared to the surrounding landscape (39%). Similarly, a larger percentage of area in the surrounding landscape is in high or low intensity developed land uses (3%), while areas inside the park contain no low- or high-intensity developed areas. While more accurate land cover data is available within the park units from fine scale aerial photography interpretation (Tavernna and Patterson 2008), the coarse scale satellite image land cover mapping of NPScape (from the National Land Cover Database; Homer et al. 2007) provide regionally consistent land cover interpretations.

Figure 2. Night lights imagery showing location of Fredericksburg and Spotsylvania National Military Park (FRSP) units and 30-km NPScape Area of Analysis (green circles) within the heavily populated I-95 corridor. [Data source: image from NASA using data from NOAA Geophysical Data Center, http://earthobservatory.nasa.gov/Features/IntotheBlack/]

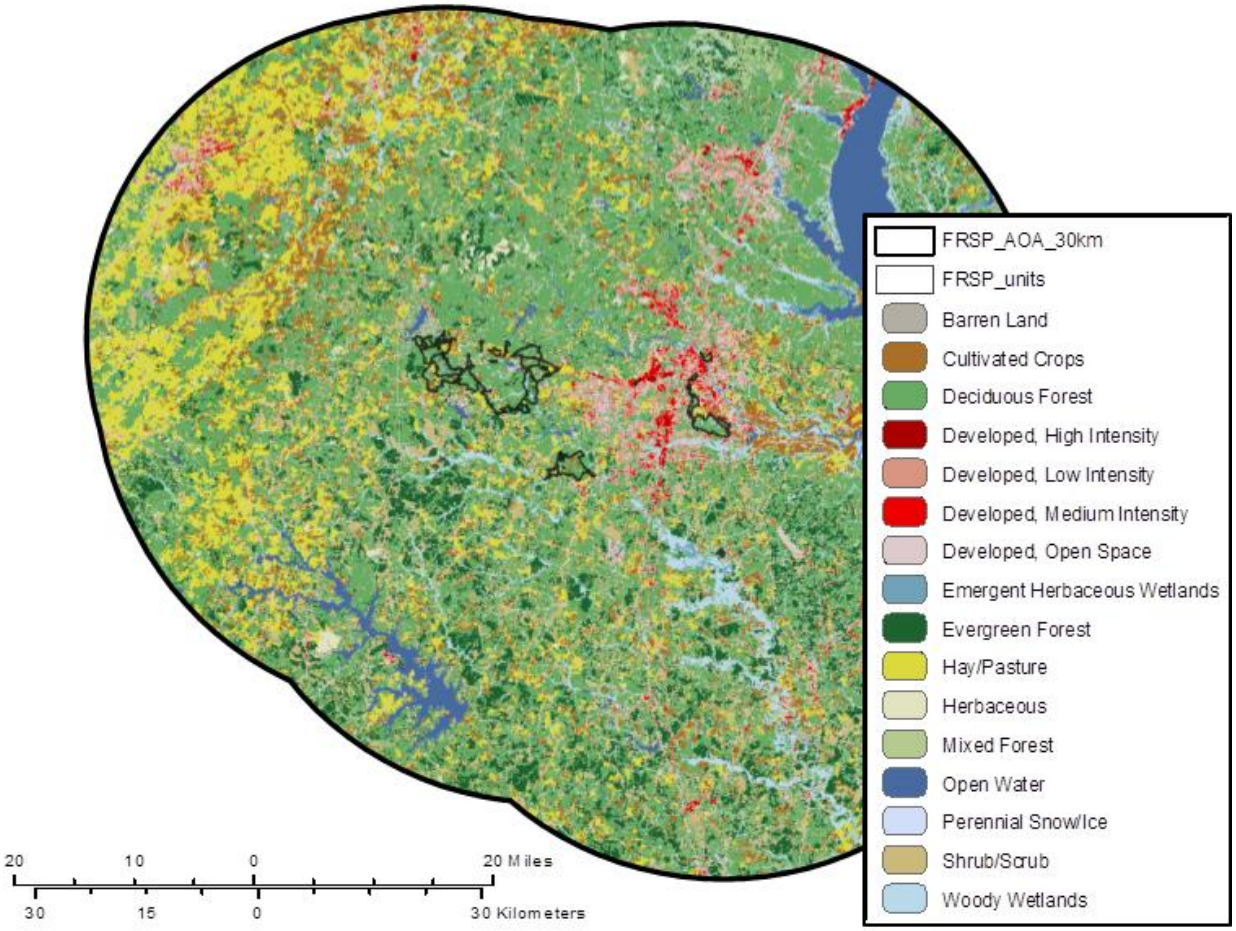


Figure 3. NPScape 2006 land use in 30-km Area of Analysis (AOA) surrounding Fredericksburg and Spotsylvania National Military Park units. [Data source: NPScape 2006, Monahan et al. 2012]

Table 2. National Land Cover Database (NLCD) 2006 land uses within the NPScape 30-km area of analysis (AOA) around Fredericksburg and Spotsylvania National Military Park (FRSP) and land uses within FRSP unit boundaries.

Land use type	AOA hectares	Percent of total area	Within FRSP hectares	Percent of total
Open water	26,108.28	5	0	0
Developed, open space	33,716.16	6	270.63	9
Developed, low intensity	10,488.15	2	15.57	< 1
Developed, medium intensity	3,580.83	1	1.62	< 1
Developed, high intensity	971.37	< 1	0.09	< 1
Barren land	2,303.01	< 1	0	0
Deciduous forest	218,743.56	39	1,834.02	58
Evergreen forest	59,135.67	10	234.54	7
Mixed forest	17,593.38	3	74.88	2
Shrub/Scrub	40,478.31	7	101.97	3
Herbaceous	5,141.34	1	7.11	< 1
Hay/Pasture	68,802.21	12	208.53	7
Cultivated crops	45,621.36	8	219.69	7
Wooded wetland	33,170.04	6	184.23	6
Emergent herbaceous wetland	2,228.58	< 1	0	0

As with land cover, impervious surface data are available through the National Land Cover Database (Homer et al. 2007) and has been summarized by the NPScape program (Monahan et al. 2012). Impervious surface maps from the NLCD represent the percentage of each 30m x 30m land area that is covered by hard (generally man-made) material impervious to water infiltration as estimated from Landsat satellite imagery, aerial photography, and ancillary data. Impervious surface area is important to water quality because rainfall runoff that enters streams and rivers directly rather than infiltrating through soil and bedrock generally has higher levels of contaminants picked up from roads, parking lots, and other surfaces, and creates higher peak flow events that can lead to erosion. While impervious surface areas are generally low in NPS units, the surrounding landscape may have significant impervious surface area that can impact water quality of streams flowing through the parks (Figure 4).

Watershed Context

The FRSP park units are in the watersheds of the Rapidan, Rappahannock, and Mattaponi River sub-basins (Figure 5) as characterized by the US Geological Survey 8-digit-hydrologic-unit watershed map (Seaber et al. 1987). The Spotsylvania Courthouse unit sits between the Po and Ni Rivers

(headwaters of the Mattaponi) along with a portion of the Chancellorsville and Wilderness Units. The Stonewall Jackson Shrine unit is downstream and within the Poni River drainage. The Fredericksburg and Chatham units are completely within the lower Rappahannock watershed, while the Northern portions of the Wilderness and Chancellorsville units straddle a divide between the upper Rappahannock and the Mattaponi River systems. Additionally, the fall line, a geomorphic break in slope where the harder geologic substrates of the Piedmont physiographic province meets the Coastal Plain, divides the park units (Thornberry-Ehrlich 2010). The fall line separates the tidally influenced lower portions of many Atlantic slope river systems from non-tidal upland river reaches. In colonial times, the fall line served as a physical barrier to upstream boat navigation and led to the establishment of many east coast U.S. cities (including Fredericksburg) at these locations where cargo had to be transferred to overland forms of transportation. The fall line also serves as a biogeographic transition point between the slow moving, brackish, and large river aquatic habitats of the Coastal Plain and the swifter, smaller, and rockier aquatic habitats of the upper river reaches. The FRSP units also straddle many smaller watersheds sub-basins (Figure 6), predominantly the Wilderness Run, upper Ni River, and Hazel Run.

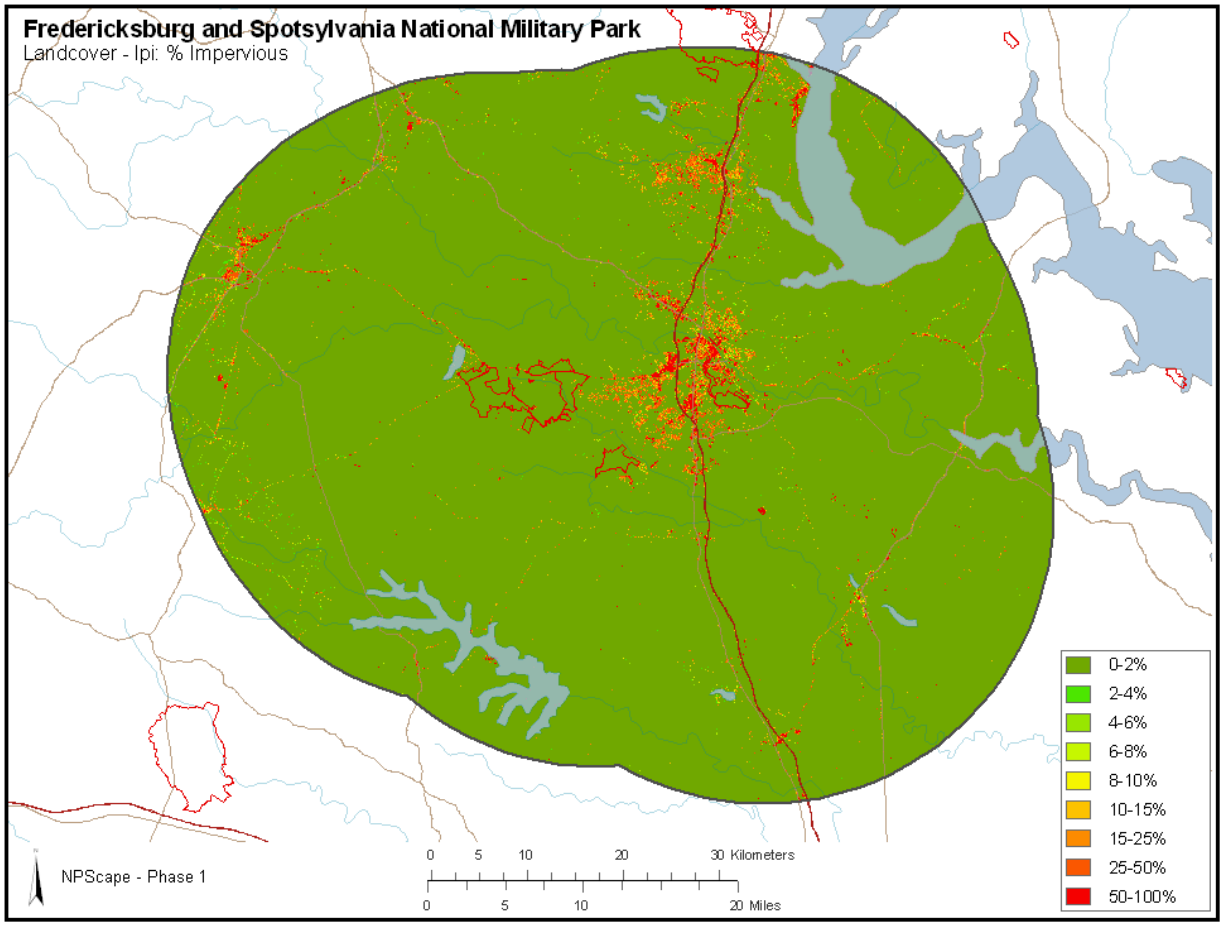


Figure 4. Impervious surface areas (circa 2006) in proximity to Fredericksburg and Spotsylvania National Military Park units as mapped by the NPScape program (Monahan et al. 2012) in a 30-km Area of Analysis (AOA) or buffer area surrounding the park.

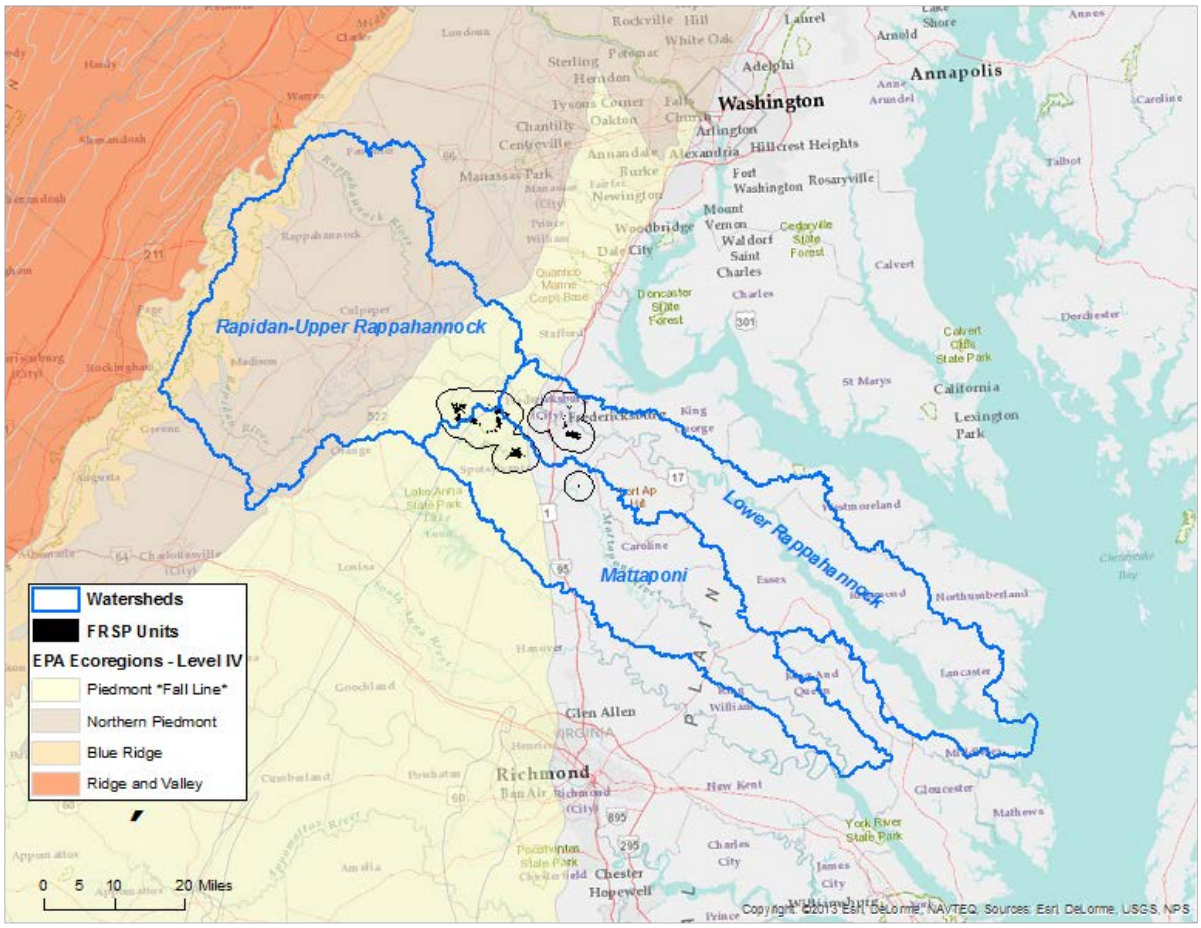


Figure 5. Major watersheds encompassing the Fredericksburg-Spotsylvania National Military Park units. Also shown are the general locations of physiographic provinces. [Data sources: USGS Hydrologic Units (Seaber 1987), EPA Level IV Ecoregions (Omernik 1987), ESRI, Inc.]

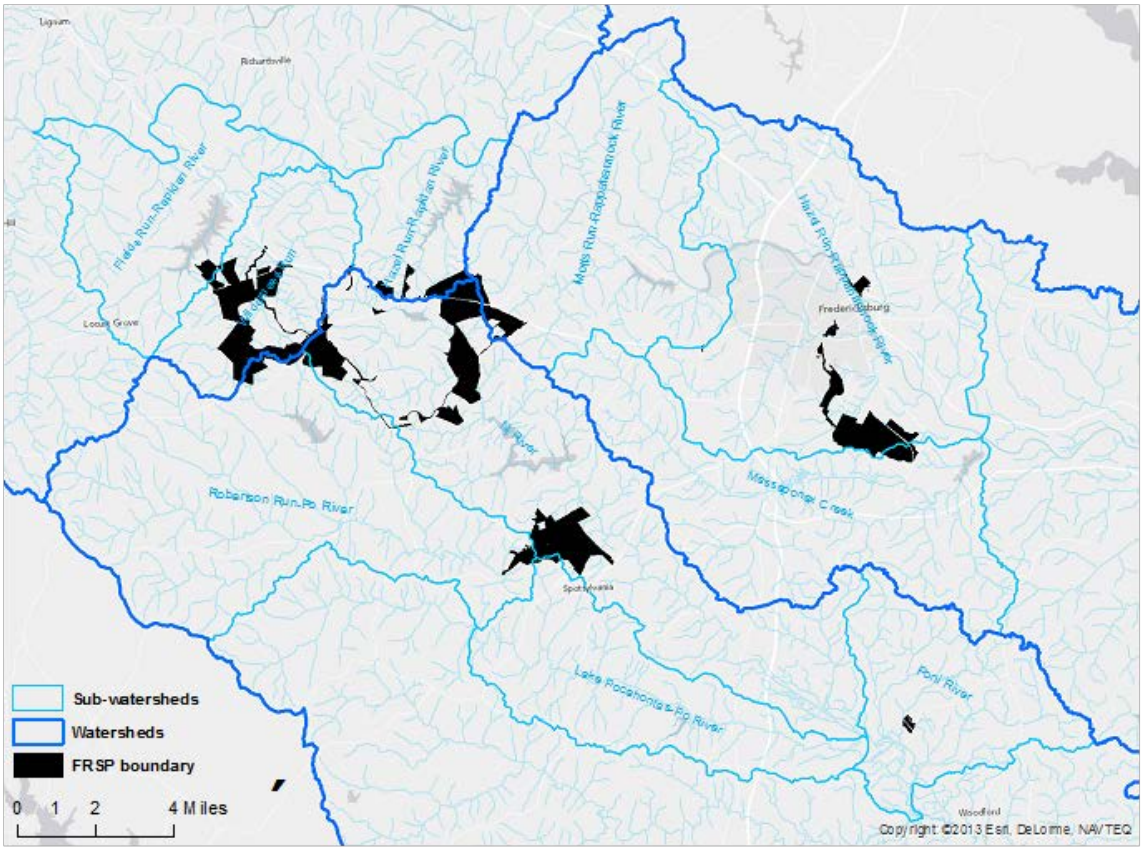


Figure 6. Watershed sub-basins encompassing the Fredericksburg and Spotsylvania National Military Park units. [Data sources: USGS Hydrologic Units (Seaber 1987)]

Geological and Topographical Context

The FRSP park units straddle the rolling hills formed from crystalline rocks of the Piedmont physiographic province to the west as well as the low, flat Coastal Plain province to the east consisting of softer sediments eroded from the Appalachian Mountains over the past 100 million years (Thornberry-Ehrlich 2010). Elevations of the Coastal Plain province range from 0-300 feet (0-91.4 m), while those of the Piedmont range to 1000 feet (304.8 m) above sea level. In addition to the location along the fall line, other geologic features of note include the history of mining in the local area due to an abundance of mineral resources including iron ore, gold, sulfides, and quarrying for siltstone, gneiss, and basalt (Thornberry-Ehrlich 2010). Smelting iron ore required significant logging in the local area to supply a fuel source. The dense, coppice undergrowth that re-established as secondary forests in these heavily logged areas gave the Wilderness battlefield its character and name.

Natural Resource Conditions

Air Quality (also a Mid Atlantic Inventory and Monitoring Network [MIDN] vital sign)

The area surrounding Fredericksburg and Spotsylvania National Military Park has experienced a surge of growth in the past 15 years as a result of increased use of I-95 as a major north-south transportation corridor. This expansion has resulted in new industries, increased development, and traffic adjacent to the park. In 1992, Stafford County was listed as a "non-attainment" area under the Clean Air Act, suggesting serious air quality problems. Hydrocarbon pollution from three major areas (Washington DC, Richmond, and Fredericksburg metro areas) is a potential contributor to the decline of air quality in the park. Air pollution may be causing yet undetermined impacts on the park's natural and cultural resources. The park was classified as a Class II park in the Clean Air Act of 1977. This designation relates to the amount of air quality degradation that is allowable. This classification allows only moderate amounts of degradation of the existing air quality condition (NPS-Air Resources Division 2014).

In 2014, the Mid-Atlantic Inventory and Monitoring Network (MIDN) updated its Air Quality Related Values report and outlined issues related to air quality in the mid-Atlantic region. The major source of airborne pollutants in this region is from coal-burning power plants located in the Ohio River Valley, northEastern West Virginia, southwestern Pennsylvania, and east-central Virginia (Burns et al. 2011). FRSP is a park that has “low” risk of acidification impacts on park resources. Although the park is exposed to acid pollution (SOx and NOx), ecosystems within the park are not sensitive to acidification due to a combination of high acid neutralizing capacity in several park areas and the relatively flat topography of the park. Similarly, nitrogen (N; as a nutrient) pollution is expected to have little effects in FRSP due to the forested landscape and herbaceous plant cover which have an influence on N-cycling. Mercury (Hg) as an airborne contaminant remains high in the region. Although the effects of ozone (O_3) exposure on plants have not been studied at FRSP, the park contains several plant species that are sensitive to the pollutants’ effects. These species include white ash (*Fraxinus americana*), oak (*Quercus* spp.), tuliptree (*Liriodendron tulipifera*), and sugar maple (*Acer saccharum*). From the period 2005-2009, the average ozone exposure indices at FRSP were 12.01 ppm/hr (moderate ranking) and 15.46 ppm/hr (high ranking) in winter and summer, respectively.

Ozone, sulfur (SO_4), nitrogen (NH_4), and particulate matter contribute to haze in and around FRSP and have had negative impacts on visibility at the park. The Interagency Monitoring of Protected Visual Environments (IMPROVE) estimates that ambient haze in and around the park is very high (23.11; haze index [deciview; dv]). This value contrasts with the estimated natural or background haze for the park of 8.24 dv (NPS-Air Resources Division 2014). Recent federal and state air quality management programs (e.g., Burns et al. 2011) appear to be having an effect on decreasing haze throughout the mid-Atlantic. For example, a recent analysis conducted by the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) indicates that ambient haze has decline at FRSP from 2005 to 2009—although it is still high.

Lightscape- Dark Night Sky

The NPS is obligated to preserve the dark night skies of parks (Albers and Duriscoe 2001). Protection and management of this resource considers both the lightscape – the human perception of the nighttime scene, including both the night sky and the faintly illuminated terrain, and the photic environment – the totality of the pattern of light at night at all wavelengths.

Lightscapes include aesthetic and experiential qualities that are integral to natural resources and cultural resources. A lightscape can be important as a natural feature, a cultural feature, or both. Natural lightscapes are an important component of wilderness character and are an air quality related value. The photic environment affects a broad range of species, is integral to ecosystems, and is a natural physical entity. Recent studies have indicated that light pollution may have adverse effects on water quality, salamander foraging, migratory birds, and turtle breeding (Harder 2004).

The recommended parameter for characterizing the quality of the photic environment and lightscape is the anthropogenic light ratio (ALR) which quantifies the average anthropogenic sky luminance presented as a ratio of anthropogenic to natural light. Average anthropogenic light is calculated by taking the total observed sky brightness and then removing the natural night sky component from the observed conditions.

For Level 1 parks (which have at least 90% of the park property outside an urban area), the threshold separating green (good) and amber (caution) conditions is set at an ALR of 0.33 or 1/3rd brighter than natural conditions. This value for average anthropogenic sky luminance corresponds with the point at which portions of the sky typically become bright enough that humans are unable to fully adapt to the dark (i.e. scotopic vision) when looking toward them. Above this threshold, humans lose visual sensitivity and require time under dark conditions to re-adapt their eyes. This attribute of human “night” vision is likely similar in other mammals, although certain mammals may be more or less sensitive.

For Level 2 parks (which have at least 90% of the park property within an urban area), the threshold separating green and amber conditions is set at an ALR of 2.0. This value corresponds with a point at which portions of the sky typically cast shadows, at which the Milky Way can no longer be seen in its entirety, at which the Zodiacal lights is very seldom seen, and full dark adaptation is not possible no matter which direction an observer looks. The threshold separating amber and red conditions is set at an ALR of 18.0. This corresponds to the point at which extended features of the night sky (e.g. Milky Way, Andromeda Galaxy) are invisible in nearly all situations, and constellations become difficult to identify. At this level of anthropogenic light, contrast of illuminated monuments is reduced, photographs at night easily capture the altered appearance of the night sky, and it becomes difficult to retain a historical cultural landscape at night.

The ALR thresholds are applied spatially to the park. For both urban and non-urban parks, the designated condition (green, amber, red) corresponds to the ALR level that exists in at least half of (median condition) the parks’ landscape. Thus it is probable that a visitor will be able to experience the specified night sky quality. It is also probable that the majority of wildlife and habitats found within the park will exist under the specified night sky quality.

Artificial light in and around the park associated with roads, buildings, and signage is a potential threat to the dark night skies of FRSP as evidenced by NOAA night-time photography (Figure 2). Although the visual environment of dark night skies has not been directly measured at FRSP, the NPS Natural Sounds and Night Sky Division (NSNSD) modeled the visual environment for FRSP (Figure 7). For level 2 parks, FRSP models in the amber range (Moderate Condition).

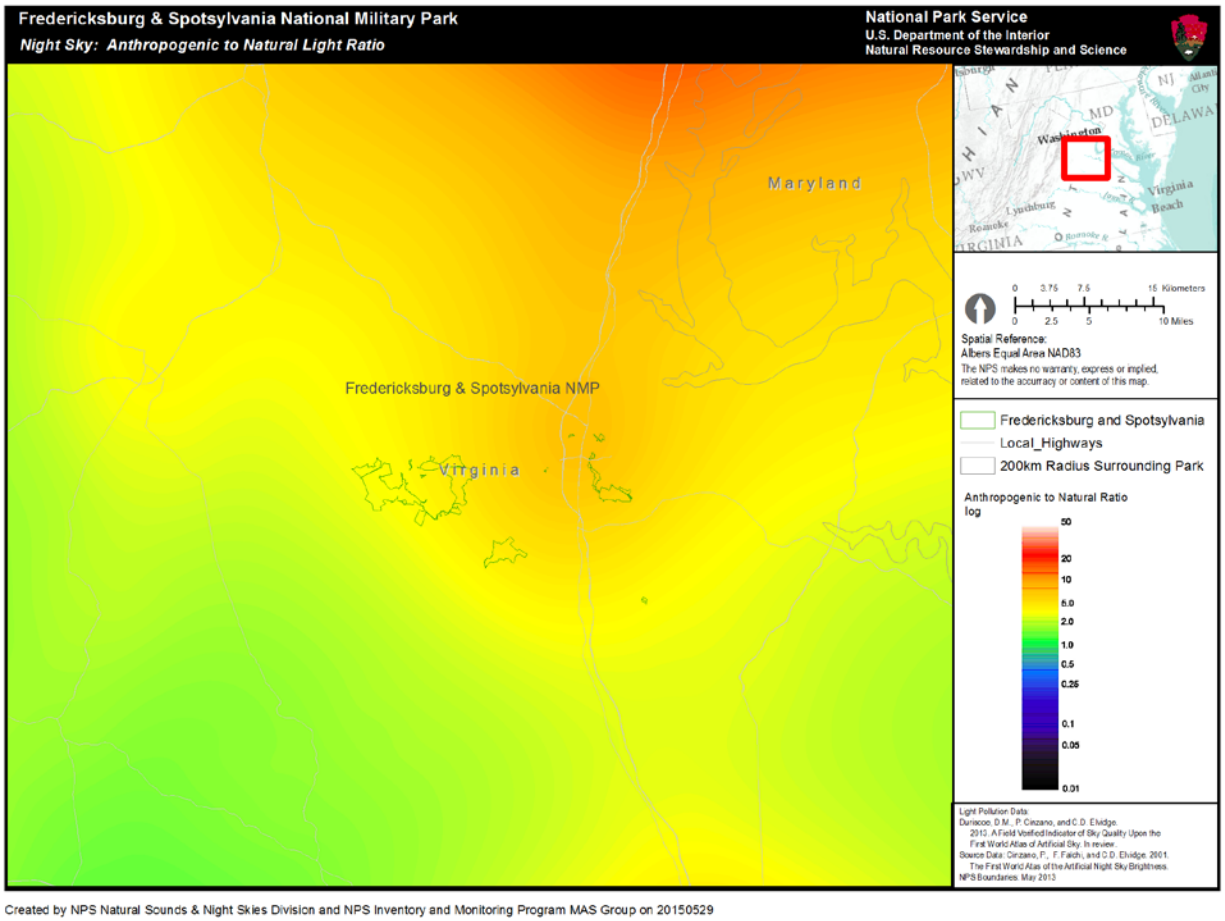


Figure 7. Modeled night sky Anthropogenic to Natural Light ration (ALR) for Fredericksburg and Spotsylvania National Military Park and surrounding area.

Soundscape- Acoustical Environment

The natural soundscape is an inherent component of "the scenery and the natural and historic objects and the wildlife" protected by the Organic Act of 1916. NPS Management Policies (§ 4.9) require the NPS to preserve the park's natural soundscape and restore the degraded soundscape to the natural condition wherever possible. Additionally, NPS is required to prevent or minimize degradation of the natural soundscape from noise (i.e., inappropriate/undesirable human-caused sound). Although the management policies currently refer to the term soundscape as the aggregate of all natural sounds that occur in a park, differences exist between the physical sound sources and human perceptions of those sound sources. The physical sound resources (i.e., wildlife, waterfalls, wind, rain, and cultural or historical sounds), regardless of their audibility, at a particular location are referred to as the acoustical environment, while the human perception of that acoustical environment is defined as the

soundscape. Clarifying this distinction will allow managers to create objectives for safeguarding both the acoustical environment and the visitor experience.

An unimpaired acoustical environment is an important part of overall visitor experience and enjoyment as well as vitally important to overall ecosystem health. Studies have shown that wildlife can be adversely affected by sounds that intrude on their habitats. While the severity of the impacts varies depending on the species being studied and other conditions, research strongly supports the fact that wildlife can suffer adverse behavioral and physiological changes from intrusive sounds (noise) and other human disturbances.

No monitoring of the acoustical environment of FRSP has been conducted. In cases where ability to collect acoustical data on site is limited, alternatives for assessing condition and trend are also available. Using acoustic data collected at 244 sites and 109 spatial explanatory layers (such as location, landcover, hydrology, wind speed, and proximity to noise sources such as roads, railroads, and airports), NSNSD has developed a geospatial sound model which predicts natural and existing sound levels with 270 meter resolution (Figures 8 and 9) (Mennitt et al. 2013). In addition to predicting these two ambient sound levels, the model also calculates the difference between the two metrics, providing a measure of impact to the natural acoustic environment from anthropogenic sources (Figure 10). The resulting metric (L50 dBA impact), described in Table 3, indicates how much anthropogenic noise raises the existing sound pressure levels in a given location.

Using the modeled impact results, FRSP is assessed in amber or moderate condition threshold. Transportation noise from an adjacent major highway poses the greatest threat to the acoustical environment.

Table 3. Example condition thresholds for the acoustical environment of non-urban and urban parks.

Indicator	**Threshold for non-urban parks (dBA)**	**Threshold for urban parks (dBA)**
Mean L_{50} impact (dBA) Calculated as difference between existing ambient and natural ambient models	Threshold ≤ 1.5 *Listening area reduced by ≤ 30%*	Threshold ≤ 6.0 *Listening area reduced by ≤ 75%*
	1.5 < Threshold ≤ 3.0 *Listening area reduced by 30 - 50%*	6.0 < Threshold ≤ 12 *Listening area reduced by 75 - 94%*
	3.0 < Threshold *Listening area reduced by > 50%*	12 < Threshold *Listening area reduced by > 94%*

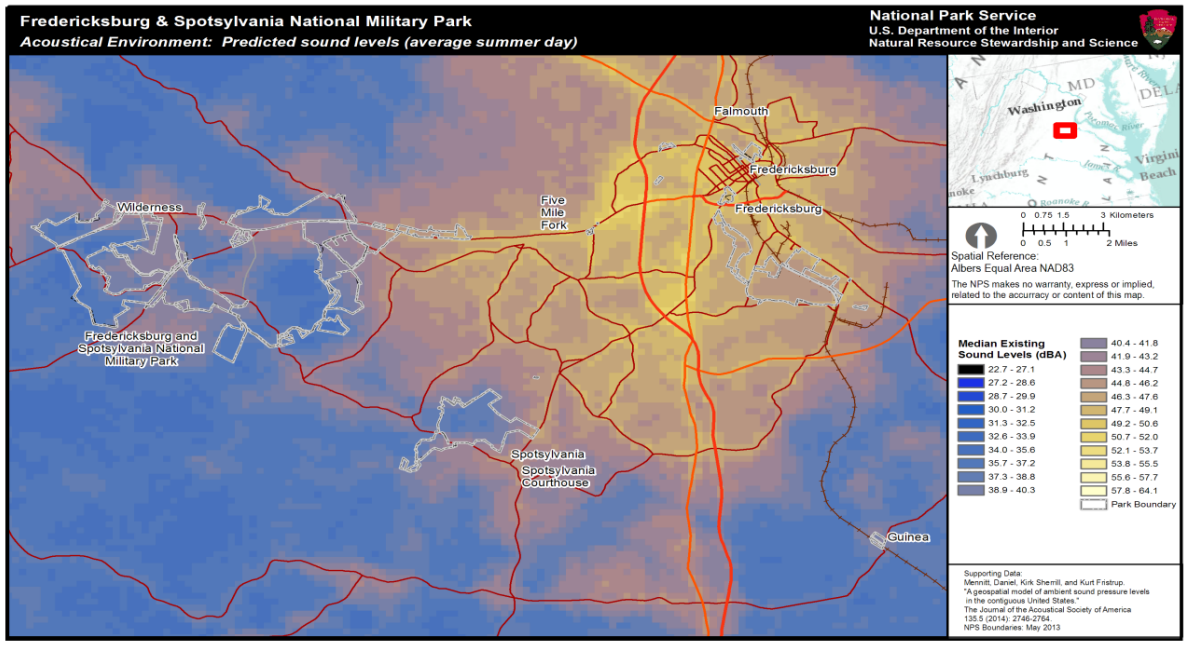


Figure 8. The NSNSD modeled existing ambient sound levels which refers to the current sound intensity of an area, including both natural and human-caused sounds.

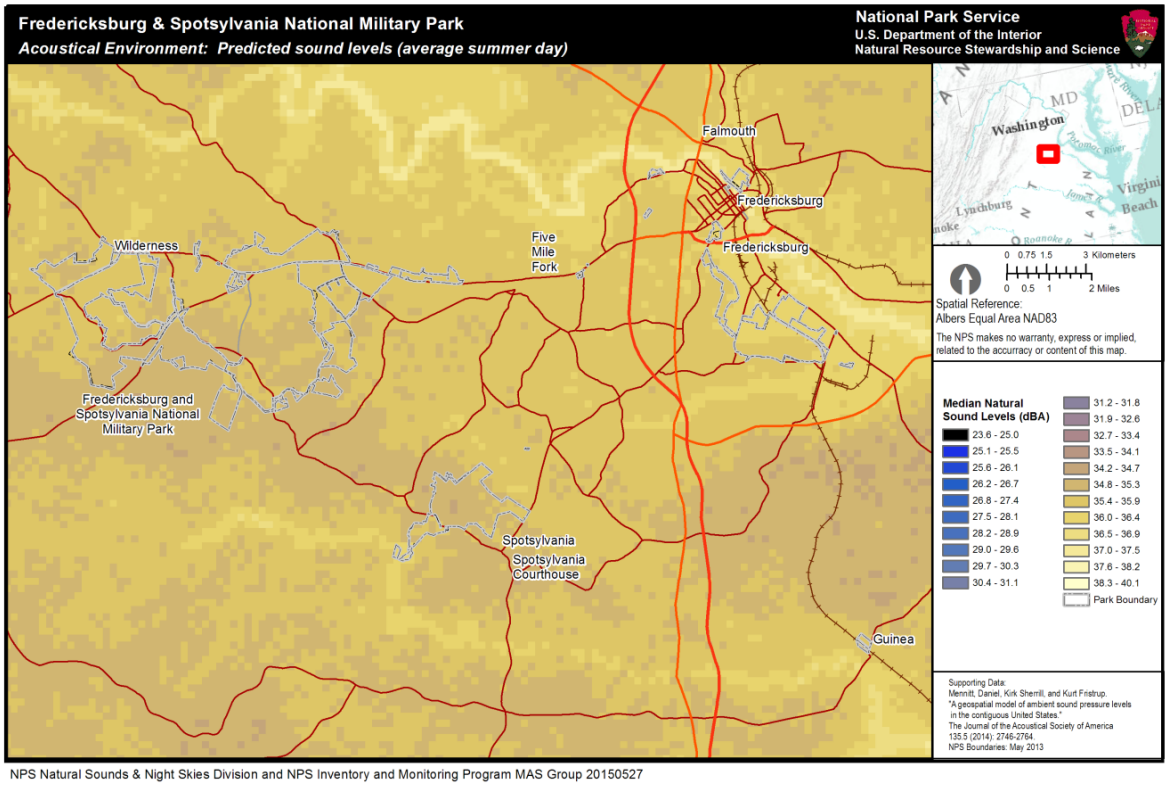


Figure 9. The NSNSD also modeled natural ambient sound level, which refers to the acoustical conditions that exist in the absence of human-caused noise and represents the level from which the NPS measures impacts to the acoustical environment.

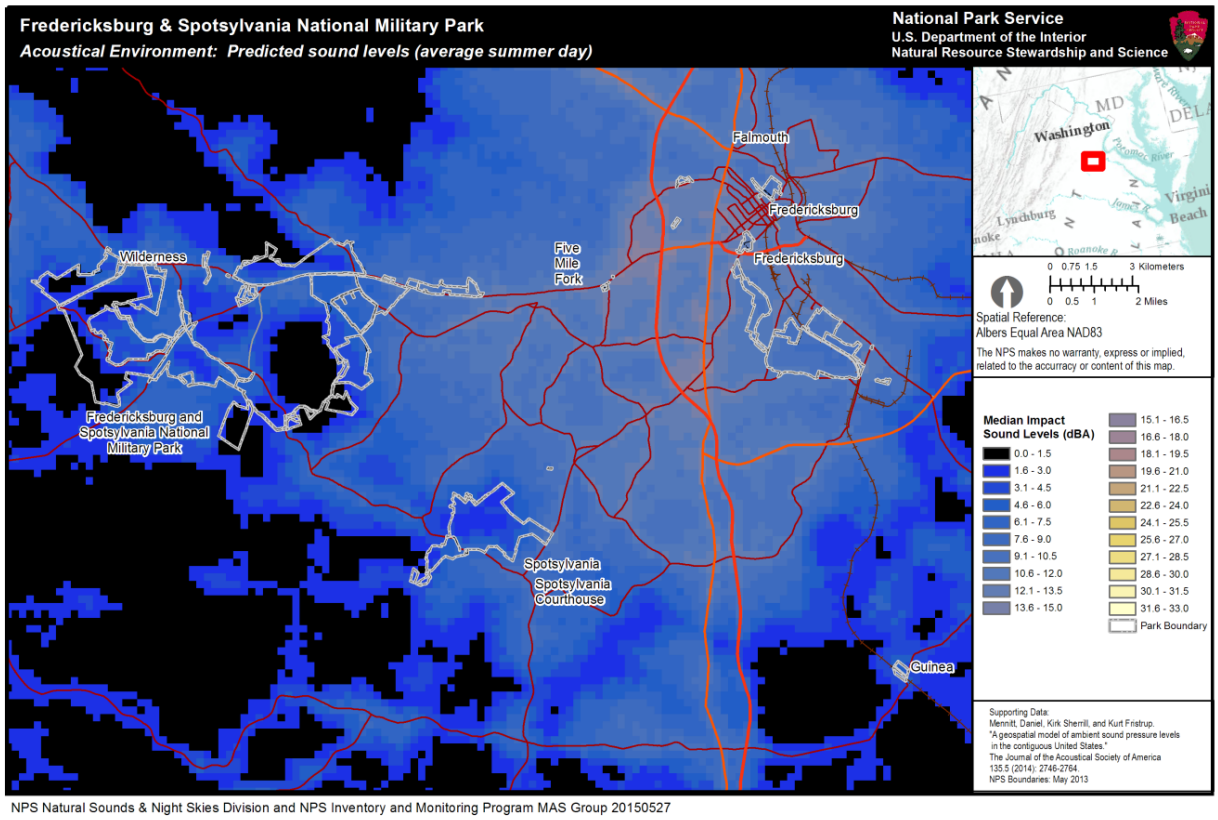


Figure 10. To assess the condition of the acoustic environment, NSNSD calculated the impact to the natural acoustic environment from human-caused sources. This metric indicates how much human-caused noise raises the existing sound levels in the park.

Water Quality (MIDN vital sign)

The streams that occur in and adjacent to FRSP are located in a highly fragmented landscape with a variety of land uses. For example, streams at FRSP travel through forests, agricultural landscapes, and residential and urbanized areas. At FRSP, 98% of the surface waters are categorized as class III (non-tidal waters) for designated use. This designation means that water quality parameters should meet the following threshold criteria (with some small seasonal variation acceptable): dissolved oxygen (DO) 4.0 mg/l (minimum); DO (minimum daily average) 5.0 mg/l; pH 6.0-9.0; maximum water temperature 32 degrees Centigrade (Commonwealth of Virginia Administrative Code 2010). In addition, 97% of the waters at FRSP have tier II anti-degradation protection which means:

"Where the quality of the waters exceed water quality standards, that quality shall be maintained and protected unless the board [Virginia Water Control Board] finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the Commonwealth's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the board shall assure water quality adequate to protect existing uses fully. Further, the board shall assure that there shall be achieved the highest statutory

and regulatory requirements applicable to all new or existing point source discharges of effluent and all cost effective and reasonable best management practices for nonpoint source control."

In 2004, the Virginia Department of Environmental Quality (DEQ) designated sections of Hazel Run and the Rappahannock River as impaired due to high fecal coliform bacteria. In addition, these same stream sections were designated as impaired due to the presence polychlorinated biphenyls (PCBs) in fish tissue that surpassed 54 parts per billion. Therefore, fish consumption is not supported in these waters. In Hazel Run the fish species with highest levels of PCBs is American eel (scientific names are listed in Table 4). In the Rappahannock River, gizzard shad, channel catfish, common carp, and blue catfish have PCB levels that exceeded accepted limits.

In 2008, 17 water quality sampling locations were established by MIDN at FRSP (Figure 11; Table 4). Water quality parameters are sampled yearly at these locations. Under this program water quality parameters collected at these locations include:

- Acid Neutralizing Capacity
- Aluminum, Organic + Inorganic Monomeric (reactive aluminum)
- Aluminum, Organic Monomeric (reactive aluminum)
- Anion/Cation Ratio
- Anions, Sum of
- Calcium
- Carbon, organic
- Cations, Sum of
- Chloride
- Magnesium
- Nitrogen as NH4
- Nitrogen as NO3
- pH
- Phosphorus
- Potassium
- Silica
- Sodium
- Specific Conductance
- Specific Conductance, Calculated/Measured Ratio
- Sulfur as SO4

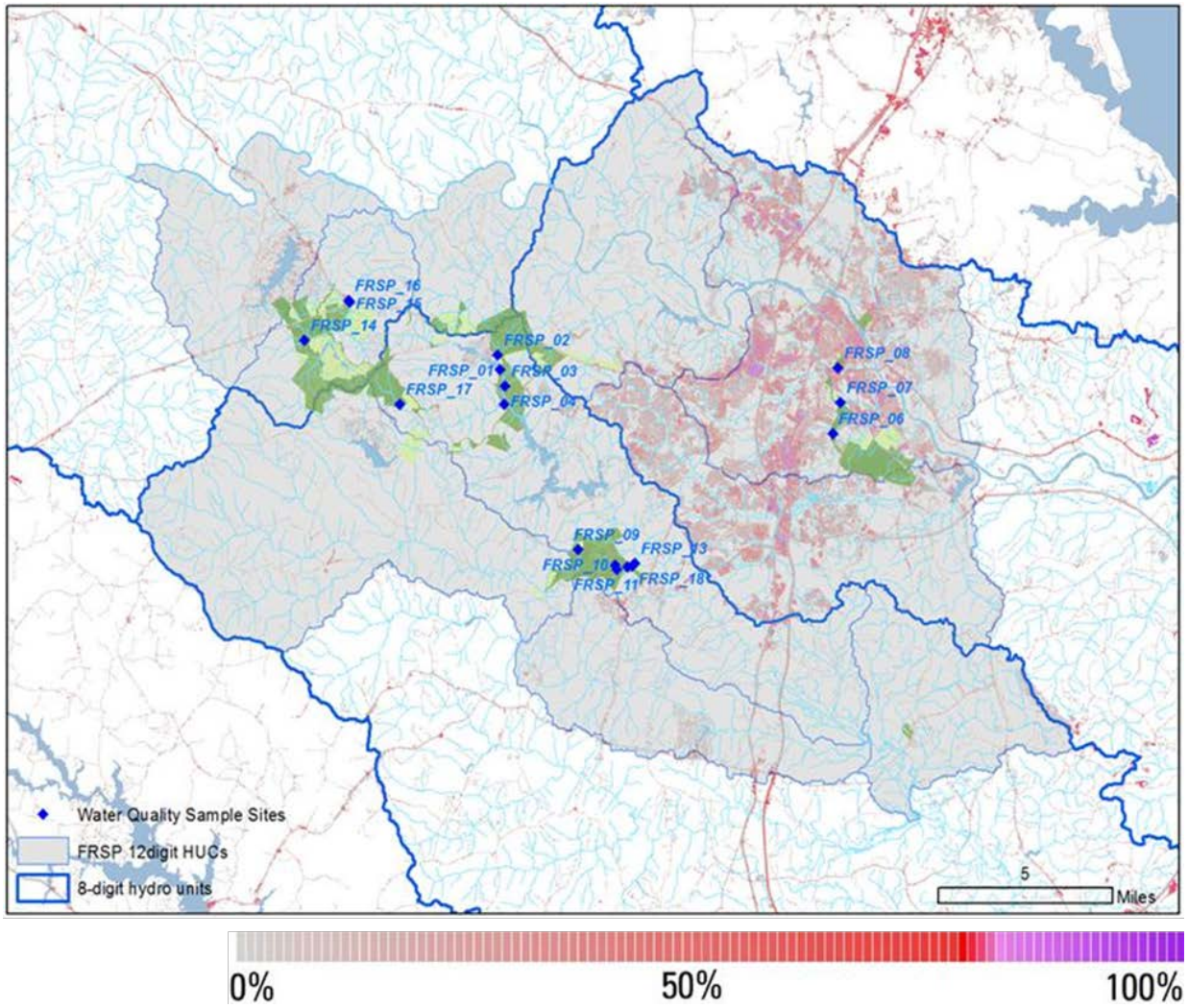


Figure 11. Water quality monitoring locations and intensity of impervious surface area development at Fredericksburg and Spotsylvania National Military Park, 2013. Color scale represents proportion (0-100%) of each mapped 30x30 m^2 land surface area (pixel) in impervious surface land cover. [Data source: National Land Cover Database, 2006]

Table 4. Percent impervious surface associated with watershed catchments upstream of currently used water quality sampling points at Fredericksburg and Spotsylvania National Military Park, 2013.

Water quality sampling point	Acres (hectares) in watershed catchment	Impervious surface
FRSP_01	1445 (3571)	1.21%
FRSP_03	225 (556)	0.75%
FRSP_04	1375 (3398)	0.34%
FRSP_06	121 (298)	17.66%
FRSP_08	3110 (7685)	23.15%
FRSP_09	83 (205)	0.19%
FRSP_10	113 (280)	0.39%
FRSP_11	76 (187)	0.20%
FRSP_14	289 (715)	0.36%
FRSP_15	2034 (5026)	0.56%
FRSP_16	437 (1079)	2.30%
FRSP_17	223 (550)	0.30%
FRSP_18	166 (410)	1.72%

These water quality parameters reflect pollution or nutrient inputs from catchments above the sampling sites and portions of these catchments fall outside of park boundaries (Figures 12-14). Data for most monitoring locations were collected from 2008 - 2012. Analysis results of measured parameters are compared to EPA's compilation of national recommended water quality criteria (EPA 2011) and/or numeric criteria for surface water established by the Virginia Department of Environmental Quality (Commonwealth of Virginia Administrative Code 2010), when applicable.

At FRSP, water monitoring sites FRSP 07 (unnamed tributary to Rappahannock River at Lee Drive) and FRSP 06 (North Branch of Deep Run at Lee Drive) recorded pH readings consistently below the state threshold of 6.0. For example, the average pH at FRSP 07 and FRSP 06 were 5.6 and 5.9, respectively. In addition, FRSP 06 also contained the highest levels of silica (an average of 718.6 μmol/l [twice the level found in other sampling locations]). Total (organic + inorganic monomeric) aluminum averaged 39.92 μg/l at the two Lee Drive sites—both silica and aluminum are elements that can leach from soils under acidic conditions. Aluminum, in particular, is toxic to aquatic life. The EPA water quality criterion for aluminum is set at 750 μg/l for acute toxicity and 87 μg/l for chronic toxicity in waters in the pH range of 6.5 to 9.0 .

Brock Run in Wilderness Battlefield (FRSP 17) had an average pH reading below 6.0 (5.9) and total aluminum averaging 194.3 μg/l. However, Brock Run drains the Acidic Seepage swamp vegetation community type—a natural source of acidic inputs. These acidic inputs are evident by the presence

of high levels of dissolved organic carbon (average of 12.2 mg/l which includes a single measurement of 19.4 mg/l—the highest in the park) which lowers aquatic pH. Therefore, secondary data indicate that low pH at Brock Run is probably due to naturally occurring sources.

Not surprisingly, pH of FRSP waters is correlated with the acid neutralizing capacity (ANC) of the stream. Water sampling sites at Wilderness Run (FRSP 14, 15, 16) had the highest mean ANC (687.8 µeq/l) and the highest pH of streams at the park (7.05). Conversely, water sampling sites along Lee Drive (FRSP 6, 7) had the lowest ANC in the park (55.0 µeq/l) and the lowest average pH (5.74). Similar to Brock Run, acidic inputs from soil and vegetation communities may be contributing to the low ANC and low pH along Lee Drive in the Fredericksburg unit of the park. The Acidic Oak-Hickory vegetation community type within the catchment indicates naturally-occurring acidic conditions.

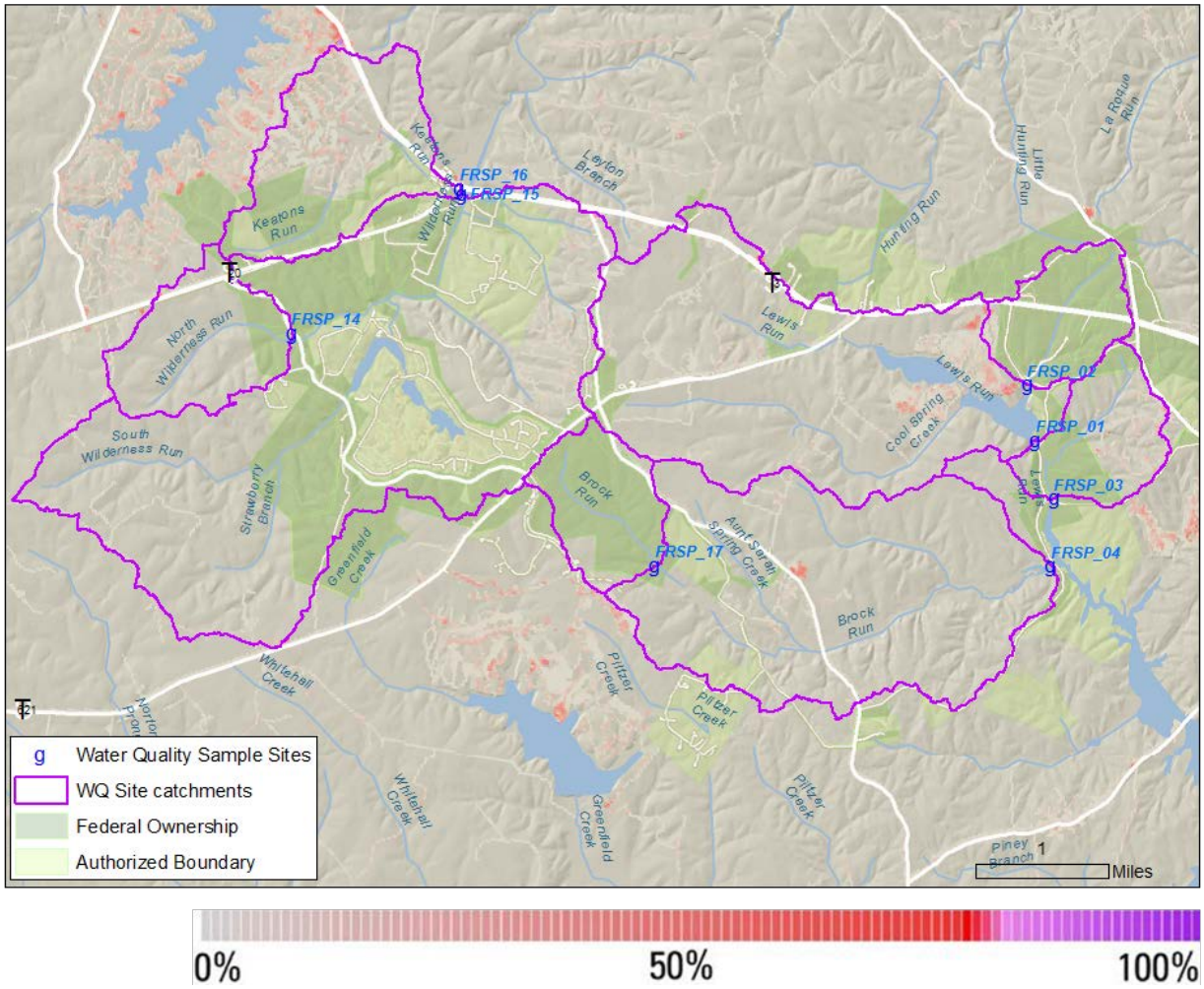


Figure 12. Water quality sampling sites and catchments above sampling sites, in reference to percent impervious in watershed, Wilderness and Chancellorsville units at Fredericksburg and Spotsylvania National Military Park, 2013. Color scale represents proportion (0-100%) of each mapped 30x30 m^2 land surface area (pixel) in impervious surface land cover. [Percent impervious data source: National Land Cover Database, 2006]

However, high levels of development and impervious surface surrounding Lee Drive may also contribute to the low pH readings (Figure 13).

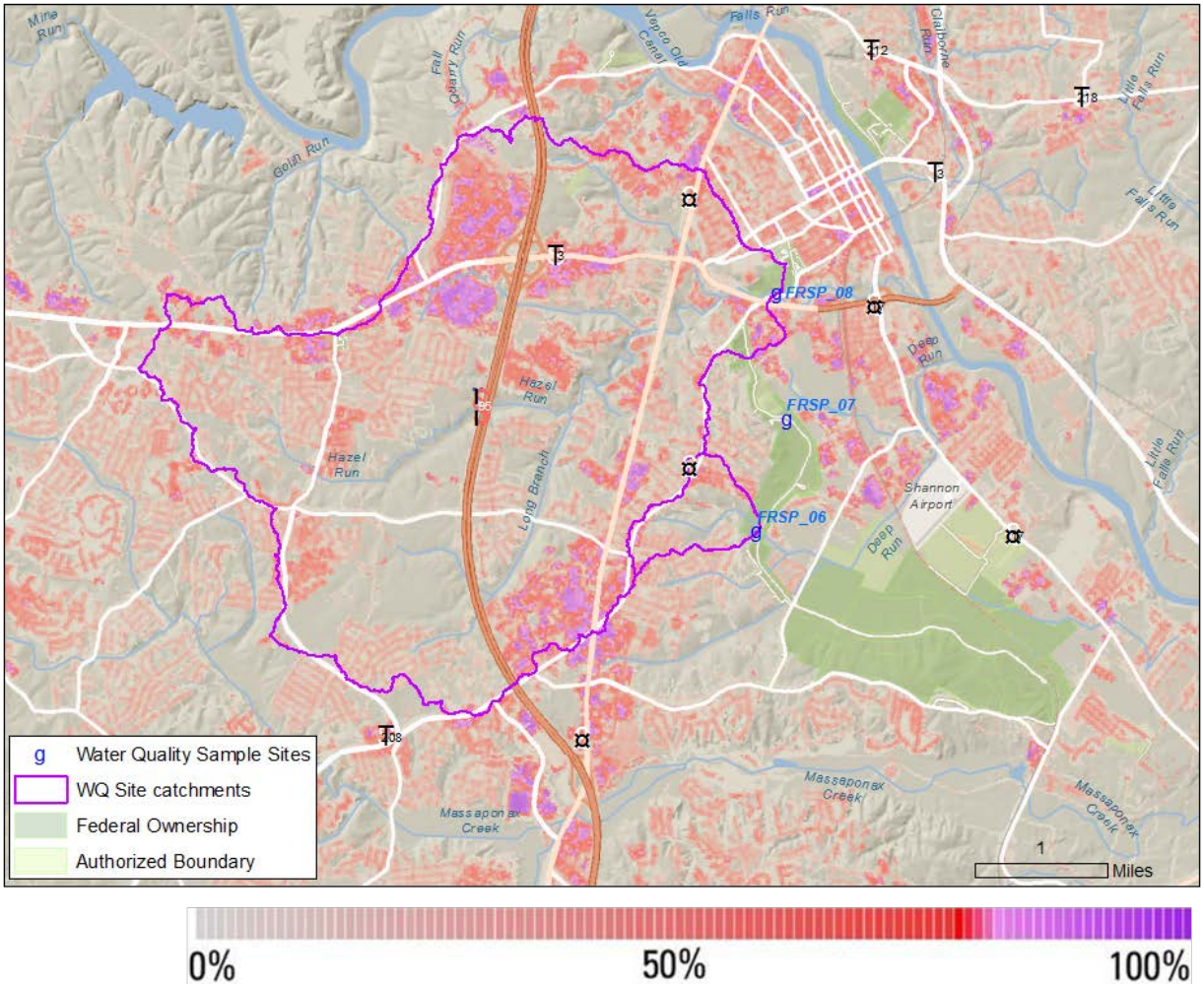


Figure 13. Water quality sampling sites and catchments above sampling sites, in reference to percent impervious in watershed, Fredericksburg and Chatham units at Fredericksburg and Spotsylvania National Military Park, 2013. Color scale represents proportion (0-100%) of each mapped 30x30 m^2 land surface area (pixel) in impervious surface land cover. [Percent impervious data source: National Land Cover Database, 2006]

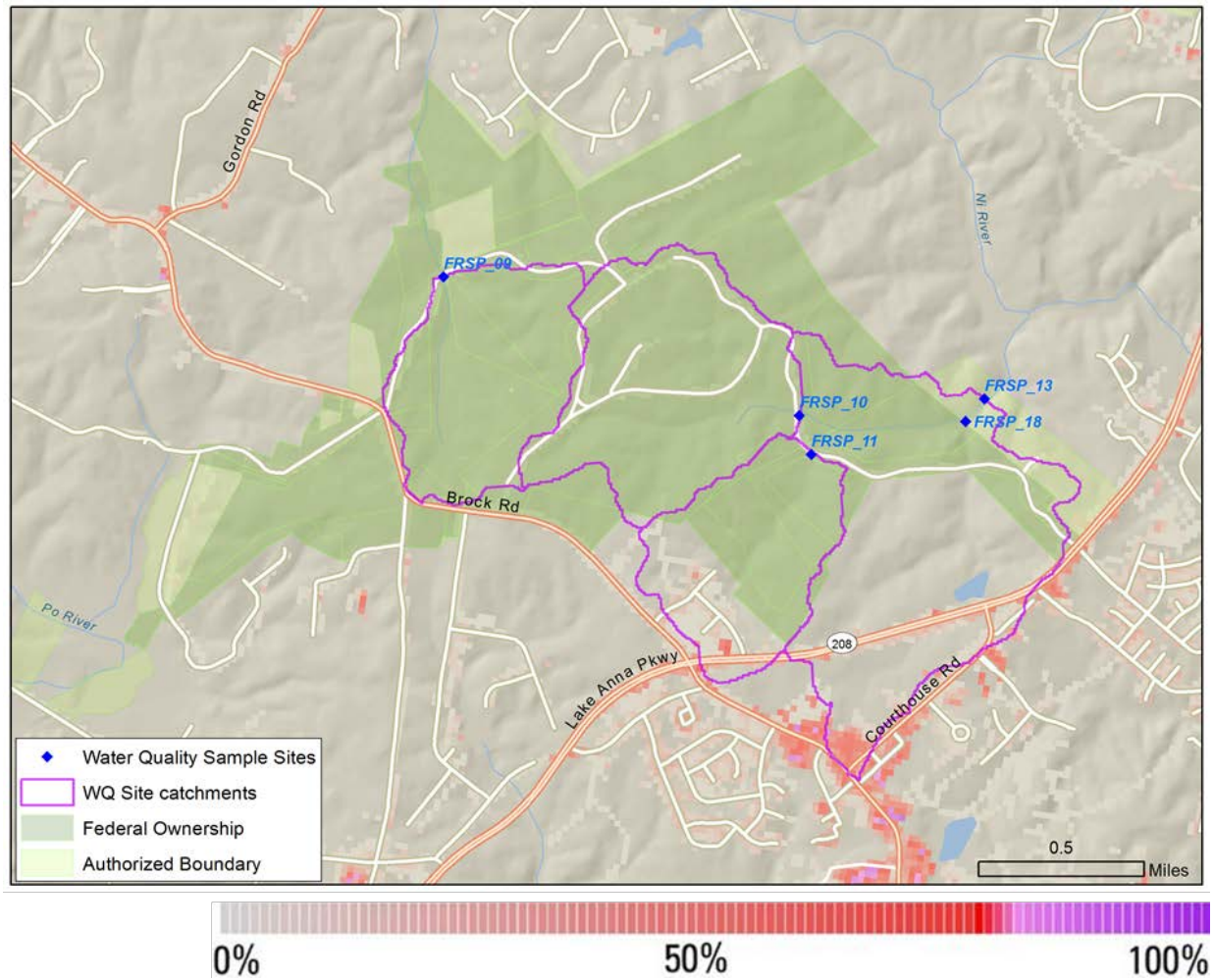


Figure 14. Water quality sampling sites and catchments above sampling sites, in reference to percent impervious in watershed, Spotsylvania unit at Fredericksburg and Spotsylvania National Military Park, 2013. Color scale represents proportion (0-100%) of each mapped 30x30 m^2 land surface area (pixel) in impervious surface land cover. [Percent impervious data source: National Land Cover Database, 2011]

On January 31, 2011, a specific conductance reading of 530.1 µS/cm was recorded at Lower Burnside Drive Creek (FRSP 18). This reading exceeds the initial range of specific conductance (300 to 500 µS/cm) found to negatively affect aquatic life (Pond 2008). Over all sampling events, the average specific conductance at this location was 122.3 µS/cm indicating that this reading was an anomaly. Specific conductance is based on the amount of solid compounds which are dissolved into the water sample. Specific conductance can be used to indirectly test the level of pollution present in water. Phosphorus (phosphate-PO_4) was also recorded at relatively high levels at this site in August 2011 (22.7 µg/l), and at Wilderness Run (FRSP 15) in October 2008 (113.1 µg/l). Phosphorus can be an indicator of pollution from agriculture or urbanized land uses via fertilizer run-off that enters waterways. Activities on land within the catchment, perhaps, should be examined to determine potential causes of the high specific conductance and phosphorus levels that occur periodically at this monitoring location.

Measures of dissolved oxygen (DO) met stated thresholds for all seasons and locations at sampling sites along Deep Run (FRSP 6, 7), Hazel Run (FRSP 8), Ni River trib. (FRSP 9), Burnside Drive Creek (FRSP 10-13, 18), and the upper reaches of Brock Run (FRSP 17). All of these sites are located within forested (shaded) settings which help keep water temperatures cool and, therefore, increase the ability of water to hold oxygen. In contrast, DO levels below 4.0 mg/l were noted in August at Lewis Run (FRSP 1, 2, 3), the lower reaches of Brock Run (FRSP 4) and the unnamed tributary of the Rappahannock River along Lee Drive (FRSP 7). The average water temperature at these sites was not significantly higher (24.6 C) than that of other sites (24.2 C), indicating that a combination of surrounding land use and, perhaps, water flow (which also effects waters' ability to hold oxygen) may be affecting DO levels during late summer. In addition, several sites with low DO (FRSP 2, 3, 4) are associated with impounded streams. Stream impoundments affect water flow and may result in lower DO levels (Kittrell 1959).

All other parameters (SO_4, nitrogen, chloride, potassium) measured well below or within thresholds set by the EPA, CBF, VA DEQ, mid-Atlantic streams assessment, and/or MD biological stream survey.

Macroinvertebrate Indicators of Water Quality (MIDN vital sign)

Aside from direct measures of water quality, a macroinvertebrate index is being used at FRSP to help assess water quality at the park. Park managers use the Virginia Stream Condition Index for non-coastal streams (VSCI; Burton and Gerritsen 2003). This multimetric index is based on macroinvertebrate samples taken in riffle/run micro- habitat using a D-frame dip net. All macroinvertebrates captured at sampling locations in the park were identified to the family level. The VSCI is an aggregation of the following eight individual metrics: 1) number of total taxa, 2) number of Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa, 3) percent abundance of Ephemeroptera, 4) percent abundance of Plecoptera + Trichoptera (-) Hydropshychidae, 5) percent abundance of scrapers, 6) percent abundance of Chironomidae, 7) percent abundance of the two dominant taxa, and 8) the Hilsenhoff biotic index (Burton and Gerritson 2003). The minimum threshold value for VSCI is 60 meaning that a VSCI score $\geq$ 60 indicates a high quality (e.g., least disturbed) stream; while a VSCI score < 60 indicates an impaired or stressed stream.

At FRSP, macroinvertebrates are sampled at 5 of the water quality sampling locations (FRSP 1, 6, 8, 13, and 17; Figure 7). Macroinvertebrate data was summarized for this report using information from 2009, 2010, and 2011. The average VSCI scores were below 60 for all sampled sites indicating stream impairment. Lewis Run (FRSP 1) had the lowest average VSCI score of 23.2 while Brock Run (FRSP 17) had the highest average VSCI score of 47.2 and had a single VSCI score > 60 in 2011. The average VSCI score for all sites sampled at the park was 35.8; the average scores for each site are listed below:

- Lewis Run FRSP 1 (23.2)
- Deep Run Lee Drive FRSP 6 (27.7)
- Hazel Run FRSP 8 (26.3)
- Burnside Drive Creek FRSP 13 (52)

- Brock Run FRSP 17 (47.2)

The VSCI score is sensitive to water quality parameters (chemical/physical) as well as habitat parameters of the stream such as stream channel alteration, sediment deposition, streambank disruption, and width of coverage of riparian vegetation along a stream (Burton and Gerritson 2003). Therefore, these indices potentially indicate that landscape features and pollutant inputs in and around the stream are negatively affecting aquatic life at the park.

Fish (MIDN vital sign)

Sampling for fish within streams in and around FRSP was conducted in 2002, 2003, and 2004 by the NPS (Atkinson 2008). A variety of habitat types (riffles, pools, runs) in streams in the Rappahannock and York drainage were sampled. In particular, Hazel Run, Deep Run, and Wilderness Run were sampled within the Rappahannock drainage; while Lewis Run, an unnamed tributary of the Ni River, and Lucy's pond (an unnamed tributary of the Poni River) were sampled within the York drainage (Figure 15).

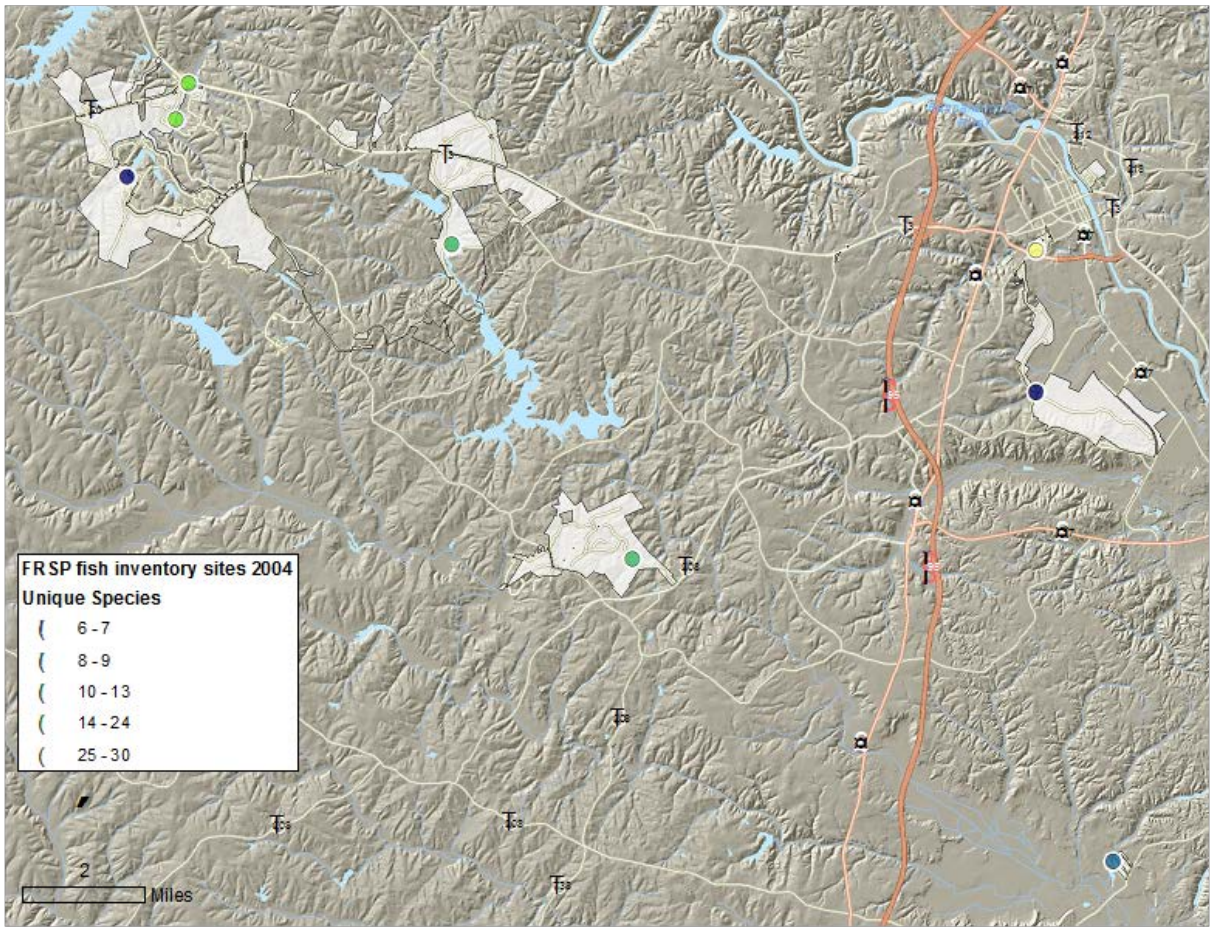


Figure 15. Fish species richness at Fredericksburg and Spotsylvania National Military Park fish sampling locations, 2004.

Forty-one species of fish were captured at inventory locations during the sampling period (Table 4). Of the fish captured, 70% were native and 27% were non-native. Fish had the highest proportion of non-native species of all vertebrates inventoried at the park. Most nonnative species collected at the park (8 of 11) were game fish, indicating that they have been introduced by or for anglers. In addition, non-native golden shiners and bluehead chubs probably occur in the park because they are often used by anglers as bait (scientific names are found in Table 5). Hazel Run has the highest number of species of non-native fish with rock bass, redbreast sunfish, bluegill, pumpkinseed, warmouth, smallmouth and largemouth bass found in this stream. Non-native fish in Wilderness Run include redbreast sunfish, bluegill, white crappie, largemouth bass, and golden shiner. Largemouth bass is the most widely distributed, non-native species at FRSP, as it was found at all sampling locations in the park. White sucker and brown bullhead are the most widely distributed native fish in FRSP. Finally, the common carp, native to Asia, is widespread in the United States and was found at FRSP. This species probably was brought into US waterways as a food and/or ornamental fish. At FRSP, common carp was only encountered in Lucy's pond and its spread in the park should be monitored carefully and prevented.

FRSP has the highest total number and number of native of fish species of any of the parks within the Mid-Atlantic Network of the NPS (Atkinson 2008). This relatively high species diversity probably is due to the fact that FRSP occupies two physiographic provinces (Piedmont and Coastal Plain), two drainages, and crosses a fall line. In particular, Hazel Run and Wilderness Run contain a high number of species (76% of fish species encountered). However, there are dramatic seasonal differences in the distribution and densities of fish within these streams. Both streams support populations of tessellated darter while Wilderness Run also contains the stripeback darter. Since darters lack swim bladders, they lie on the bottom of a waterbody and, therefore, are closely associated with a particular substrate. Stripeback darters require rock bottoms while the tessellated darter is associated with sandy substrates on moderate to slow-flowing water. In addition, the tessellated darter can tolerate rather poor water quality (Schmidt 1980).

Hazel Run contains American Eel, Sea Lamprey, and Gizzard Shad. These species require connectivity to ocean environments to complete their life cycle. In 2010, the US Fish and Wildlife Service received a petition seeking to extend federal protection to the American eel. The Service found that this petition, from the Council for Endangered Species Act Reliability, presents substantial information that warrants the initiation of a more extensive status review of the species.

The mottled sculpin (found in Wilderness Run) and silverjaw minnow (found in Hazel Run) are particularly noteworthy finds within the park. Mottled sculpin are typically found in cold water streams in the Blue Ridge and Ridge and Valley Provinces in Virginia. Its occurrence in the Piedmont represents just one of a few disjunct populations (Jenkins and Burkhead 1994). The occurrence of silverjaw minnow within Hazel Run represents the only known record of this species (and, hence, a range expansion) within the Rappahannock Drainage from the Upper Coastal Plain.

Table 5. Common name, scientific name, and number of individuals captured during fish inventories conducted at Fredericksburg and Spotsylvania National Miliary Park, 2002-2004 (modified from Atkinson 2005, 2008).

Common name	Scientific name	Number captured
Eel, American	*Anguilla rostrata*	240
Perch, Pirate	*Aphredoderus sayanus*	147
Chubsucker, Creek	*Erimyzon oblongus*	260
Sucker, White	*Catostomus commersonii*	228
Bass, Largemouth*	*Micropterus salmoides*	64
Bass, Rock*	*Ambloplites rupestris*	1
Bass, Smallmouth*	*Micropterus dolomieui*	2
Bluegill*	*Lepomis macrochirus*	866
Crappie, Black*	*Pomoxis nigromaculatus*	1
Crappie, White*	*Pomoxis annularis*	76
Flier	*Centrarchus macropterus*	1
Pumpkinseed	*Lepomis gibbosus*	1692
Sunfish, Bluespotted	*Enneacanthus gloriosus*	760
Sunfish, Green*	*Lepomis cyanellus*	79
Sunfish, Mud	*Acantharchus pomotis*	432
Sunfish, Redbreast	*Lepomis auritus*	95
Warmouth*	*Lepomis gulosus*	20
Shad, Gizzard	*Dorosoma cepedianum*	1
Sculpin, Mottled	*Cottus bairdii*	3
Carp, Common*	*Cyprinus carpio*	2
Chub, Bluehead*	*Nocomis leptocephalus*	355
Chub, Creek	*Semotilus atromaculatus*	45
Dace, Blacknose	*Rhinichthys atratulus*	172
Dace, Longnose	*Rhinichthys cataractae*	45
Dace, Rosyside	*Clinostomus funduloides*	50
Fallfish	*Semotilus corporalis*	364
Minnow, Eastern Silvery	*Hybognathus regius*	174
Minnow, Silverjaw**	*Ericymba buccata*	9
Shiner, Common	*Luxilus cornutus*	106
Shiner, Golden*	*Notemigonus crysoleucas*	1382
Shiner, Satinfin	*Cyprinella analostana*	50
Shiner, Swallowtail	*Notropis procne*	26
Pickeral, Chain	*Esox niger*	13
Bullhead, Brown	*Ameiurus nebulosus*	184
Bullhead, Yellow	*Ameiurus natalis*	13
Madtom, Margined	*Noturus insignis*	2
Darter, Stripeback	*Percina notogramma*	1
Darter, Tessellated	*Etheostoma olmstedi*	145
Lamprey, Sea	*Petromyzon marinus*	5
Mosquitofish, Eastern	*Gambusia holbrooki*	124
Mudminnow, Eastern	*Umbra pygmaea*	87

*Indicates non-native species to park waters

**Indicates new record and previously-undocumented range expansion for park waters

Amphibians and Reptiles (Herpetofauna)

Amphibians

The mosaic of habitats at FRSP including streams and wetlands provide habitat for a diverse assemblage of amphibians. NPSpecies (2013) lists 26 species of amphibians known from FRSP. These species represent 85% of the amphibian species known from the Piedmont and Coastal Plain of Virginia (NPSpecies 2013; Table 6). One species of special concern, the carpenter frog, is found at FRSP (scientific names are found in Table 6). Mitchell (2007) found that pond and vernal pool breeding frogs (American toad, eastern gray treefrog, Cope's gray treefrog, spring peeper, and northern green frog) were the most abundant frogs at FRSP. However, four species of frogs encountered at FRSP also use streams for breeding including northern green frog, pickerel frog, carpenter frog (a species of special concern in VA), and southern leopard frog. Three vernal pool breeding salamanders also were found at FRSP including marbled salamander, spotted salamander, and red spotted newt. Stream breeding salamanders found at FRSP included two-lined salamanders, three-lined salamanders, northern red salamanders, and dusky salamanders. In addition, two species of terrestrial woodland salamanders (red-backed salamander and white-spotted slimy salamander) were found in low numbers at FRSP.

Potential threats to amphibians at FRSP include vehicular traffic, human modification of vernal pools, and water quality declines in streams. In particular, development or modification of impoundments, floodplains, and wetlands should be avoided to protect amphibians in the park. The wetlands at Stonewell Jackson Shrine should be protected as the carpenter frog, a species of special concern, was documented here. In particular, resource managers at FRSP should work with surrounding landowners in this area of the park to maintain connectivity of the Stonewall wetlands with forested landscapes. Furthermore, little is known about the occurrence and distribution of vernal pools and other small wetlands in the park and their use by amphibians. Invasive, non-native plants in these wetlands and riparian areas may adversely affect breeding habitats for amphibians. The Ambystomid salamanders (e.g., marbled and spotted) require a combination of habitat types to meet their life history requirements. In particular, hardwood forests surrounding known breeding pools must be protected if these species are to persist in the park.

Finally, two pathogens, chytrid fungus (Batrachochytrium dendrobatidis [Bd]) and ranaviruses, could negatively affect salamander and frog populations at FRSP (e.g., Murray et al. 2009, Chatfield et al. 2012). Both of these pathogens have been found throughout the southeastern United States but their presence and prevalence in salamander and frog populations at FRSP is unknown. Die-offs of frogs caused by ranaviruses have been documented at the Patuxent Research Center—located 75 miles north of FRSP (www.nwhc.usgs.gov/publications/quarterly_reports/index.jsp). Dodd (2003) provides a comprehensive approach to monitoring amphibian and reptiles with specific techniques recommended so that humans do not become unintended vectors of these pathogens. In addition, Green et al. (2010) document procedures for detecting Bd and ranaviruses in amphibian populations.

Table 6. Scientific and common names for amphibians and reptiles documented during herpetological inventories conducted in 2002–2004 at Fredericksburg and Spotsylvania National Military Park, Virginia. Species are presented by park unit[1] (modified from Mitchell 2007).

Scientific name	Common name	WI	CH	SP	CM	FR	SJ
Frogs							
Acris crepitans	Eastern cricket frog	X	X	X			X
Bufo americanus	American toad	X	X	X	X	X	
Bufo fowleri	Fowler's toad			X		X	
Gastrophryne carolinensis	Eastern narrow-mouthed toad						
Hyla chrysoscelis	Cope's gray treefrog	X	X	X	X	X	X
Hyla versicolor	Eastern gray treefrog	X					
Pseudacris crucifer	Northern spring peeper	X	X	X		X	X
Pseudacris feriarum	upland chorus frog			X		X	
Scaphiopus holbrookii	Eastern spadefoot						
Rana catesbeiana	American bullfrog		X	X		X	X
Rana clamitans	Northern green frog	X	X	X	X	X	X
Rana palustris	pickerel frog	X	X	X		X	
Rana sphenocephala	Southern leopard frog		X			X	
Rana sylvatica	wood frog	X	X				
Rana virgatipes	carpenter frog						X
Salamanders							
Ambystoma maculatum	spotted salamander	X	X	X		X	
Ambystoma opacum	marbled salamander		X	X		X	
Desmognathus fuscus	Northern dusky salamander	X					
Eurycea bislineata	Northern two-lined salamander	X			X	X	
Eurycea guttolineata	three-lined salamander	X					
Hemidactylium scutatum	four-toed salamander						
Notophthalmus viridescens	red-spotted newt	X	X	X		X	
Plethodon cylindraceus	white-spotted slimy salamander	X	X				
Plethodon cinereus	red-backed salamander	X	X		X	X	
Pseudotriton montanus	Eastern mud salamander						
Pseudotriton ruber	Northern red salamander		X				
Turtles							
Chelydra serpentina	Eastern snapping turtle	X	X	X		X	X
Chrysemys picta	Eastern painted turtle	X	X	X			X
Clemmys guttata	spotted turtle		X				
Kinosternon subrubrum	Eastern mud turtle						
Pseudemys concinna	Eastern river cooter						
Pseudemys rubriventris	Northern red-bellied cooter		X		X		
Sternotherus odoratus	Eastern musk turtle or stinkpot	X	X	X		X	X
Terrapene carolina	Eastern box turtle	X	X	X		X	

Table 6. (continued) Scientific and common names for amphibians and reptiles documented during herpetological inventories conducted in 2002–2004 at Fredericksburg and Spotsylvania National Military Park, Virginia. Species are presented by park unit[1] (modified from Mitchell 2007).

Scientific name	Common name	WI	CH	SP	CM	FR	SJ
Lizards							
Cnemidophorus sexlineatus	Eastern six-lined racerunner						
Eumeces fasciatus	five-lined skink	X	X	X	X	X	X
Eumeces laticeps	broad-headed skink						
Sceloporus undulatus	Northern fence lizard	X		X			X
Scincella lateralis	little brown skink						
Snakes							
Agkistrodon contortrix	Northern copperhead	X	X			X	
Carphophis amoenus	Eastern worm snake	X		X	X	X	X
Coluber constrictor	Northern black racer	X				X	
Diadophis punctatus	Northern ring-necked snake	X	X			X	
Elaphe alleghaniensis	Eastern ratsnake	X	X			X	
Elaphe guttata	cornsnake						
Heterodon platirhinos	Eastern hog-nosed snake			X[2]			
Lampropeltis calligaster	mole kingsnake					X	
Lampropeltis getula	Eastern kingsnake		X[2]				
Nerodia sipedon	Northern watersnake	X	X	X			X
Opheodrys aestivus	rough greensnake	X					
Regina septemvittata	queen snake	X					
Storeria dekayi	Northern brownsnake	X					
Storeria occipitomaculata	Northern red-bellied snake	X					
Thamnophis sauritus	Eastern ribbonsnake	X		X			
Thamnophis sirtalis	Eastern gartersnake	X			X		X
Virginia valeriae	Eastern smooth earthsnake	X			X		

[1] Park unit abbreviations: WI = Wilderness, CH = Chancellorsville, SP = Spotsylvania, CM = Chatham, FR = Fredericksburg, SJ = Stonewall Jackson Shrine

[2] Species documented by Gregg Kneipp and others at FRSP.

Reptiles

Thirty species of reptiles have been documented at FRSP. This number represents 44% of the 68 species of native reptiles known to occur in Virginia. Recent inventories documented that the eastern painted turtle was the most numerous species of reptile found at the park and it occupies both stream and impoundment habitat (Mitchell 2007; Table 6). An additional four species of freshwater turtle - snapping turtle, red-bellied cooter, spotted turtle, and stinkpot are also found in FRSP (scientific names are found in Table 6). Box turtles also occur at FRSP - especially in the Spotsylvania portion of the park. Although not listed as a species of special concern in VA, spotted turtles and box turtles are declining throughout their range due to habitat loss and illegal collecting for pet trade.

Populations of fence lizards and five-lined skinks occur in old field habitat at FRSP. A variety of snakes also are found at FRSP including the northern watersnake, northern copperhead, ribbon snake, and eastern garter snake. Mitchell (2007) found these snake species in association with forested wetlands and riparian areas at the park. In contrast, the eastern rat snake and black racer were found in upland forests and shrublands at FRSP. Finally, eastern hog-nosed snakes and eastern kingsnakes are found at FRSP but in low numbers (Mitchell 2007).

When amphibians and reptiles are examined together, the herpetofaunal species richness is highest at the Spotsylvania Courthouse and Jackson Shrine units (Figure 16). Portions of the Wilderness Battlefield also support a diverse assemblage of herpetofaunal species. Reptiles were found in all habitat types at FRSP. However, additional inventories for frogs and snakes should be conducted - perhaps using permanent sampling points that contain coverboards (Mitchell 2007; Grant et al. 1992). Reptiles, like amphibians, are susceptible to vehicular traffic, especially in spring and summer when they may cross roadways to breed or thermoregulate. Reptile nests, especially turtle nests, may be heavily preyed upon by raccoons. Raccoon numbers tend to increase in urbanizing areas, such as those that surround FRSP, so turtle nest predation should be monitored at the park. Education programs for visitors to FRSP about the damage that collecting has on local populations of amphibian and reptiles may help proactively protect these species. Furthermore, the public should be discouraged from releasing captive amphibians and reptiles in the park.

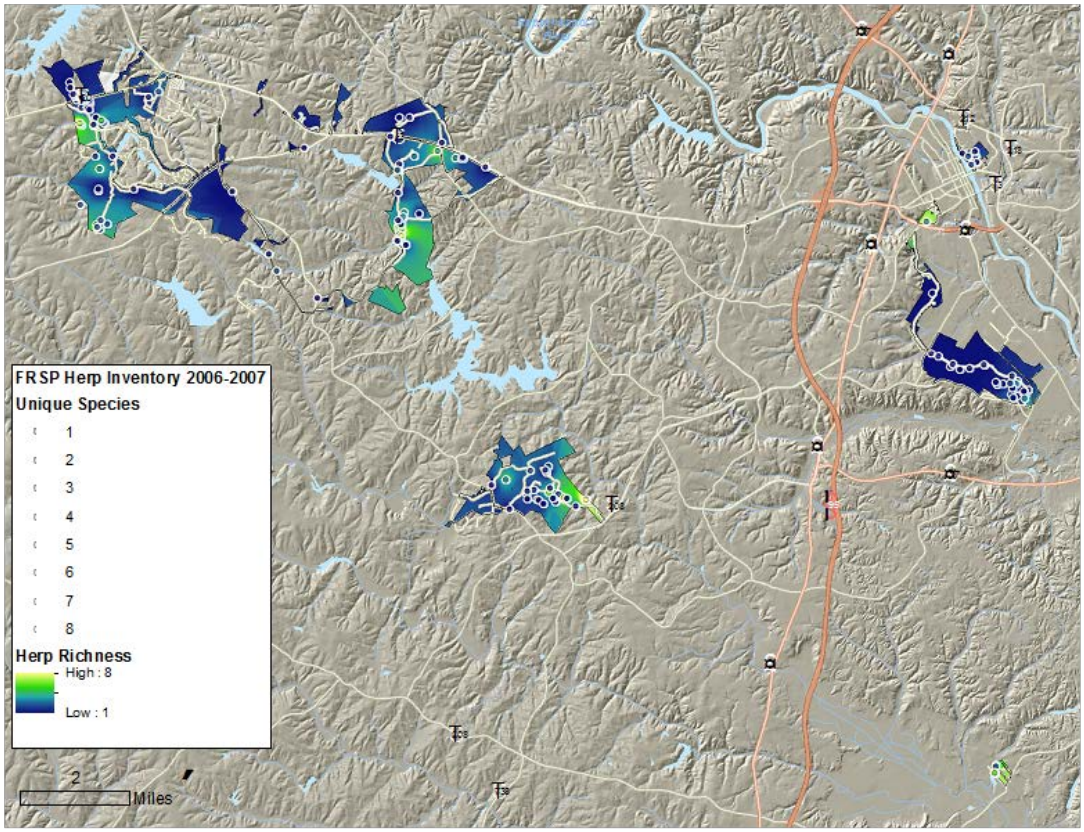


Figure 16. Herpetofauna species richness at Fredericksburg and Spotsylvania National Military Park, 2007.

Birds (MIDN vital sign)

Currently, 159 species of birds are known to occur in FRSP (NPSecies 2013). This represents 74.4% (125 of 168 species) of the species found in Virginia and 42% (25 of 59 species) of the species identified as state species of special concern or on the Partners in Flight (PIF) watchlist (Virginia Department of Game and Inland Fisheries 2012; Table 7). PIF distinguishes species of concern facing immediate threats as "watchlist" species. Additionally, PIF further classifies birds as "Stewardship" species if they are representative of avifaunal biomes that may or may not be in immediate danger. Of the 159 species found in FRSP, approximately 115 were detected during the breeding season and, therefore, may nest in the park (NPS 2009; Wakamiya 2012). Recent monitoring efforts at the park led to the detection of 17 watchlist species and 18 stewardship species during at least one breeding season between 2009 and 2013 (Johnson 2014). Besides providing breeding and nesting areas for numerous avian guilds, the varied habitats at FRSP may also provide important foraging and resting locations for migratory birds (Lionel and Rodewald 2006). In particular, Canada Warbler (*Cardellina canadensis*), Cerulean Warbler (*Setophaga cerulea*), Black-throated Green Warbler (*Setophaga virens*), and Blue-winged Warbler (*Vermivora cyanoptera*), all species of conservation concern, were documented during migration in FRSP. Highest bird species richness was documented at Wilderness battlefield, probably due to the large expanse of mature, unfragmented forest that still persists in that park unit (Figure 17; Wakamiya 2012).

Forest birds

FRSP provides breeding habitat for neotropical migratory birds (neotropical migrants) including 16 species of wood warblers (Family Parulidae). Many species in this family depend upon unfragmented mixed-deciduous forests with full canopies, gap dynamics (e.g., tree falls), and well-developed understories in place. At FRSP, six species of Parulidae including Worm-eating Warbler, Kentucky warbler, Northern Parula (*Setophaga americana*), Prothonotary Warbler (*Protonotaria citrea*), Louisiana Waterthrush (*Parkesia motacilla*), and Hooded Warbler (*Setophaga citrina*) require mature forests along streams, swamps, and other bottomlands with well-developed shrub layers for breeding and foraging habitat. This habitat type represented by Coastal Plain Piedmont Floodplain forest and Mixed Mesic hardwood forest is present at FRSP, especially in the Wilderness portion of the park. Wood Thrush, Scarlet Tanager (*Piranga olivacea*), Acadian Flycatcher (*Empidonax virescens*), and Vireos (Yellow-throated [*Vireo flavifrons*], Red-eyed [*V. olivaceus*], and White-eyed [*V. griseus*]) also breed at FRSP and, although not warblers, all of these species rely on large forest patches with well-developed understory for breeding.

Several forest breeding birds at FRSP including Wood Thrush, Kentucky Warbler, and Worm-eating Warbler are on the Partners in Flight (PIF) watchlist (USFWS 1999). The PIF watchlist does not include federally threatened or endangered species. Rather, it identifies those species that are still fairly common but which will probably someday become threatened or endangered (USFWS 1999). Several species on the watchlist have declined precipitously over the past several decades because they occupy habitats that are under severe threat, are found in low numbers, or have such restricted ranges that their existence is tenuous (USFWS 1999).

Table 7. Bird species of conservation concern, residency status, and conservation status detected during 2003 and 2004 at Fredericksburg and Spotsylvania National Military Park, Virginia. Species are presented by park unit (modified from NPS 2009; Goodwin and Wakamiya 2011).

Species	Residency Status	Park Unit[1]	Conservation Status[2]
green heron	Breeding	CH,SJ	PIF 10
northern bobwhite	Breeding	SP,WI	PIF 10
yellow-billed cuckoo	Breeding	CH,FR,SJ,SP,WI	PIF 44
chimney swift	Breeding	CH,CM,FR,SP,WI	PIF 10, PIF 44
red-headed woodpecker	Breeding	CH	R5
hairy woodpecker	Breeding	CH,CM,FR,SP,WI	PIF 44
eastern wood-pewee	Breeding	CH,CM,FR,SJ,SP,WI	PIF 44
Acadian flycatcher	Breeding	CH,FR,SJ,SP,WI	PIF 10, PIF 44
eastern kingbird	Breeding	CH,CM,FR,SJ,SP,WI	PIF 44
yellow-throated vireo	Breeding	CH,FR,SJ,SP,WI	PIF 44
Carolina chickadee	Breeding	CH,CM,FR,SP,WI	PIF 44
wood thrush	Breeding	CH,FR,SP,WI	BCR27, BCR29, R5, PIF10, PIF44
gray catbird	Breeding	CH,FR,SP,WI	PIF44
brown thrasher	Breeding	CH,FR,SJ,SP,WI	PIF44
northern parula	Breeding	CH,CM,SJ,SP,WI	PIF44
blue-winged warbler	Migratory	SP	BCR29, R5, PIF10
black-throated green warbler	Migratory	FR,SP	BCR27
pine warbler	Breeding	CH,FR,SP,WI	PIF44
prairie warbler	Breeding	CH,CM,FR,SJ,SP,WI	BCR27, BCR29, R5, PIF10, PIF44
worm-eating warbler	Breeding	FR,WI	R5, PIF10, PIF44
Louisiana waterthrush	Breeding	CH,SJ,SP,WI	PIF10, PIF44
Kentucky warbler	Breeding	CH,SP,WI	BCR29, R5, PIF10
Canada warbler	Migratory	WI	R5, PIF10
scarlet tanager	Breeding	CH,FR,SP,WI	PIF10, PIF44
rose-breasted grosbeak	Migratory	CH,FR,SP	PIF44
eastern towhee	Breeding	CH,FR,SJ,SP,WI	PIF10, PIF44
field sparrow	Breeding	CH,FR,SJ,SP,WI	PIF10, PIF44

[1] Park unit abbreviations: WI = Wilderness, CH = Chancellorsville, SP = Spotsylvania, CM = Chatham, FR = Fredericksburg, SJ = Stonewall Jackson Shrine

[2] Conservation status includes United States Fish and Wildlife Service Birds of Conservation Concern for Bird Conservation Regions 27 (BCR27) and 29 (BCR29) and USFWS Region 5 (R5) and Partners in Flight priority species for regions 10 (PIF10) and 44 (PIF44).

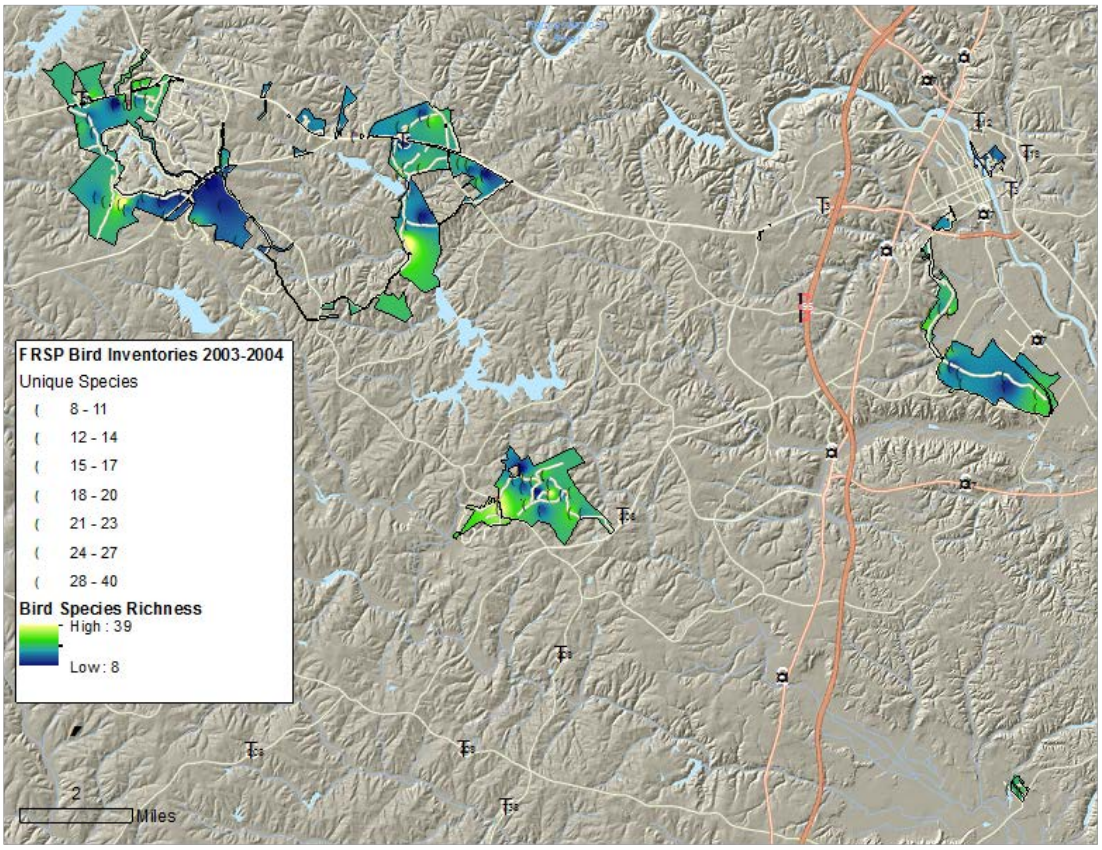


Figure 17. Breeding bird species richness at Fredericksburg and Spotsylvania National Military Park, 2005.

Populations of neotropical wood warblers are threatened by loss of forest habitat and forest fragmentation caused by human development and road construction adjacent to the park. Although not studied, forest patches at FRSP may be large enough to support breeding wood warblers but small enough to act as ecological traps where nest predation and parasitism are high (Schlaepfer et al. 2002). Future research should be conducted at FRSP to determine reproductive success of warblers in these forest patches. Resource managers should work with adjacent landowners to minimize forest removal adjacent to forests at the park.

Aside from wood warblers that depend on the mixed deciduous forests, Yellow-throated Warblers (*Setophaga dominica*) and Pine Warblers (*Setophaga pinus*) depend upon pine stands for breeding. In addition, Red-breasted Nuthatch (*Sitta canadensis*) and Northern Bobwhite (*Colinus virginianus*) use pine forest stands for foraging and breeding. Pine forests are declining throughout the southeastern United States due to development and fire suppression (Orwigs and Abrams 1994). At FRSP, these pine-dependent bird species were detected in the Spotsylvania Courthouse unit within or adjacent to the successional Virginia Pine vegetation community. Currently, FRSP has a fire management plan in place to help maintain these pine forests at the park (FRSP 2012).

Mature forests contain dead and decaying trees which are vital habitat elements for woodpeckers (family Picidae). Mature forests at FRSP support 6 species of woodpeckers (Pileated Woodpecker [*Dryocopus pileatus*], Red-bellied Woodpecker [*Melanerpes carolinus*], Red-headed Woodpecker [*Melanerpes erythrocephalus*], Northern Flicker [*Colaptes auratus*], Hairy Woodpecker [*Picoides villosus*], Downy Woodpecker [*Picoides pubescens*]) including all of the resident species found within the northern piedmont of Virginia. In western U.S. and Europe, woodpecker abundance and diversity is an indicator of overall bird diversity and forest health (Drever et al. 2008). The high diversity of woodpeckers at FRSP may reflect the maturity and ecological value of forests within the park.

Early successional (shrubland) birds

Partners in Flight (PIF), considers the shrubland suite of birds a high or moderate priority for conservation action. Most shrubland birds can be considered species of conservation responsibility rather than species of immediate concern. Species of conservation responsibility require long-term conservation planning and population monitoring to ensure that adequate habitat will be maintained and long-term threats eliminated (Dettmers 2003). In the Virginia piedmont, shrubland species are declining as early successional habitat converts to older forests or are cleared for agriculture and/or development (Wolter et al. 2008). At FRSP, shrublands (represented by the successional vegetation community types) provide breeding habitat for Indigo Buntings (*Passerina cyanea*), Common Yellowthroats (*Geothlypis trichas*), Orchard Orioles (*Icterus spurius*), Eastern Kingbirds (*Tyrannus tyrannus*), Eastern Whip-poor-will (*Antrostomus vociferus*), Brown Thrashers, Eastern Towhees, and Yellow-breasted Chats. Although Indigo Buntings, Common Yellowthroats, Orchard Orioles, and Eastern Kingbirds are common and wide-spread throughout their breeding range, Eastern Whip-poor-will, Brown Thrashers, Yellow-breasted Chat and Eastern Towhees are declining throughout their range in the eastern United States (Brawn et al. 2001).

Grassland birds

The historic (cultural) meadows maintained at FRSP support a number of breeding grassland birds: Eastern Bluebirds (*Sialia sialis*), Blue Grosbeak, Field Sparrow, Grasshopper Sparrow (*Ammodramus savannarum*), Eastern Meadowlark (*Sturnella magna*), and Bobolink (*Dolichonyx oryzivorus*). Like shrubland species, grassland bird species are declining in the eastern US and conservation of appropriate habitat for these species at FRSP is critical. Grassland birds are declining throughout the mid-Atlantic due to mowing practices, conversion of meadows to other habitat types, and urbanization (Brawn et al. 2001). At FRSP, cultural meadows at Wilderness, Chancellorsville, and Spotsylvania units support the highest diversity of breeding grassland bird species. Based upon research conducted in the Virginia piedmont, the minimum size of a meadow to support breeding grassland birds is 20 acres (8.09 ha), with 100 acres (40.5 ha) or larger being optimum (Wolter et al. 2008). Wolter et al. (2008) recommends that in the VA piedmont patches that are 20 acres (8.09 ha) or smaller that are not adjacent to existing forest or grassland should be considered for permanent maintenance as shrubland. At FRSP, however, some small grasslands may be maintained as such for cultural and interpretive purposes. Maintenance of existing shrublands requires periodic (about every four or five years) disturbances through such means as burning, mowing, grazing, selective removal of trees, and where necessary, herbicide use. No disturbance should occur from mid-April through

mid-August when birds are nesting and raising young. To control trees, burning or cutting should be accomplished as soon as possible after mid-August because these types of control work best if accomplished before the trees become dormant for winter. FRSP has a cultural meadow management plan in place that uses these recommended approaches (FRSP 2006, 2010). The management plan should continue to be implemented to maintain diverse vegetation and bird communities while maintaining the historic landscape of the battlefields.

Waterbirds and waterfowl

The waterways of FRSP support species of birds that depend on good water quality. For example, Belted Kingfisher (*Megaceryle alcyon*) and Louisiana Waterthrush depend on clean streams (O'Connell et al. 2000). Other water-dependent species found in FRSP, such as Green Herons (*Butorides virescens*), Great Blue Herons (*Ardea herodias*), Spotted Sandpipers (*Actitis macularius*), Common Snipe (*Gallinago gallinago*), and various species of waterfowl (e.g., Wood Duck [*Aix sponsa*]), use riparian corridors along streams and swamps for foraging habitat. To maintain waterbirds at FRSP, resource managers should work to improve and prevent further degradation of water quality in streams and wetlands, as well as maintain or expand vegetated riparian buffers in and around the park.

Raptors

Thirteen species of raptors are found in FRSP (NPSpecies 2013). Species of interest at the park include Broad-winged Hawk (*Buteo platypterus*), Northern Harrier (*Circus cyaneus*), and Bald Eagle (*Haliaeetus leucocephalus*) which rely on forests, grasslands, and riparian corridors, respectively, for breeding. Great Horned (*Bubo virginianus*), Barred (*Strix varia*), and Eastern Screech-owl (*Megascops asio*) breed in the forests at FRSP. Maintaining a mix of habitat types will help to ensure that these species persist at FRSP.

Mammals (White-tailed deer are a MIDN vital sign)

There are 26 species of terrestrial mammals documented in FRSP (NPSpecies 2013; Table 8). These species represent 28% of the mammalian species known to occur in Virginia. There are no federally- or state-listed species of mammals known to occur in FRSP. Barry et al. (2008) used a combination of trapping (Figure 18) and visual encounter surveys (Figure 19) to inventory mammals at sampling sites within all park units. They documented 24 of 37 (65%) of the terrestrial mammal species predicted to occur at FRSP and 87% (13 of 15) of those for which historical records exist.

The white-footed mouse is the most abundant terrestrial mammal found at FRSP and occupies all habitat types (Barry et al. 2008; scientific names are found in Table 8). Field (meadow) habitats at FRSP support populations of meadow voles, eastern harvest mouse (at very high densities), and northern short-tailed shrew. The eastern harvest mouse occurs at high density within FRSP, perhaps, due to meadow restoration programs. These restoration programs should be continued not only for their cultural significance but for their importance to maintaining field communities of small mammals at the park.

Table 8. Scientific and common names for historically-present (based on historical records from the Virginia State Museum) and presently-known (based on mammal inventory conducted in 2005) mammal species for Fredericksburg and Spotsylvania National Military Park (modified from Barry et al. 2008).

Scientific Name	Common Name	FRSP Historical	FRSP Observed
Didelphis virginiana	Virginia opossum	X	X
Blarina brevicauda	Northern short-tailed shrew		X
Cryptotis parva	North American least shrew		X
Sorex hoyi	American pygmy shrew		X
Sorex longirostris	southeastern shrew		X
Condylura cristata	star-nosed mole		
Scalopus aquaticus	eastern mole		X
Sylvilagus floridanus	eastern cottontail	X	X
Castor canadensis	American beaver	X	X
Microtus pennsylvanicus	meadow vole		X
Microtus pinetorum	woodland vole		
Ondatra zibethicus	common muskrat		
Oryzomys palustris	marsh oryzomys		X
Peromyscus leucopus	white-footed deermouse	X	X
Peromyscus maniculatus	deer mouse	X	
Reithrodontomys humulis	eastern harvest mouse		X
Mus musculus	house mouse	X	X
Rattus norvegicus	brown rat		X
Glaucomys volans	southern flying squirrel		
Marmota monax	woodchuck	X	X
Sciurus carolinensis	eastern gray squirrel	X	X
Sciurus niger	eastern fox squirrel		
Tamias striatus	eastern chipmunk	X	X
Tamiasciurus hudsonicus	red squirrel		
Zapus hudsonius	meadow jumping mouse		X
Canis latrans	coyote		
Canis lupus	domestic dog		X
Urocyon cinereoargenteus	gray fox	X	X
Vulpes vulpes	red fox	X	X
Felis catus	domestic cat		
Lynx rufus	bobcat		
Mephitis mephitis	striped skunk	X	X
Lontra canadensis	North American river otter		
Mustela frenata	long-tailed weasel		
Neovison vison	American mink		
Procyon lotor	raccoon	X	X
Ursus americanus	black bear	X	
Odocoileus virginianus	white-tailed deer	X	X

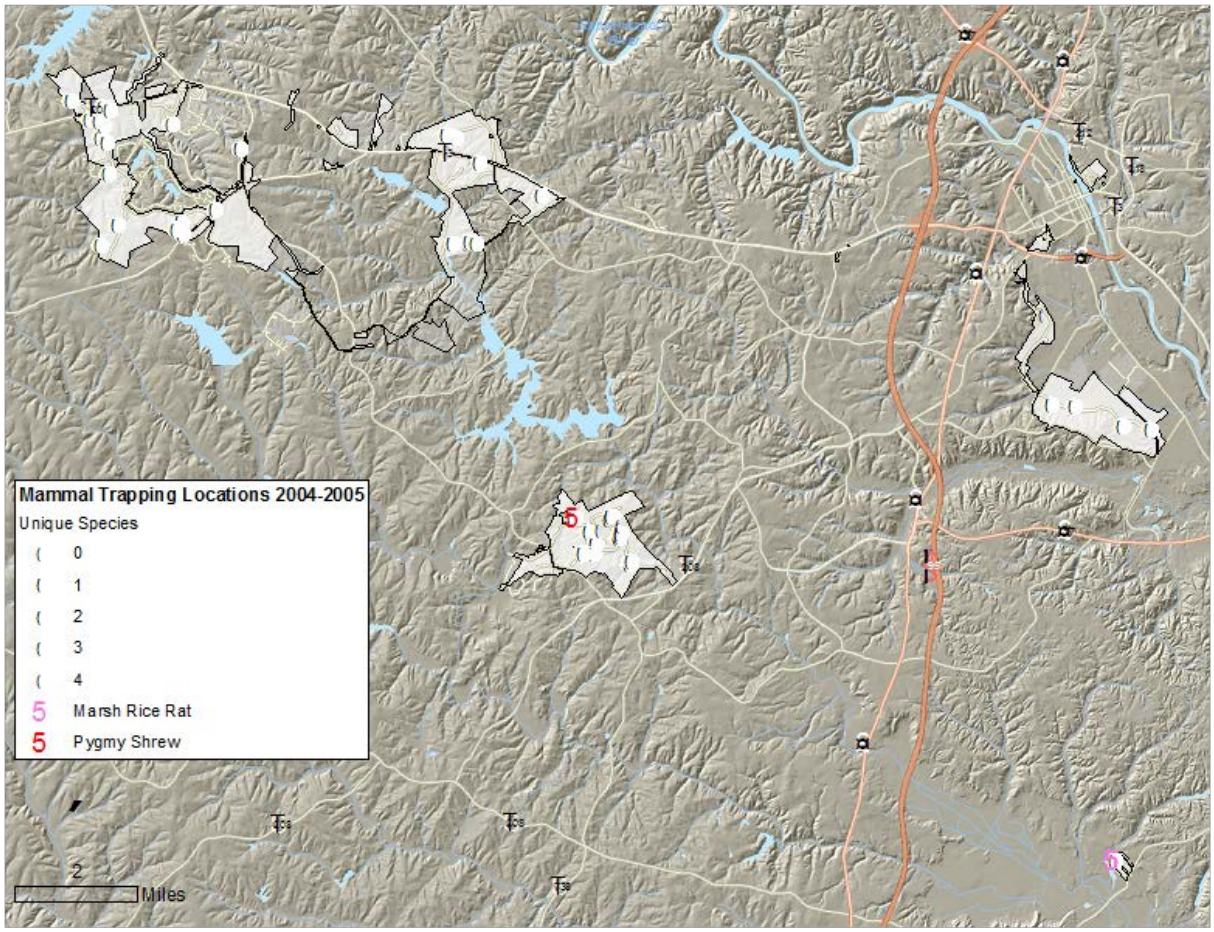


Figure 18. Mammal trapping results for Fredericksburg and Spotsylvania National Military Park, with locations of marsh rice rat and pygmy shrew noted, 2014.

The American least shrew, a rare insectivore, was found adjacent to a pine stand at the Spotsylvania unit at the park and may occur in low abundance. Pine forests should be surveyed more intensely to determine population size of American least shrew. In addition, this habitat component should be maintained at FRSP through active fire management to protect the plants, birds, and mammals that rely on this habitat type (e.g., FRSP 2012).

Wetland and riparian areas at FRSP provide habitat for raccoons, beavers, and eastern moles. In addition, one specimen of rice rat was captured in 2005 at the Stonewall Jackson Shrine wetlands. This identification is located within the extreme northwest of rice rat's geographic distribution (Barry et al. 2008).

Four species of squirrels are known from FRSP: gray squirrel, southern flying squirrel, woodchuck, and eastern chipmunk. Red squirrel and eastern fox squirrel were not detected during recent mammals surveys although suitable habitat (e.g., pine stands) exists within the park (Barry et al. 2008). Therefore, targeted surveys should be conducted for these species.

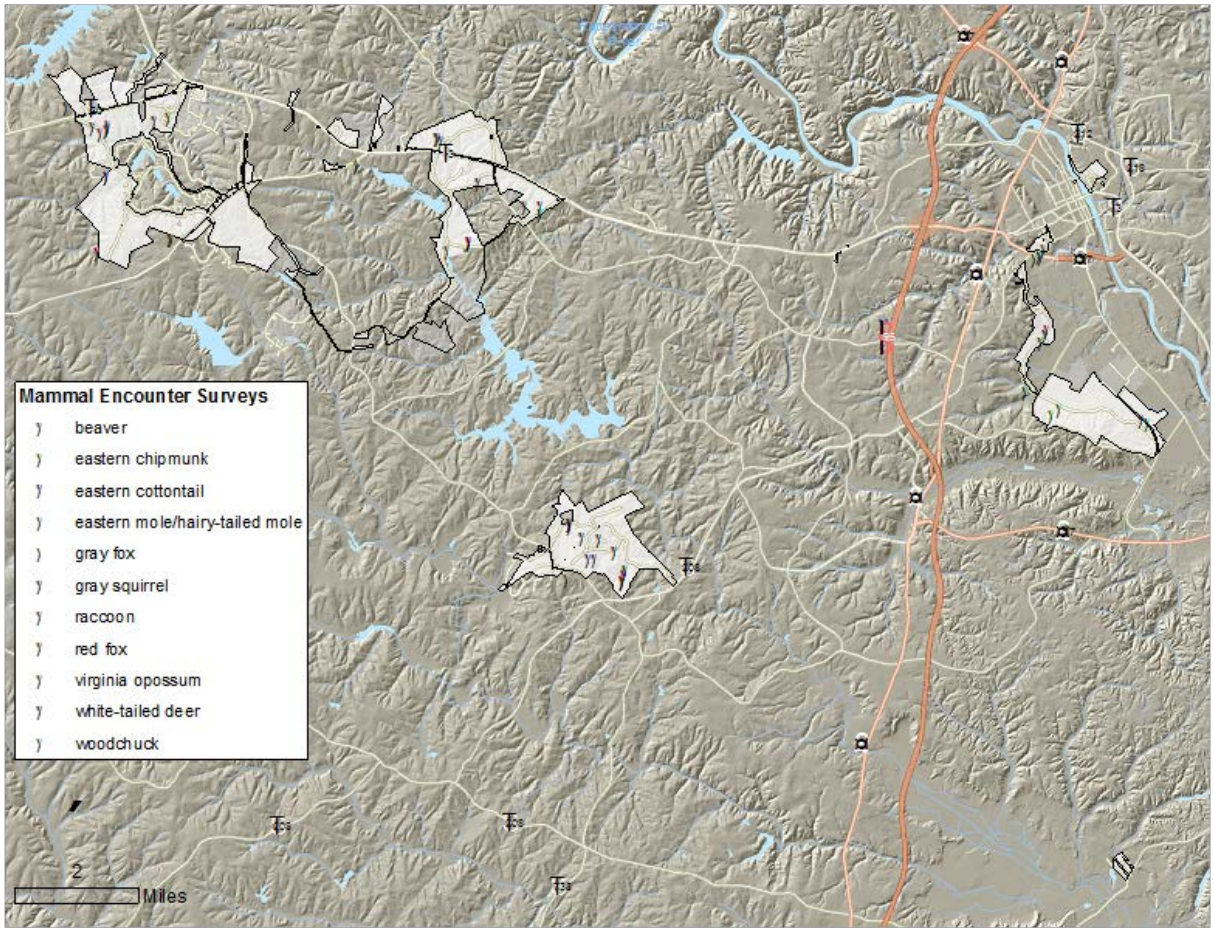


Figure 19. Mammal visual encounter survey results for Fredericksburg and Spotsylvania National Military Park, 2005.

Additionally, variety of other mammals occur at FRSP. For example, three species of canids are found at FRSP. The coyote is known to breed in the park and red and gray foxes are present but their residency status is unknown (NPSpecies 2013). Virginia opossum and eastern cottontails are found along forest edges and in old-fields at FRSP. Two species of non-native mammals, house mouse and Norway rat, are found at the park and are closely associated with human structures. These non-native rodents should be monitored and remove (if possible).

Although no targeted survey has been conducted, at least two species of bats are known from FRSP. These bats, big brown and eastern red, forage in the park but their residency status is unknown. Big brown bats and little brown bats (not documented in park) probably use human structures at FRSP for roosting during the summer (Agosta 2002).

Some cave and mine hibernating bat populations in the eastern United States have declined more than 90% in the past decade due to a fungal disease known as white-nose syndrome. Therefore, any bats located in FRSP should be recorded and monitored, and their roosting habitat protected (Reichard and Kunz 2009).

Skunks were the only mustelid documented at FRSP although suitable habitat exists for other species. For example, river otter, American mink, and long-tailed weasels are likely to occur here, and targeted surveys for these species could be conducted.

White-tailed deer, one of the eastern United States largest and most prolific wild ungulates, has the potential to affect floral and faunal communities at FRSP (Horsley et al. 2003; Comiskey and Wakamiya 2012). According to the Virginia Department of Game and Inland Fisheries (VDGIF), Spotsylvania county contained <15 deer/mi^2 (6 deer/km^2) in 2010. The white-tailed deer population index (antlered buck killed/mi^2 of deer habitat) is 1.9 (0.6 antlered buck killed/km^2) which is considered "low" but stable for modern times. These estimates differ from those found by natural resource managers at the park. Visual encounter surveys estimate the deer population at Chancellorsville to be 12.0 deer/mi^2 (31 deer/km^2), 12.7 (33), 15.1 (39), 7.7 (20), and 8.5 (22) in 2007, 2008, 2009, 2010, and 2011, respectively, representing the lowest deer density estimates for the park. Resource managers at FRSP estimate that deer densities were as high as 22.5 deer/mi^2 (58.2 deer/km^2) at the Wilderness unit in 2010 and approximately 17.4 deer/mi^2 (45 deer/km^2) at the Spotsylvania and Fredericksburg units in 2010 (G. Kneipp, FRSP, pers. comm., 2013). Comiskey and Wakamiya (2012) indicate that forest regeneration has declined at the Wilderness unit during this same time period - perhaps due to deer herbivory. White-tailed deer density within FRSP where hunting is not permitted may be higher than densities estimated for surrounding Counties. Deer density in the southeastern United States was approximately 1.5 deer/mi^2 (4 deer/km^2) at the time of European settlement (see Horsley et al. 2003). If deer populations in and around FRSP remain high or increase, negative effects on plant diversity and forest regeneration may occur (or continue to occur) due to deer herbivory (Horsley et al. 2003).

Due to ecological concerns, white-tailed deer should be monitored periodically and controlled if damage to forest regeneration or rare vegetation becomes problematic. In addition, due to potential human health effects of Southern Tick-Associated Rash Illness (STAR), Lyme disease, and rabies, white-tailed deer (carry ticks that transmit STAR and Lyme disease), foxes (rabies), skunks (rabies) and raccoons (rabies) should be monitored.

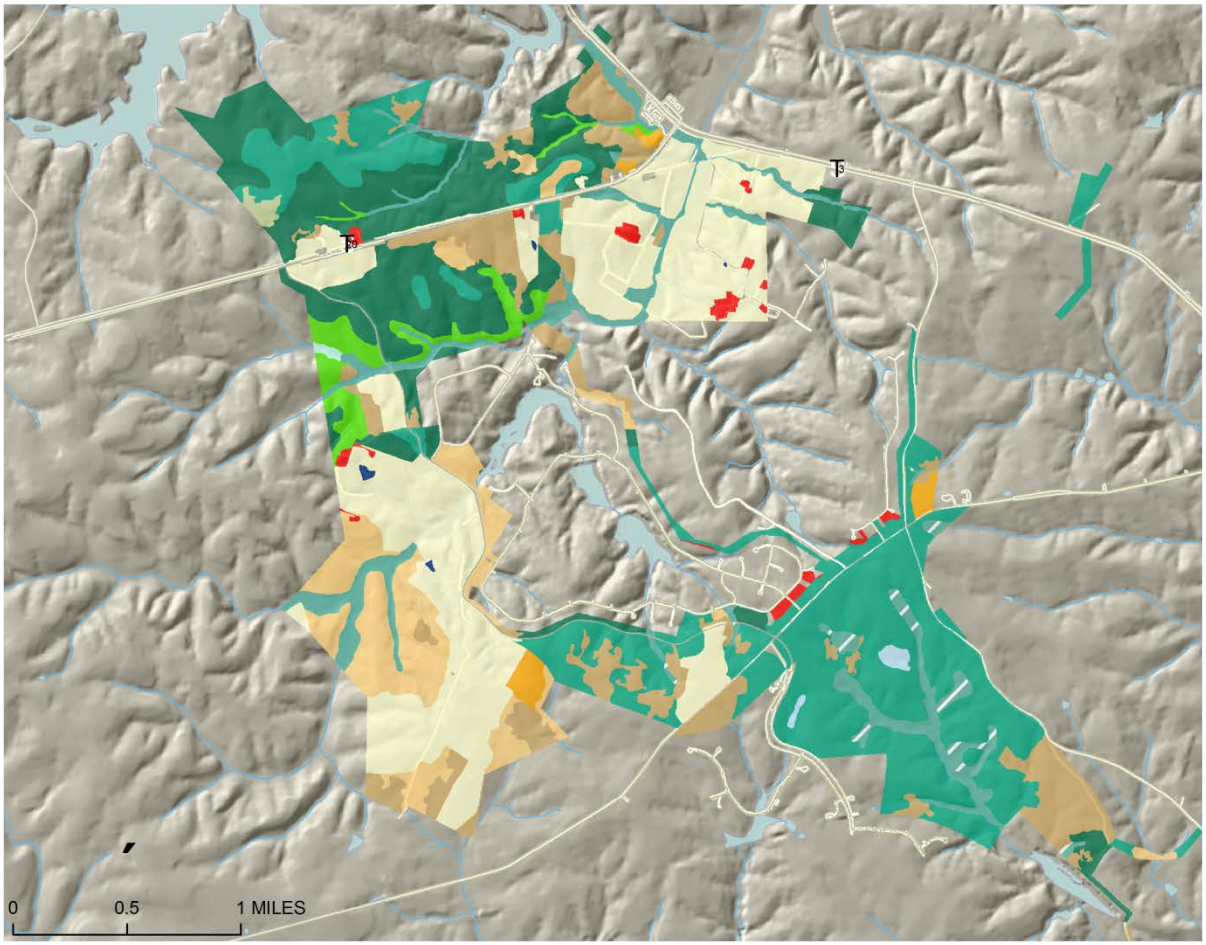
Vegetation Communities (MIDN vital sign)

FRSP is located within the northern Piedmont and the Coastal Plain of Virginia. The vegetation in this portion of Virginia has been severely altered through human activities such as clearing for agriculture, logging, and, more recently, commercial and residential development. This history of land use has resulted in a current landscape dominated by secondary forests, fields, agricultural crop lands, and urban and suburban development. Recently disturbed (e.g., successional) forests in this region tend to have Virginia or shortleaf pine as components in association with shade-intolerant hardwoods such as tuliptree and sweetgum. Mature hardwood forests in this region are often dominated by oaks - especially on dry acidic sites. Mesic, acidic ravines contain forests with American beech and tuliptree along with oak species. Mature floodplain forests contain silver maple, American sycamore, and box elder (Taverna and Patterson 2008). Vegetation was mapped by the Virginia Natural Heritage program in 2008 (Taverna and Patterson 2008), and updated in 2012 (Taverna 2014). Vegetation mapping was completed in accordance with the Federal Geographic Data

Committee (FGDC) National Vegetation Classification System. This resulted in seventeen classes of vegetation, two land cover categories ("other urban or built up land", and "transportation, communication, and utilities"), and two classes of areas covered by water (water and semi-permanent impoundment). Vegetation classes are defined at the "association" level using characteristic overstory and understory species. Figures 20-24 depict mapped vegetation associations for the major FRSP units and acreage of park units in specific vegetation cover types is given in Table 9. The largest acreage of any single vegetation class across all of the FRSP units is cultural meadow which covers 2106 acres (852.3 ha). This class includes the open fields maintained for visitor interpretation of the historic battlefields. The Wilderness unit has the largest area in cultural meadow (833 acres, 337.1 ha), followed by Chancellorsville (537 acres, 217.3 ha), Fredericksburg (393 acres, 159.0 ha), and Spotsylvania Courthouse (276 acres, 111.7). The largest forest associations in the park are Oak-Heath forests (1771 acres, 716.7 ha), successional Virginia Pine forests (1403 acres, 567.8 ha), and Acidic Oak-hickory forests (1358 acres, 549.6 ha). The Chancellorsville unit is dominated by Oak-Heath forest (631 acres, 255.4 ha), successional Virginia Pine forest (484 acres, 195.9 ha), and Coastal Plain / Piedmont Floodplain forest (212 acres, 85.8 ha) comprising 48% of the total area. The Chancellorsville unit is also the only park unit with a loblolly pine plantation (176 acres, 71.2 ha). By contrast, the Fredericksburg unit has significant area in Acidic Oak-Hickory forest (408 acres, 165.1 ha), Oak-Heath forest (211 acres, 85.4 ha) and is the only unit with forest area in Non-riverine Saturated forest (347 acres, 140.4 ha). The Wilderness unit has significant area in Oak-Heath forest (868 acres, 351.3 ha), Acidic Oak-Hickory forest (559 acres, 226.2 ha), successional Virginia Pine forest (382 acres, 154.6 ha), Successional Tuliptree forest (286 acres, 115.7 ha), and Coastal Plain / Piedmont floodplain forests (204 acres, 82.6 ha). The Spotsylvania Courthouse unit forest area is comprised primarily of successional Virginia Pine forest (393 acres, 159.1 ha), Acidic Oak Hickory forests (345 acres, 139.6 ha), and Successional Tuliptree forests (115 acres, 46.5 ha; Taverna and Patterson 2008).

Other vegetation communities of note include a total of 23 acres (9.3 ha) of Beaver Wetland complexes located in the Spotsylvania Courthouse (12 acres, 4.9 ha), Fredericksburg (7 acres, 2.8 ha), Wilderness (3 acres, 1.2 ha), and Chancellorsville (1 acre, 0.4 ha) units. Coastal Plain / Piedmont swamp forest (mixed oak-red maple type) occurs in only two units, Chancellorsville (187 acres, 75.7 ha) and Spotsylvania Courthouse (12 acres, 4.9 ha), while Eastern White Pine - Hardwood forest occurs only in the Wilderness unit (10 acres, 4.0 ha), and Piedmont - Mountain Floodplain forests occurs only in the Chatham unit (22 acres, 8.9 ha). Small areas of Mesic Mixed Hardwood forest occur in the Wilderness, Spotsylvania Courthouse, and Chancellorsville units.

Although vegetation was mapped at FRSP into seventeen vegetation classes (as described above), for a general understanding of habitat, vegetation communities at FRSP can be divided into four main categories with each containing a variety of associations: 1) mature, upland forests (41% of park areas), 2) forested wetlands (7% of park area), 3) successional forests (31% of park area), and 4) cultural meadows and historic landscapes (21% of park area).



Vegetation Type

- Acidic Oak - Hickory Forest
- Beaver Wetland Complex
- Coastal Plain / Piedmont Acidic Seepage Swamp
- Coastal Plain / Piedmont Floodplain Forest
- Coastal Plain / Piedmont Floodplain Swamp Forest (Mixed Oak - Red Maple Type)
- Coastal Plain Depression Wetland (Red Maple - Sweetgum - Willow Oak Type)
- Cultural Meadow
- Eastern White Pine - Hardwood Forest
- Loblolly Pine Plantation
- Mesic Mixed Hardwood Forest
- Non-Riverine Saturated Forest
- Oak / Heath Forest
- Other Urban or Built-up Land
- Piedmont / Mountain Floodplain Forest
- Semipermanent Impoundment
- Successional Mixed Scrub
- Successional Red-cedar Forest
- Successional Tuliptree Forest
- Successional Virginia Pine Forest
- Transportation, Communications, and Utilities
- Water

Figure 20. Vegetation communities of the Wilderness unit as mapped by Taverna and Patterson (2008) and updated in 2012.

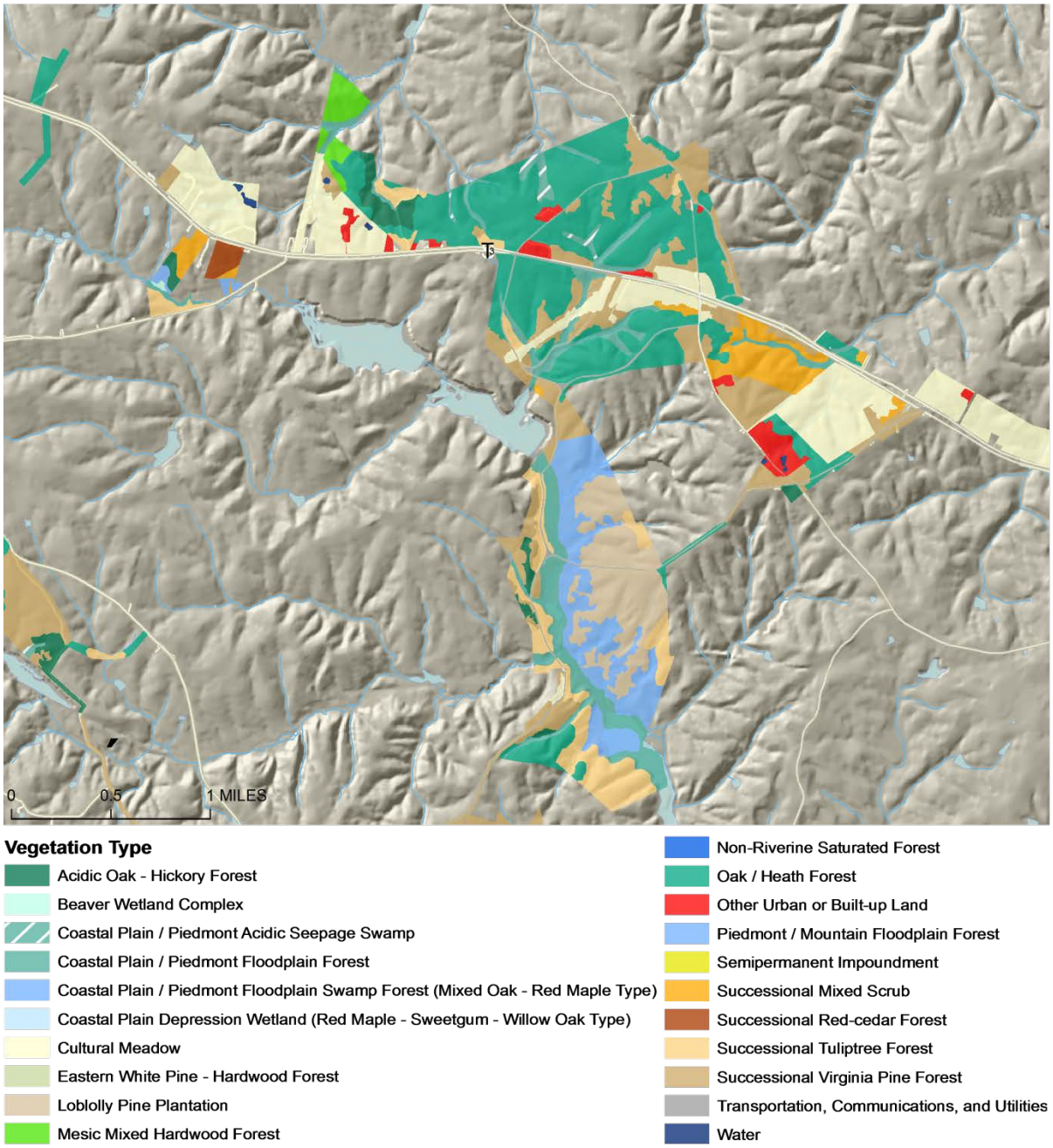


Figure 21. Vegetation communities of the Chancellorsville unit as mapped by Taverna and Patterson (2008) and updated in 2012.

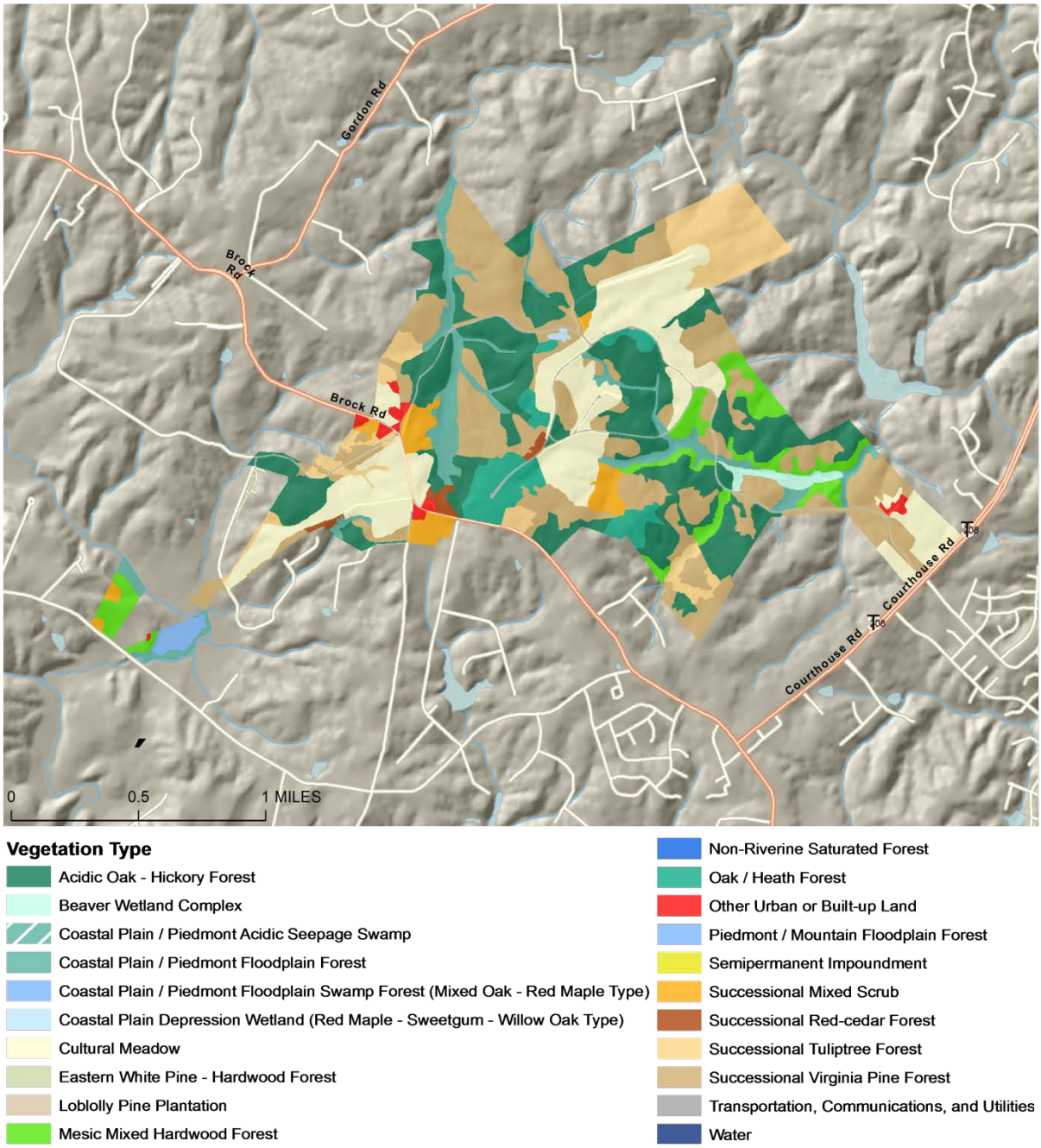


Figure 22. Vegetation communities of the Spotsylvania Courthouse unit as mapped by Taverna and Patterson (2008) and updated in 2012.

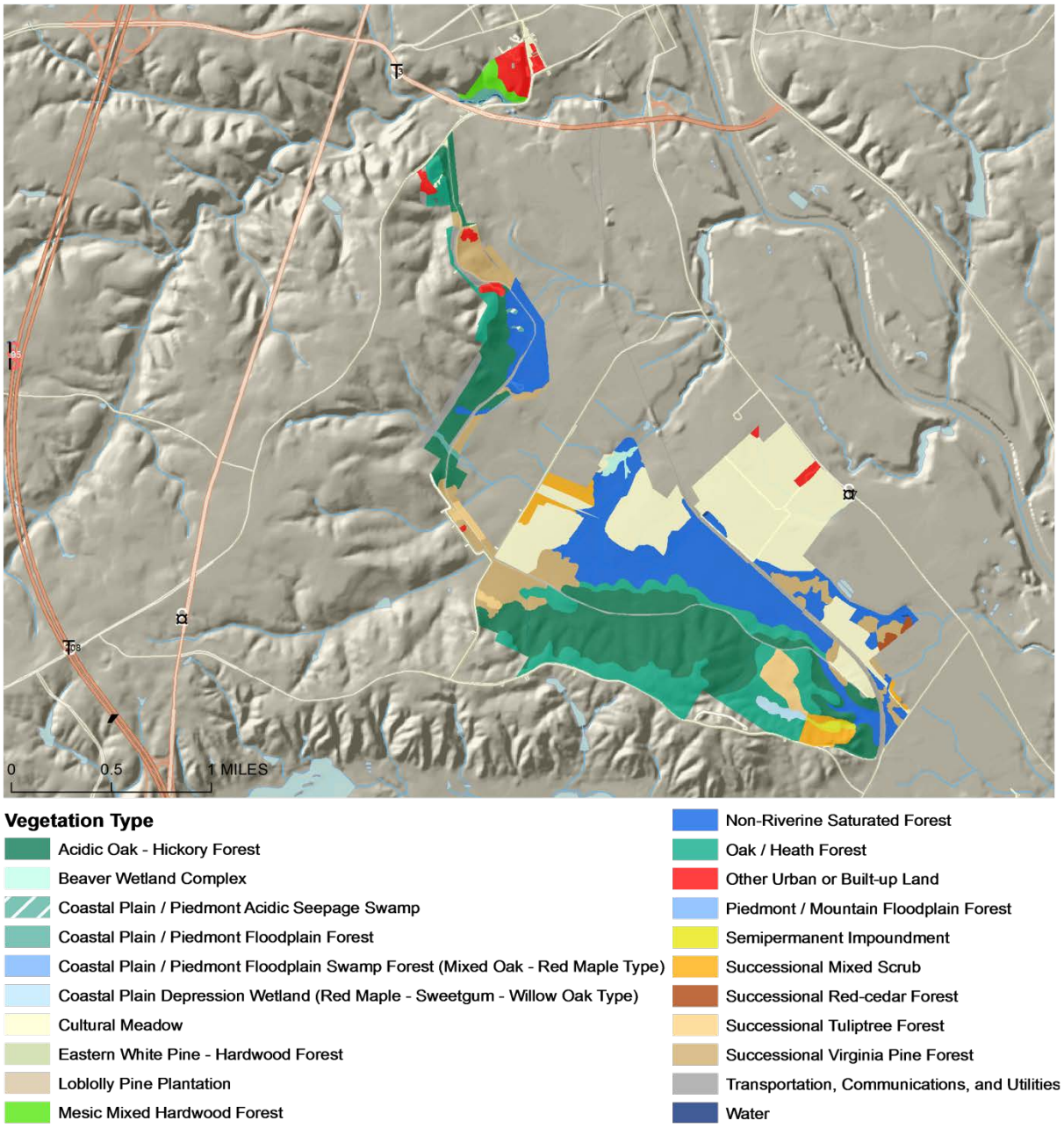


Figure 23. Vegetation communities of the Fredericksburg unit as mapped by Taverna and Patterson (2008) and updated in 2012.

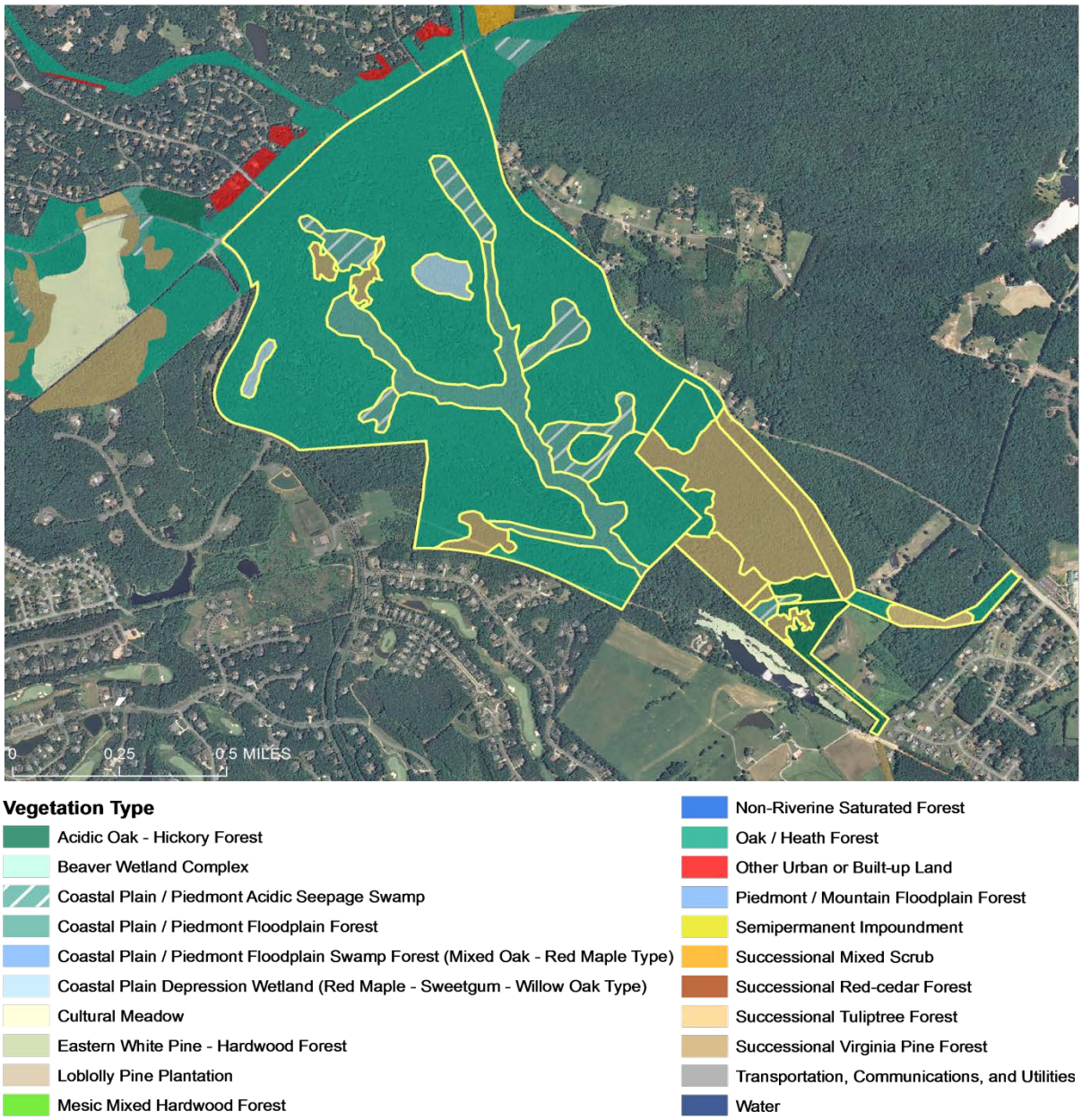


Figure 24. Vegetation of the Hamilton's thicket area (659.84 acres, 267.03 hectares), Wilderness unit as mapped by Taverna and Patterson (2008) and updated in 2012.

Table 9. Vegetation associations (Taverna and Patterson 2008; Taverna 2014) and acreage in specific vegetation cover types for each park unit at Fredericksburg and Spotsylvania National Military Park.

	Acreage by Park Unit[1]								
Vegetation Association	**CH**	**CM**	**FR**	**FRC**	**SC**	**SJ**	**SP**	**WI**	**Total**
Acidic Oak - Hickory Forest	45.90	---	407.96	---	---	---	344.88	559.32	1358.07
Beaver Wetland Complex	1.23	---	6.74	---	---	---	12.33	3.37	23.67
Coastal Plain / Piedmont Acidic Seepage Swamp	18.25	---	1.51	---	---	---	---	46.49	66.25
Coastal Plain / Piedmont Floodplain Forest	211.58	---	2.74	5.74	---	6.81	96.63	204.23	527.74
Coastal Plain / Piedmont Floodplain Swamp Forest (Mixed Oak - Red Maple Type)	187.19	---	---	---	---	---	11.54	---	198.73
Coastal Plain Depression Wetland (Red Maple - Sweetgum - Willow Oak Type)	---	---	8.12	---	---	---	1.72	9.48	19.32
Cultural Meadow	537.41	36.99	393.04	3.58	1.48	24.96	276.43	832.85	2106.73
Eastern White Pine - Hardwood Forest	---	---	---	---	---	---	---	9.81	9.81
Loblolly Pine Plantation	175.89	---	---	---	---	---	---	---	175.89
Mesic Mixed Hardwood Forest	35.93	---	---	14.20	---	---	75.34	94.01	219.47
Non-Riverine Saturated Forest	---	---	346.89	---	---	---	---	---	346.89
Oak / Heath Forest	630.89	---	210.50	---	---	---	60.81	868.33	1770.52
Other Urban or Built-up Land	56.24	8.18	16.74	24.77	---	1.30	12.61	32.14	151.97
Piedmont / Mountain Floodplain Forest	---	21.86	---	---	---	---	---	---	21.86
Semipermanent Impoundment	---	---	5.77	---	---	---	---	---	5.77
Successional Mixed Scrub	102.16	2.89	39.22	---	---	2.38	43.58	32.89	223.12
Successional Red-cedar Forest	14.50	5.24	4.33	---	---	2.28	9.34	---	35.69
Successional Tuliptree Forest	159.25	13.90	34.98	---	---	8.62	115.11	285.94	617.80
Successional Virginia Pine Forest	483.53	---	139.65	---	1.75	3.77	392.50	381.71	1402.91
Transportation, Communications, and Utilities	69.63	1.41	42.21	---	0.73	1.01	18.33	5.36	138.68
Water	7.32	---	0.52	0.52	---	---	---	3.19	11.55
Total	2736.88	90.47	1660.92	48.81	3.96	51.12	1471.16	3369.13	9432.46

[1] Park unit abbreviations: CH = Chancellorsville, CM = Chatham, FR = Fredericksburg, FRC = Fredericksburg National Cemetery, SC = Salem Church, SJ = Stonewall Jackson Shrine, SP = Spotsylvania Courthouse, and WI = Wilderness.

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Mature, upland forests

Mature, upland forest associations at FRSP include Oak/Heath Forest; Acidic Oak-Hickory Forest, Mesic Mixed Hardwood Forest, and Eastern White-Pine Hardwood Forest. These forests are fully-stocked (average basal area/ha = 65 m^2) with intact forest canopies (Comiskey and Wakamiya 2012). This mature forest condition differs significantly from the forests that were present in this area during the Civil War period. Past land uses including the fueling of iron furnaces and repeated logging in the Wilderness and Chancellorsville portions of the park resulted in the dense, oak-dominated coppice forests that were present at the time of the two battles fought in 1863 and 1864 (Priest 1995).

Today, these forests are physically mature, relatively contiguous with well-developed canopies in place. However, the dominant cover type is still oak likely due to the well-drained, acidic soils present in much of the park as well as the disturbance, land use history. Since the time of the battles, there has been some mesofication of these forests with shade-tolerant species such as American beech and red maple dominating the understory. At many of these stands, recruitment of these mesic species out-paces that of successional forest species such as Virginia pine (Comiskey and Wakamiya 2012). This trend is evident in all age and size classes of trees (overstory, sapling, seedling) in all areas of the park (Comiskey and Wakamiya 2012). The mature condition of these stands has resulted in the forest health at FRSP being rated as good although the number of snags (< 10/ha) and woody debris present is relatively low and of concern for forests of this age (Comiskey and Wakamiya 2012).

Wilderness Battlefield contains the only patch of mature, Eastern White Pine - Hardwood forest present in the park. This forest type is more common in areas west of the park and represents a location in Virginia where White Pine reaches the eastern edge of its distribution in the state (Figure 20).

Successional vegetation

Early successional or transitional vegetation associations at FRSP include Virginia Pine, Tuliptree, Red cedar, Mixed Scrub, and Beaver Wetland Complex. These vegetation types (with the exception

of Beaver Wetland Complex) are primarily the result of recent (20-60 years) abandonment of fields or tree canopy removal. The early successional forest types also contain the highest number of non-native and invasive species with Japanese honeysuckle and Japanese stiltgrass of particular concern. Beaver-disturbed areas occur as semi-permanently flooded habitat dominated by trees and shrubs of various species and open water. This habitat type is found primarily in the Wilderness section of the park within Hamilton's thicket (Figure 24).

Due to the presence of fires and land disturbances, Virginia Pine forests were more common during the time of the Civil War than their current distribution at the park. Today, the most extensive stands of this successional forest type are found in the Spotsylvania area of the park (Figure 22), however, these pine forests are found in all park sections. Regeneration data indicate that this forest type is rapidly succeeding to hardwood forest with American beech, American ash, and American holly dominating the understory (Comiskey and Wakamiya 2011). Due to their cultural and ecological significance (supporting rare populations of birds and mammals), management intervention as proposed in the park's Fire Management plan (FRSP 2012) should be adopted.

Forested wetlands

Forested wetland vegetation associations at FRSP include Coastal Plain/ Piedmont Forest, Piedmont Mountain Floodplain Forest, Coastal Plain / Piedmont Floodplain Swamp Forests, Coastal Plain / Piedmont Acidic Seepage Swamp, Coastal Plain Depression Wetland, and Non-Riverine Saturated Forest. Forested wetland classes include three types that have a relatively restricted range and, therefore, are vegetation types of conservation significance. Coastal Plain / Piedmont Floodplain Swamp forest has a conservation rank of G3/G4 (vulnerable; rare or locally found within a restricted range) and is found only within the Chancellorsville section of the park (Figure 21). Another forested wetland type with conservation significance is the Non-Riverine Saturated Forest which is a globally rare vegetation association (G2; imperiled; very vulnerable to elimination throughout its range). At FRSP this vegetation association is found in the Fredericksburg Battlefield portion along Lee Drive—where the most extensive stand is located (Figure 23). This stand is considered an exemplary example of this vegetation type within the state (Taverna and Patterson 2008). The Coastal Plain / Piedmont Acidic Seepage Swamp is an uncommon (G3) wetland habitat throughout the mid-Atlantic. At FRSP, this wetland type is found in the Wilderness, Spotsylvania, and Fredericksburg portions of the park and has an average size of 5 acres (2.0 ha). Because of their small size and isolated hydrology, these wetlands are vulnerable to development and secondary impacts of siltation, non-native species invasions, and hydrological disturbances. Exemplary occurrences of this wetland type are found within Hamilton's thicket in the Wilderness portion of the park (Figure 24). This portion of FRSP also supports an exemplary occurrence of the Coastal Plain Depression Wetland. This isolated habitat type provides important breeding habitat for amphibians.

The Coastal Plain / Piedmont Forest at Stonewell Jackson Shrine supports an assemblage of important vertebrate species including Carpenter frog, Rice Rat, and Louisiana waterthrush. This forest community type is found adjacent to a large wetland complex (developed during the construction of the railroad near Guinea Station prior to the Civil War) which lies alongside the

designated boundary of the park. These wetlands may hold some cultural significance as well - providing a water source to Confederate soldiers camped in the vicinity in 1863.

As discussed above, wetland vegetation for FRSP units has been mapped by the Virginia Natural Heritage (Taverna and Patterson 2008) as part of the NPS vegetation mapping program. In addition, the US Fish and Wildlife Service National Wetlands Inventory (NWI; Cowardin et al. 1979) provides data on mapped wetlands in the park. Furthermore, a recent study by Sharpe et al. (2013) mapped additional wetlands in the park (in the Fredericksburg unit) and also determined that, while larger wetlands were accurately depicted by Taverna and Patterson (2008), the NWI maps had greater overall accuracy in depicting wetlands throughout the FRSP units.

Wetlands mapped by vegetation were discussed in the vegetation resources section of this report. Here, we present the wetlands mapped by the NWI with the addition of wetlands mapped by Sharpe et al. (2013) in the Fredericksburg unit. Additionally, we mapped the location of potential vernal pools by querying a herpetofauna inventory database created by Mitchell (2007) from an inventory of amphibians and reptiles in FRSP. We queried the herpetofauna database for locations where eggs or larvae of pond-breeding marbled salamander (*Ambystoma opacum*) or spotted salamander (*Ambystoma maculatum*) were found. Wetlands were mapped by the NWI by type (Figures 25- 28) and acreages were calculated for each of the park units (Table 10).

The Chancellorsville unit has the largest concentration of both palustrine emergent and palustrine forested wetlands. The Fredericksburg unit has the second highest concetration of palustrine forested wetlands, including an additional 54 acres mapped by Sharpe et al. (2013). Both the Spotsylvania Courthouse and Wilderness units have significant acreage of palustrine forested and palustrine emergent wetlands. Palustrine emergent wetland acreage at the Stonewall Jackson Shrine is small, but not insignificant due to the vegetation communities and wildlife species found at that site (Figure 25). Potential vernal pools exist in all of the major park units based on observations of amphibian breeding patterns.

We assessed integrity of wetlands using methods similar to Schneider et al. (2012) for a natural resource condition assessment of the Richmond National Battlefield Park. These methods consider wetland integrity in terms of landscape connectivity, buffer index, and surrounding land use index. The methods used by Schneider et al. (2012) are based on methods of Faber-Langendoen et al. (2009, 2008) which are themselves based on methods of Klimas et al. (2004). Wetland landscape connectivity is a measure of the percentage of unfragmented habitat with 500 meters (1640 ft) of a non-riverine wetland, or within 500 meters (1640 ft) upstream or downstream of a riverine wetland along a 100 foot (30.4 m) riparian corridor. We used National Wetland Inventory (Cowardin et al. 1979) map data layers and additional wetland polygons mapped by Sharpe et al. (2013), and GIS analysis to compute the metrics for all of the FRSP units (Figures 26-28). In addition to the wetland-landscape connectivity, we also computed a riparian forest buffer index for all streams as the percentage of the landscape surrounding streams (within 75 feet, 22.9 m) that were in forested vegetation (Figures 33-35). Finally, we computed a surrounding land use index suggested by Faber-Langendoen (2009) by scoring the intensity of human dominated land uses along a relative gradient from 0 (no impact) to 1 (maximum impact) for each pixel of a raster land use map from the 2006

National Land Cover Database, (Homer et al. 2007; Figure 36). These index values were then summarized by watershed surrounding the FRSP units (Figure 37).

All three of these approaches gave us an assessment of the current condition of wetland and riparian areas in the park and showed that riverine wetland connectivity in FRSP units at 78% is “good” (or “variegated” in the categorization of Klimas et al. 2004). Non-riverine wetland connectivity was 58% or “fair” (fragmented). Riparian buffers along streams (within 75 feet, 22.9 m) are 84% forested within the FRSP units and there are opportunities for riparian buffer restoration in all units. Most watersheds surrounding the western park units (Wilderness, Chancellorsville) and southern units (Spotsylvania Courthouse, Stonewall Jackson Shrine) are scored as “excellent” or “good” for the surrounding land use index. In contrast, the surrounding land use index for the Fredericksburg and Chatham units are scored as “fair” because of the intensity of human development surrounding these units (Figure 37).

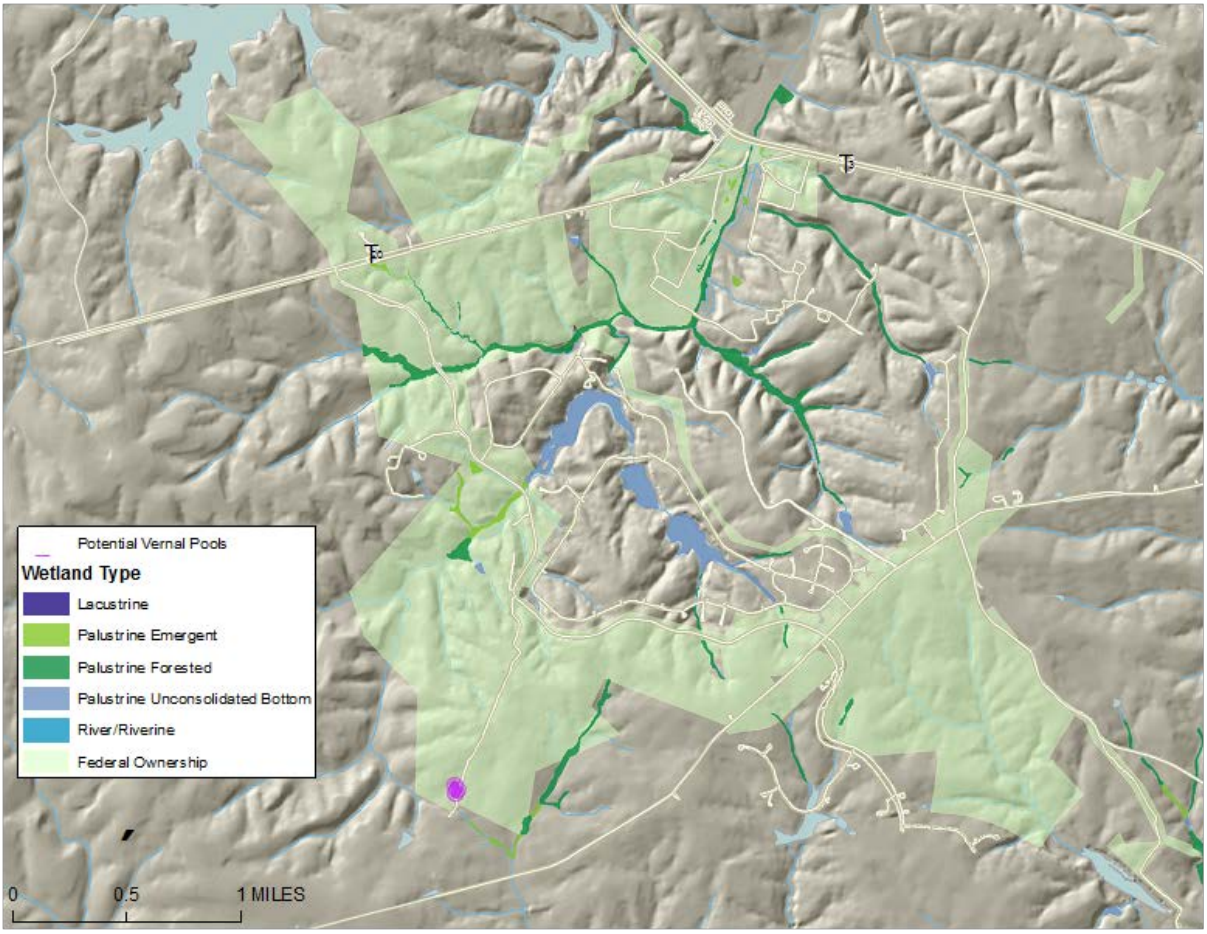

Figure 25. Wetlands of the Wilderness unit, Fredericksburg and Spotsylvania National Military Park based on National Wetland Inventory data, 2013.

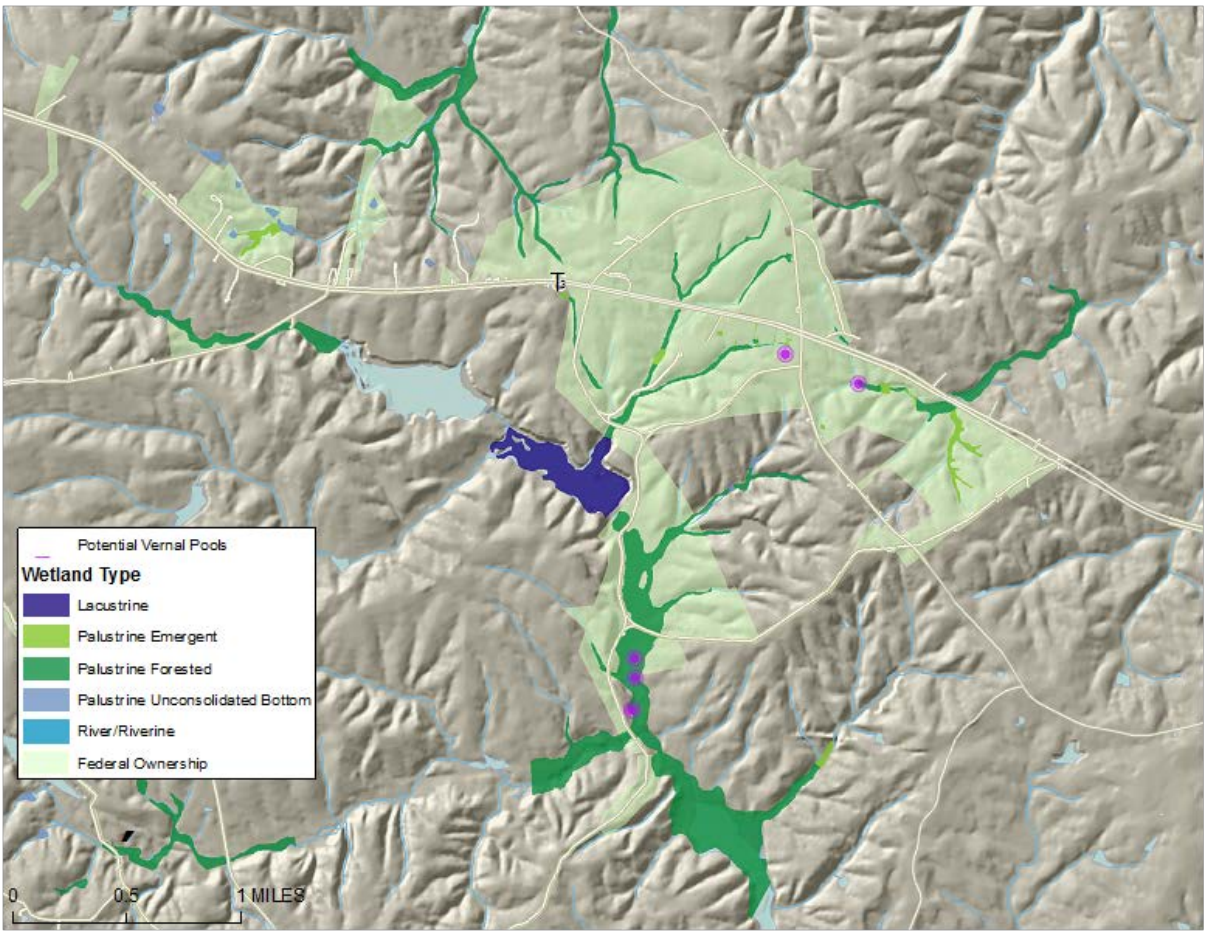

Figure 26. Wetlands of the Chancellorsville unit at Fredericksburg and Spotsylvania National Military Park based on National Wetland Inventory, 2013.

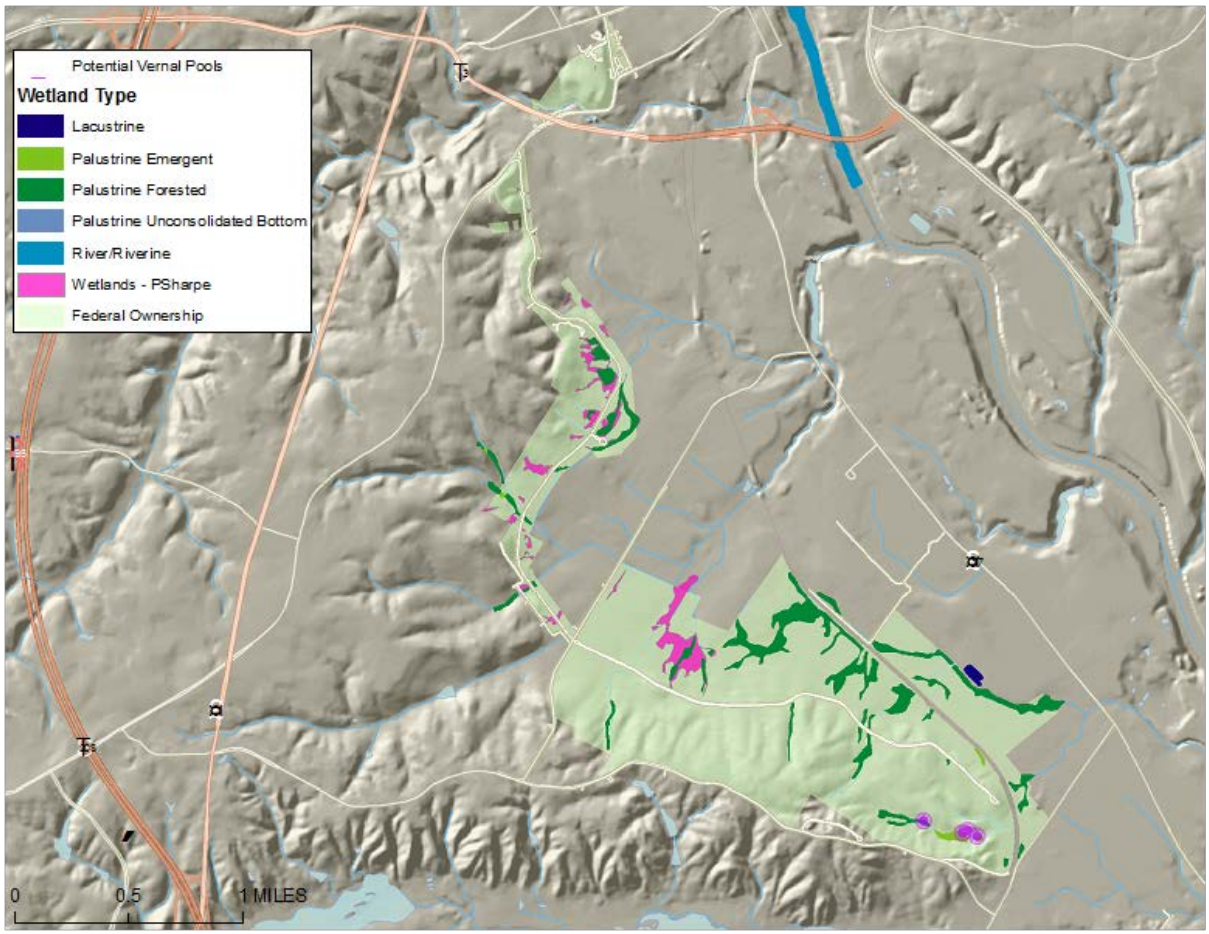

Figure 27. Wetlands of the Fredericksburg unit at Fredericksburg and Spotsylvania National Military Park based on National Wetlands Inventory data, 2013. Wetlands depicted include data from Sharpe et al. (2013) augmented by National Wetlands Inventory data.

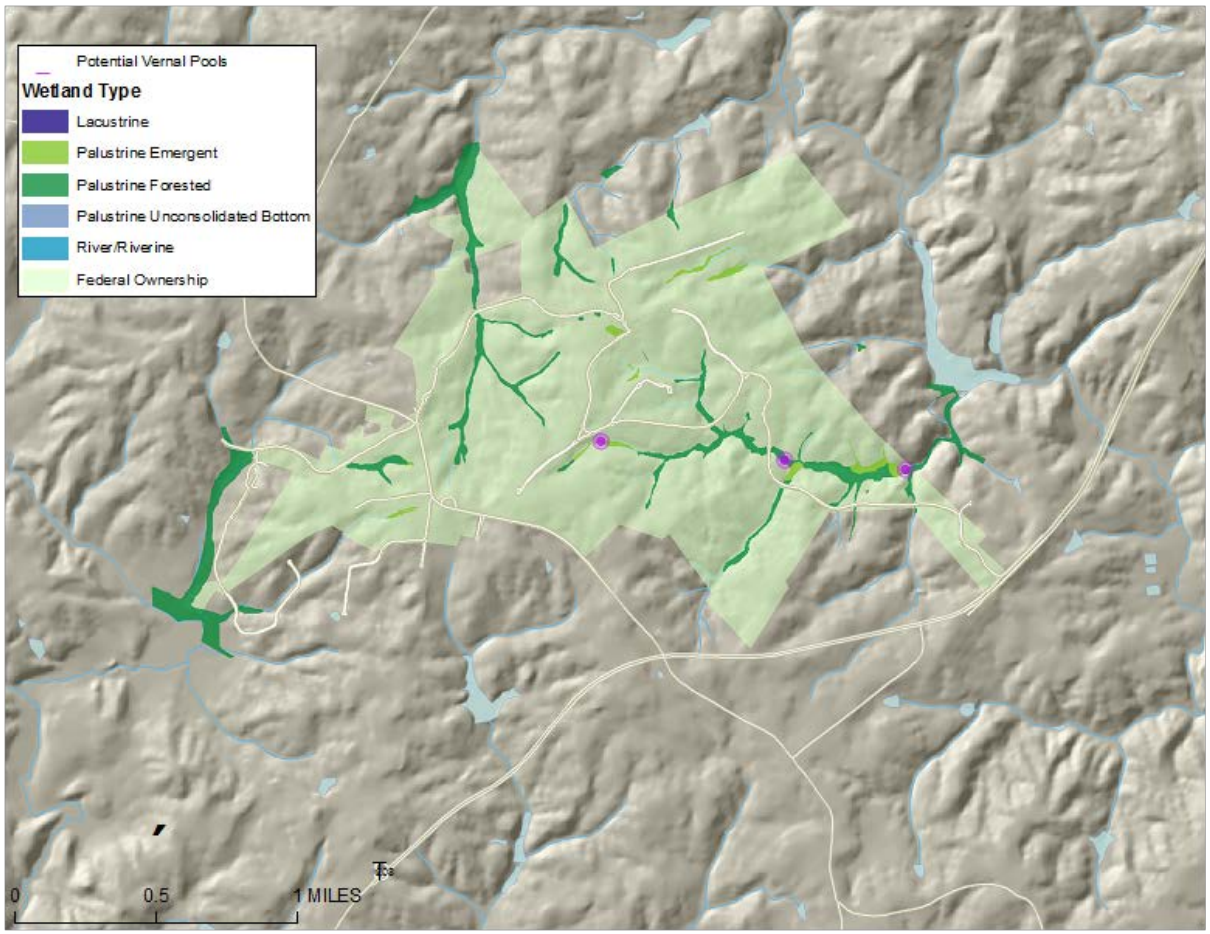

Figure 28. Wetlands of the Spotsylvania Courthouse unit at Fredericksburg and Spotsylvania National Military Park based on National Wetlands Inventory data, 2013.

Table 10. Wetlands by type (L=Lacustrine, PEM = Palustrine Emergent, PFO = Palustrine Forested, PUB = Palustrine Unconsolidated Bottom, R = Riverine, U = Upland) and area (acres) as mapped by the National Wetland Inventory (NWI) for each park unit at Fredericksburg and Spotsylvania National Military Park, 2013.

Park Unit	L	PEM	PFO	PUB	R	U	Total
Chancellorsville	0.07	18.04	207.38	4.54	--	1.21	231.24
Chatham	--	--	--	--	0.01	--	0.01
Fredericksburg	--	4.86	99.65	--	--	--	104.51
Stonewall Jackson Shrine	--	2.30	--	--	--	--	2.30
Spotsylvania Court House	--	13.02	61.33	--	--	--	74.35
Wilderness	--	12.47	45.53	1.15	--	0.15	59.29
Total	0.07	50.69	413.90	5.69	0.01	1.36	471.71

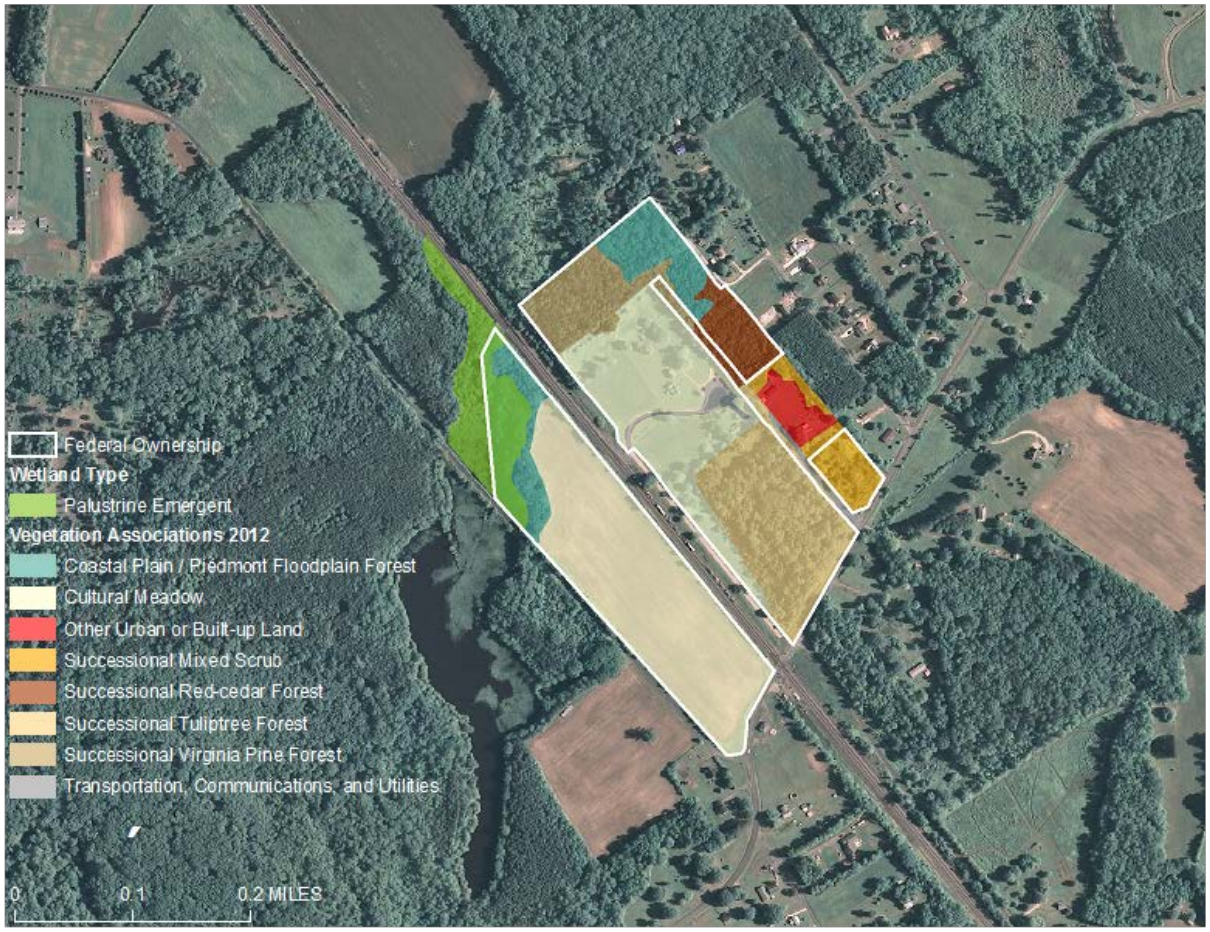

Figure 29. Wetlands (National Wetlands Inventory data) and vegetation communities of the Stonewall Jackson Shrine at Fredericksburg and Spotsylvania National Military park, 2013.

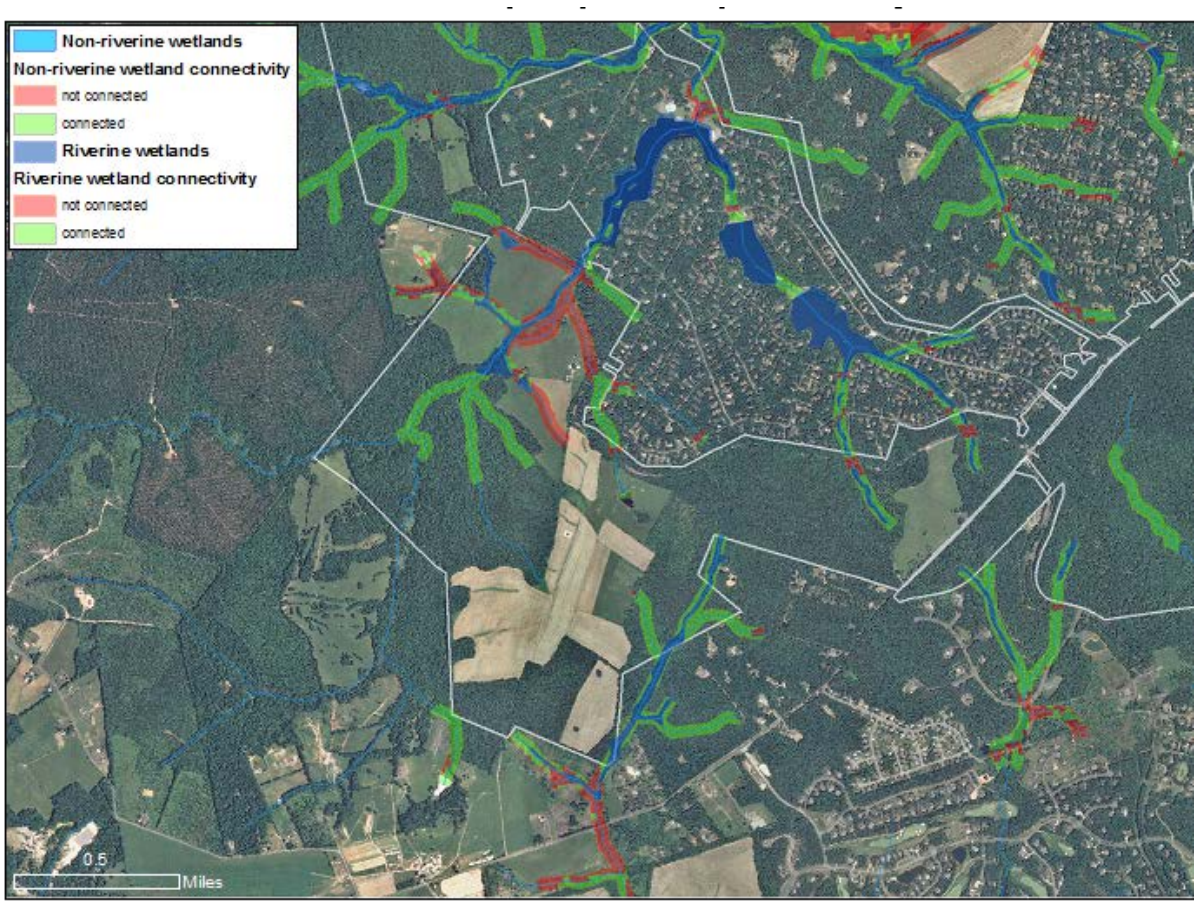

Figure 30. Detail of wetland-landscape connectivity, Wilderness unit at Fredericksburg and Spotsylvania National Military Park, 2013. Areas in red depict riverine and non-riverine wetland buffers that are not connected to other wetlands by forest. Areas in green depict riverine and non-riverine wetland buffers connected to other wetlands by forest.

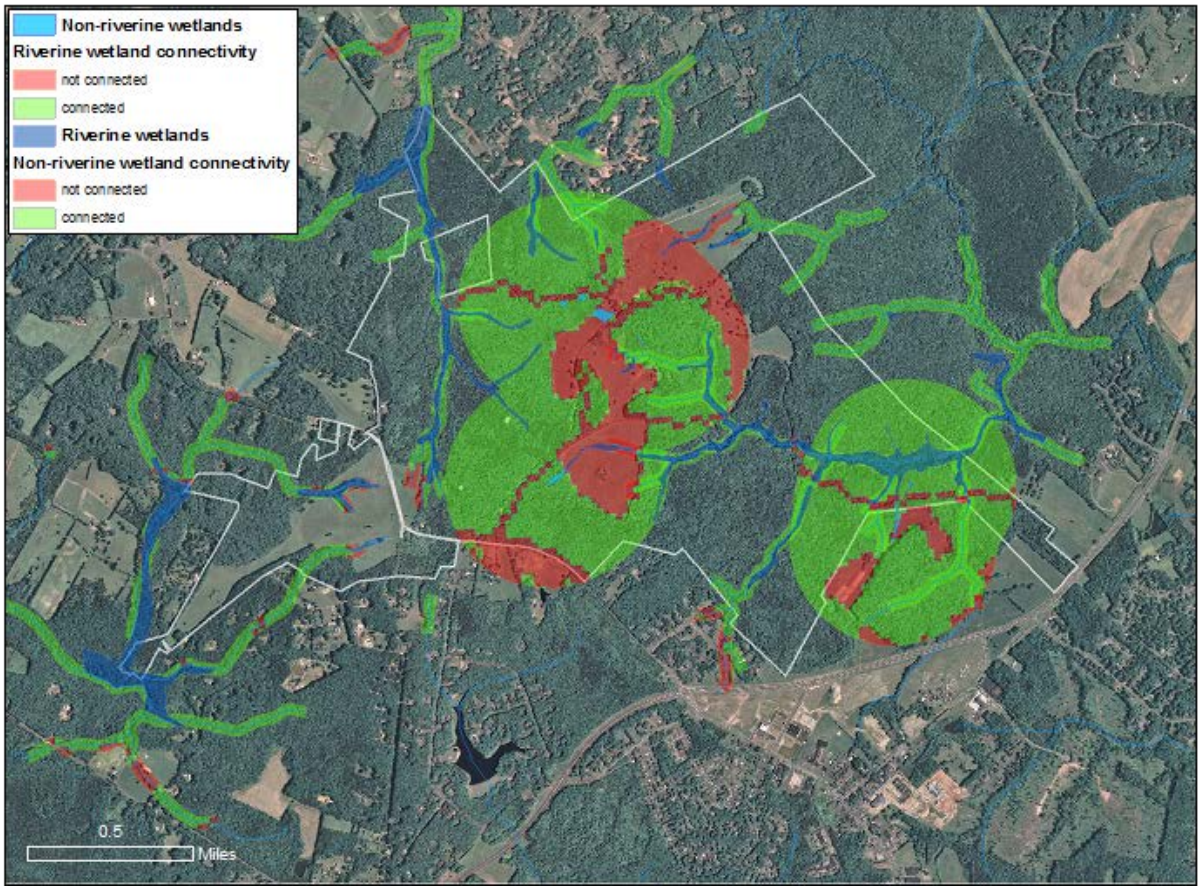

Figure 31. Wetland-landscape connectivity, Spotsylvania Courthouse unit at Fredericksburg and Spotsylvania National Military Park, 2013. Areas in red depict riverine and non-riverine wetland buffers that are not connected to other wetlands by forest. Areas in green depict riverine and non-riverine wetland buffers connected to other wetlands by forest.

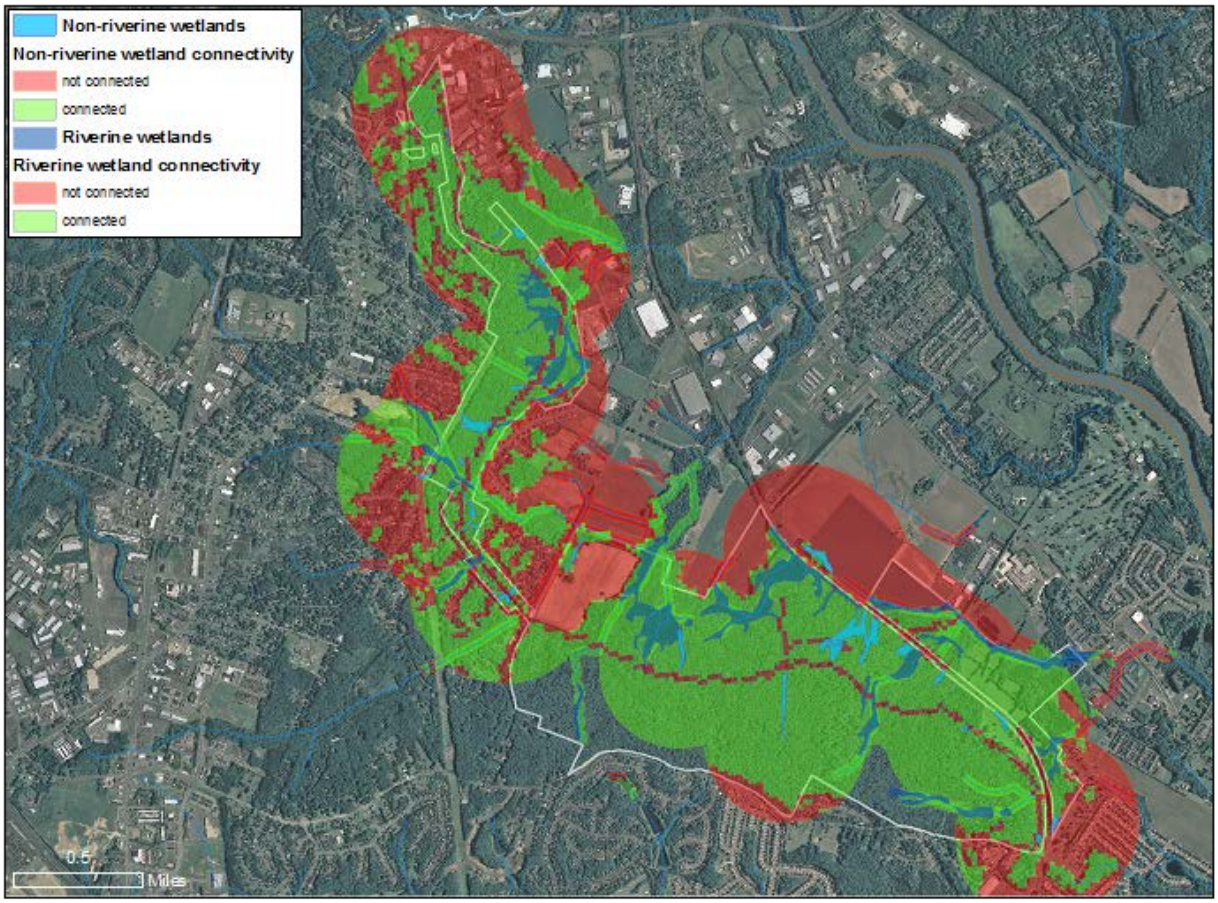

Figure 32. Wetland-landscape connectivity, Fredericksburg unit at Fredericksburg and Spotsylvania National Military Park, 2013. Areas in red depict riverine and non-riverine wetland buffers that are not connected to other wetlands by forest. Areas in green depict riverine and non-riverine wetland buffers connected to other wetlands by forest.

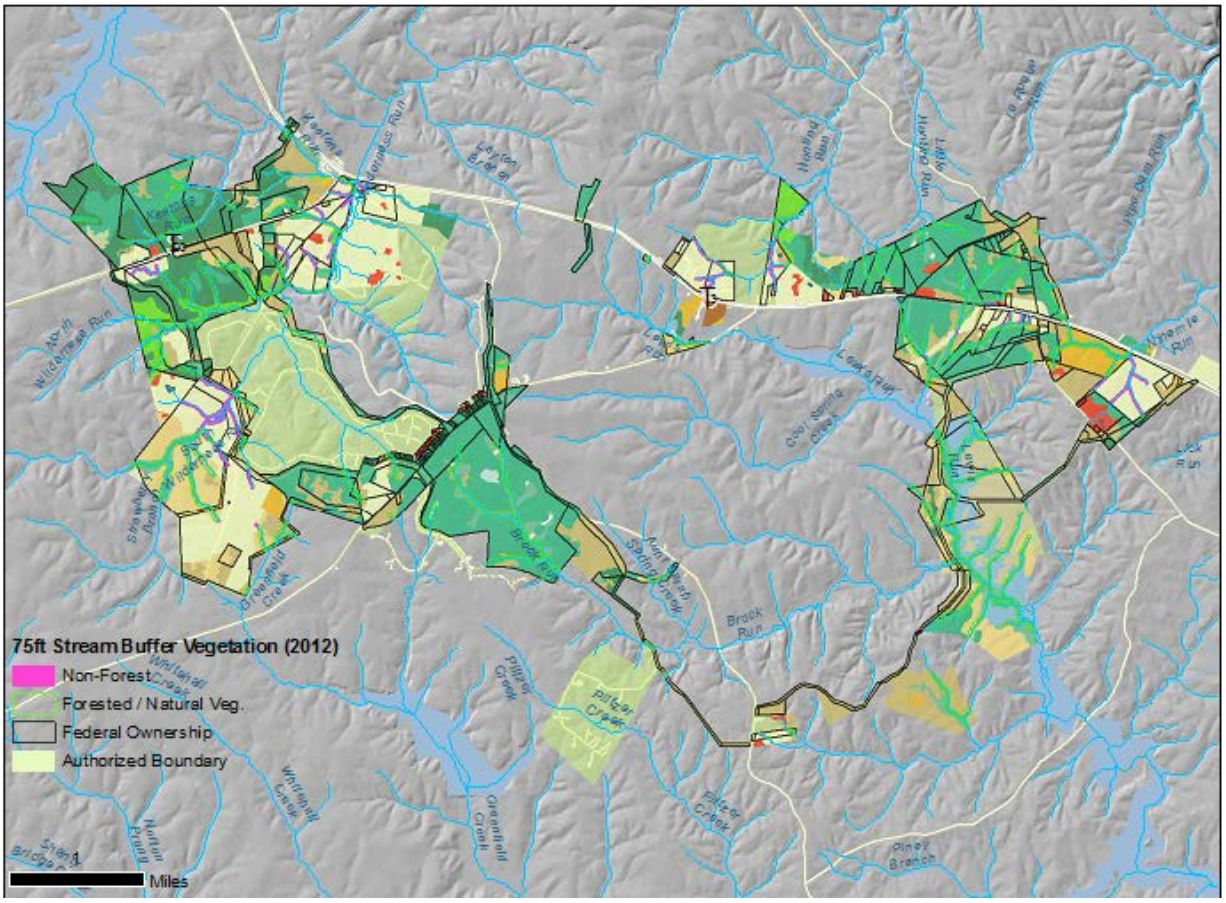

Figure 33. Vegetated riparian buffers (75 foot, 22.9 meter) at the Wilderness and Chancellorsville units within Fredericksburg and Spotsylvania National Military Park, 2013.

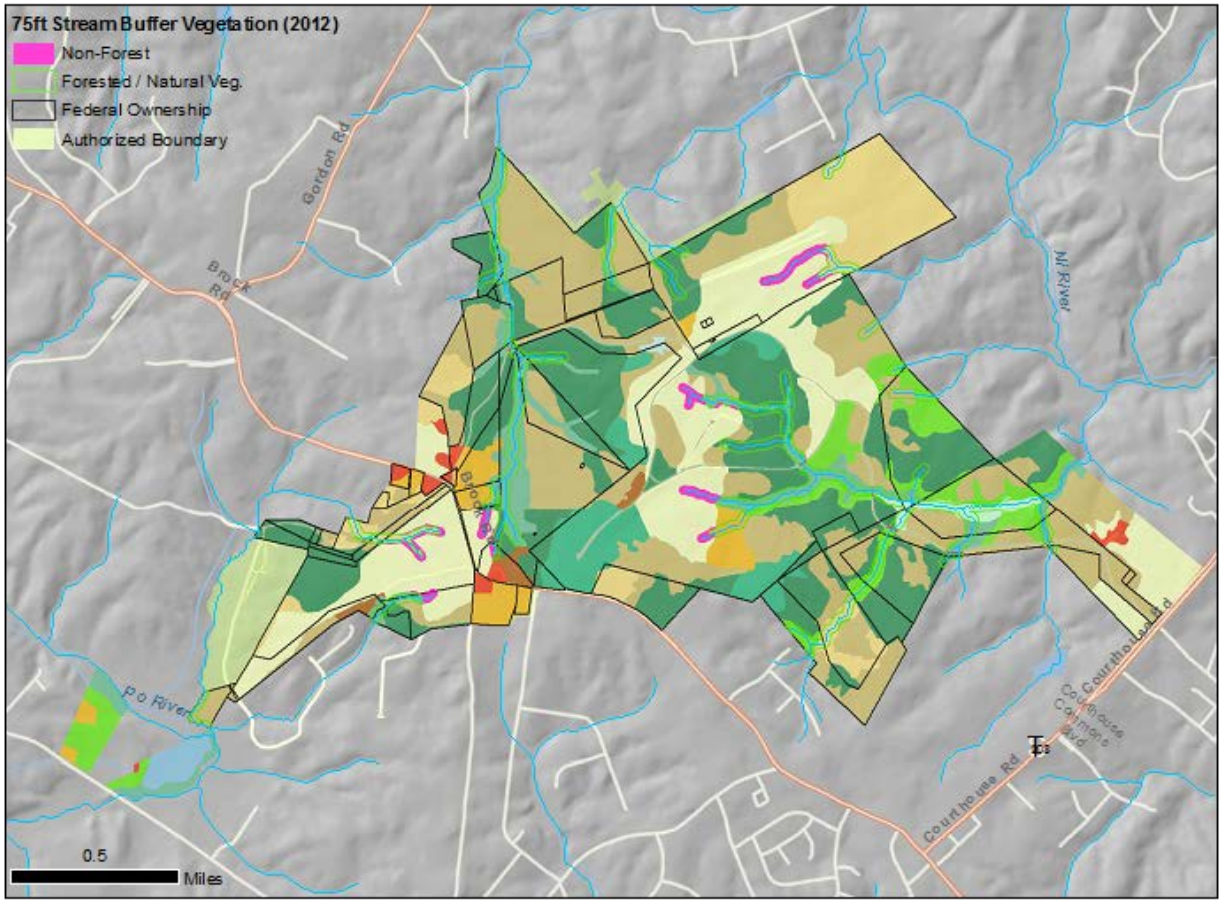

Figure 34. Vegetated riparian buffers (75 foot, 22.9 meter) at the Spotsylvania Courthouse unit within Fredericksburg and Spotsylvania National Military Park, 2013.

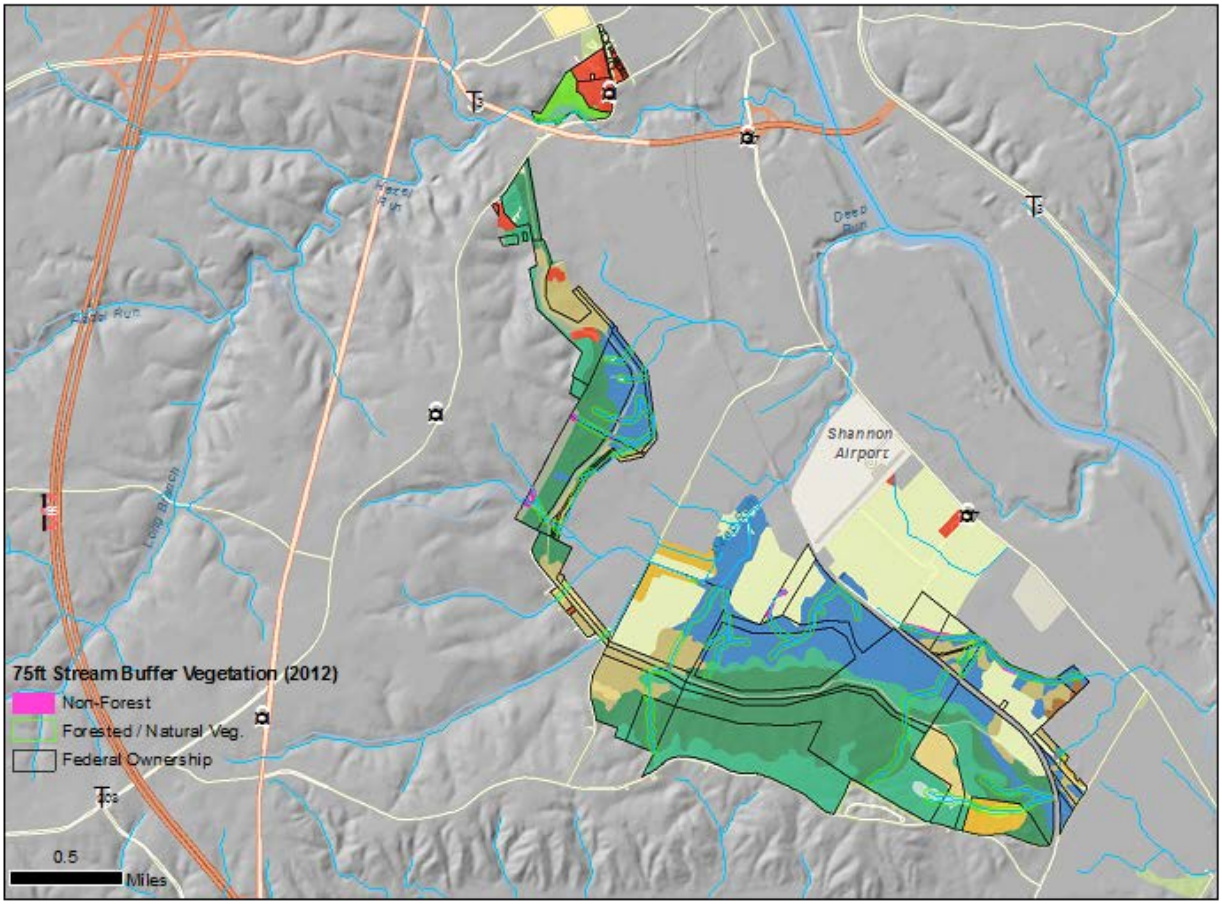

Figure 35. Vegetated riparian buffers (75 foot, 22.9 meter) at the Fredericksburg unit within Fredericksburg and Spotsylvania National Military Park, 2013.

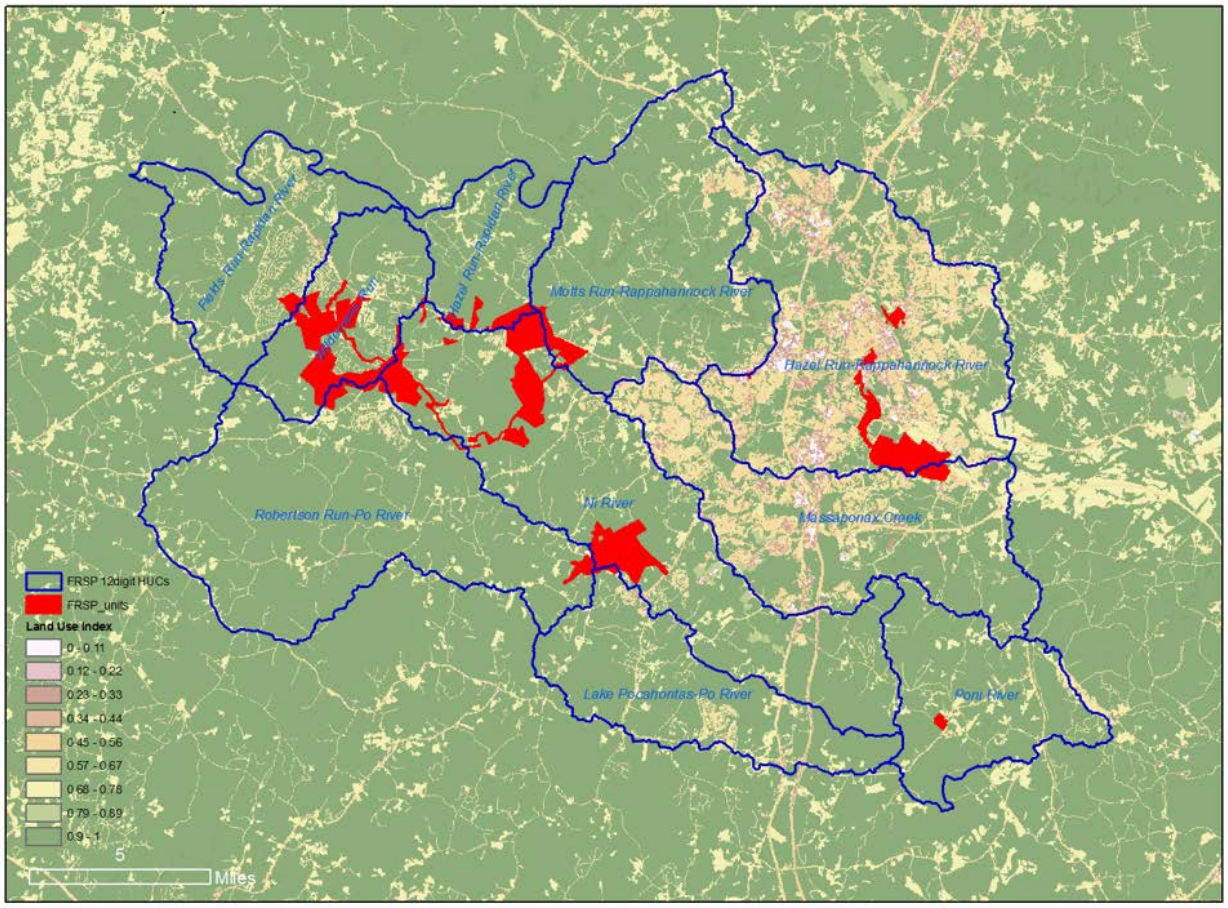

Figure 36. Surrounding land use index metric scores in watersheds surrounding Fredericksburg and Spotsylvania National Military Park, 2013.

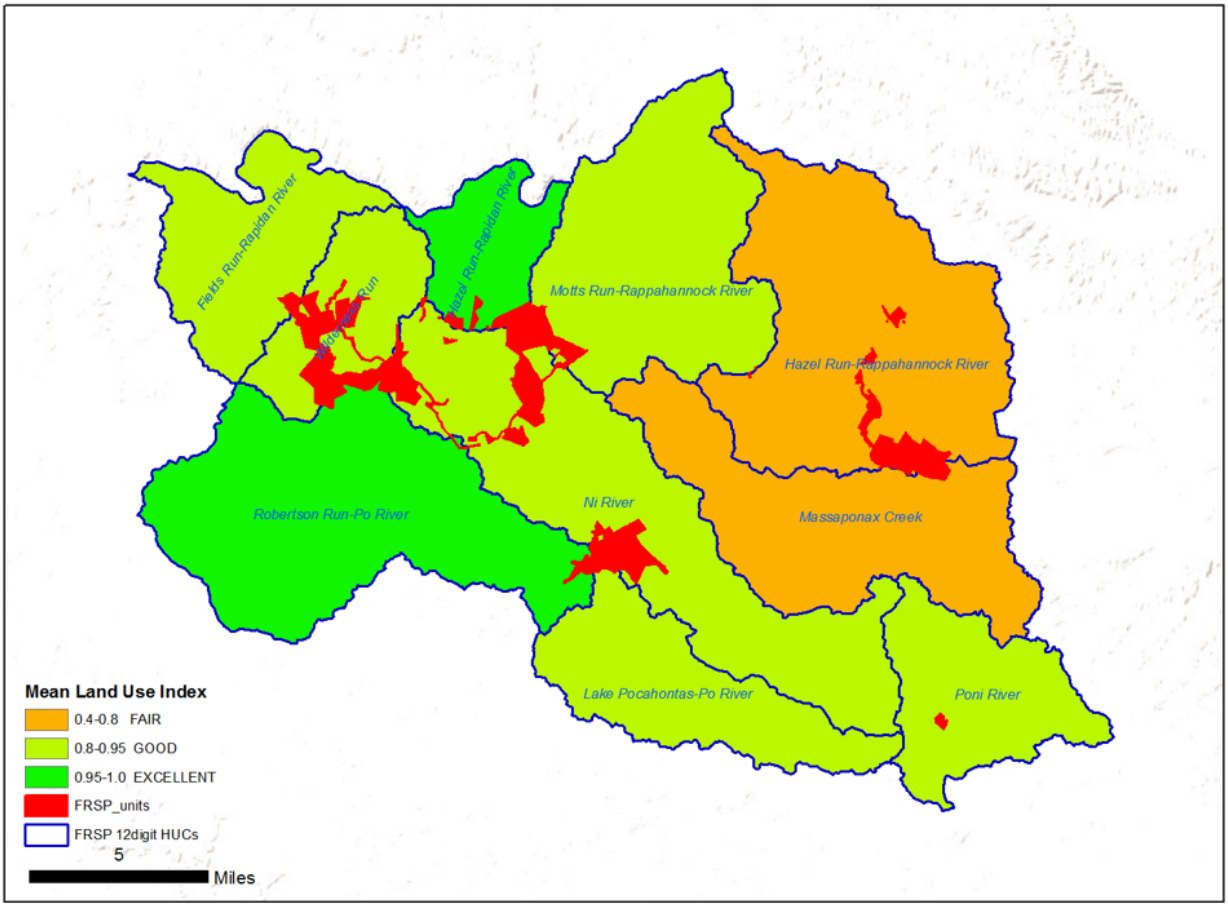

Figure 37. Surrounding land use index, average for watersheds encompassing Fredericksburg and Spotsylvania National Military Park, 2013.

Cultural meadows

The cultural meadow vegetation class is managed by park resource managers to maintain open fields characteristic of the Civil War Battlefields (FRSP 2006, 2010). Aside from their cultural significance, these meadows provide nesting habitat for grassland and shrubland birds which are declining throughout their range in the Mid-Atlantic. In order to better appreciate the current context of forested areas versus cultural meadows, we attempted to assess historic change in open versus forested areas in past time periods using two data sources. One source was a set of scanned historical maps provided by FRSP staff of Civil War battlefields mapped circa 1867 and included shading of forested areas and open areas at the time of the War. While of varying sources, most of these scanned maps were from historical Army mapping efforts and some are reproductions of earlier maps. The second source was a set of scanned aerial photographs dating from 1937 and originally obtained from the National Archives and used for a vegetation and historical features mapping effort by American University in 1981. We registered the maps and aerial photography to modern aerial photography using road intersections as control points for standard GIS rectification methods. However, due to significant distortion in the map and image sources, it was not possible to accurately match all map features from the historical sources to the modern landscape. Therefore, we present the comparison of historically open areas as a visual (non-quantitative) guide only and illustrate the potential changes

using the Spotsylvania Courthouse unit where historical maps and imagery could be best matched to the current landscape. Based on the historical 1867 map (Figure 38), it appears that while some of the current cultural meadows were open in 1867, there were many other parts of the unit that were historically open, and some areas that are open today were forested in 1867. Similarly, from the 1937 aerial photographs (Figure 39), it appears that some areas were non-forested that are forested today, and these interpretations suggest that some cultural meadows that are open today had reverted to forest between 1867 and 1937. Some of these forested areas may be considered (based on their historic and potential ecological significance) for conversion to cultural meadows. Additional comparisons for the Wilderness, Chancellorsville, and Fredericksburg units are located in Appendix B.

In general, maintenance in cultural landscapes should accomplish two things: it must recreate the vegetative patterns found historically at each site, and create viewsheds that enable visitors to view important sections of the landscape without obstructions. This, in turn, enables them to better visualize troop positions and movements and to fully understand the events leading to the outcome of each battle (FRSP 2006, 2010).

Agriculture was the primary use of the non-forested land during the Civil War. This included hay, wheat, corn, beans and pasture. As a result, modern-day agricultural use in the park is beneficial for two reasons: it provides exhibits that closely replicate the appearance of the Civil war battlefields, and it reduces park maintenance costs. However, most agricultural uses require intensive land management that results in accelerated erosion, pesticide and fertilizer use and does not provide the best protection for cultural, archeological and natural resources.

Historic earthen fortifications are one of the park's most valuable resources within its cultural landscapes and are intricately tied to vegetation management. Many sections of earthworks can be found under full forest cover, and thus little maintenance is required. In most cases, this means that the earthworks will be well protected from soil erosion due to the extensive root systems, thick leaf litter and overstory layers, and lack of human disturbance typically associated with a complete forest community. However, these earthworks cannot be viewed and appreciated by park visitors to the same degree as they can in cultural meadows. The park tries to provide a balance between protecting these structures and providing for visitors understanding and appreciation. Therefore many of the park's earthworks are maintained so that they can be viewed by visitors within cultural meadows at each park unit (FRSP 2006, 2010).

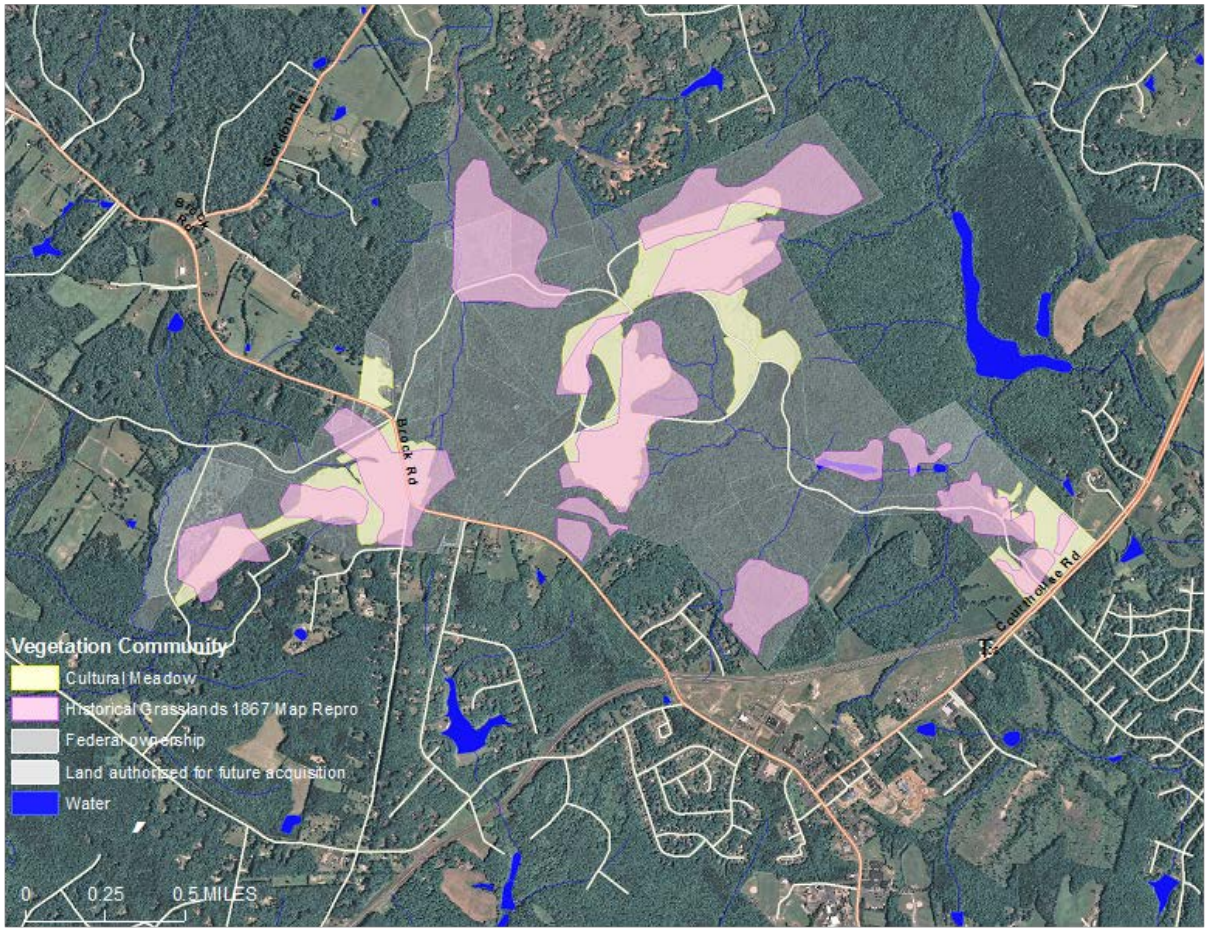

Figure 38. Areas of change in open meadow / grasslands (pink) mapped from 1867 map reproduction and current conditions (yellow) for the Spotsylvania Courthouse unit at Fredericksburg and Spotsylvania National Military Park.

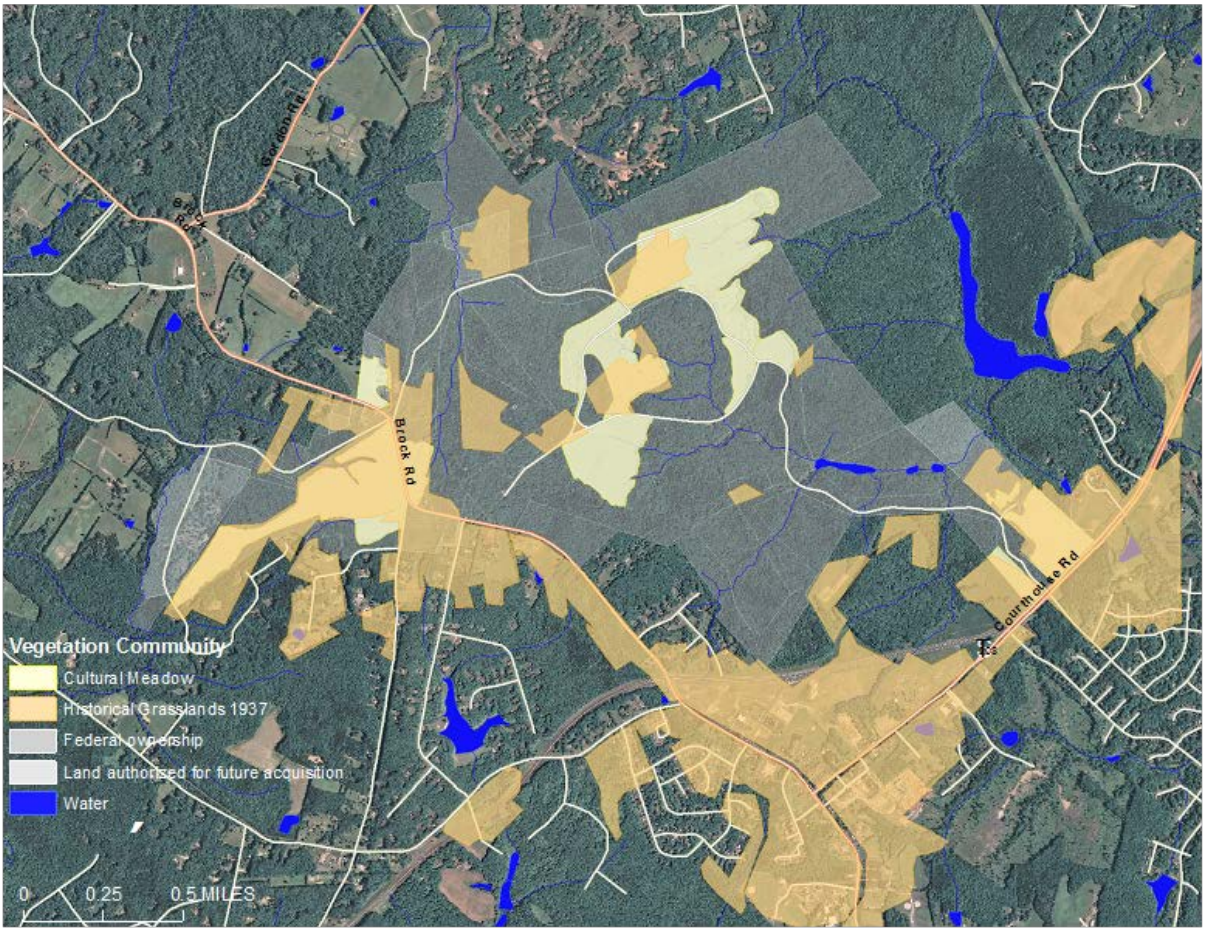

Figure 39. Areas of change in open meadow / grasslands (orange) mapped from 1937 aerial photos and current conditions (yellow) for the Spotsylvania Courthouse unit at Fredericksburg and Spotsylvania National Military Park.

Landscape Connectivity

Landscape connectivity generally refers to connectedness of intact forest patches. Connected forest patches are important as movement corridors for various species of wildlife including birds, small mammals, and amphibians—especially within landscapes fragmented by human development. In addition, maintaining landscape connectivity has been suggested as an approach to assist wildlife (plants and animals) to adapt to global climate change. Landscape corridors, in theory, would permit species to migrate northward as climate becomes unsuitable. The degree to which patches are connected is analogous to amount of forest fragmentation, but additionally considers the importance of the number, location, and size of movement corridors between patches. Landscape connectivity can be measured in several ways including nearest neighbor distances, spatial pattern analysis, and graph theoretic approaches (see Calabrese and Fagan 2004 for a review).

We examined landscape connectivity for the FRSP units using the Morphological Spatial Pattern Analysis (MSPA) technique of Vogt et al. (2007, 2009) that combines elements of spatial pattern analysis and graph-theoretic approaches. Using raster-based land cover maps, MSPA analysis

(through the software GUIDOS) computes the context and connectivity of forest pixels and classifies them as part of a large core forest patch, part of small patch, an edge of a patch, part of a corridor, or a thin bridge connecting other patches (Vogt et al. 2007). MSPA analysis can quickly determine the forest connectivity of large regions and the results can be used directly to determine the importance of particular patches for regional forest connectivity, or can be used as input for additional programs (such as Saura and Rubio 2010) to further assess movement potential for particular organisms. MSPA analysis has been implemented by the NPScape program (Monahan et al. 2012) as a key component of landscape assessments for national parks. We implemented MSPA using 2006 data from the National Land Cover Database (Homer et al. 2007).

We first classified forest areas into the MSPA categories of core, patch, edge, bridge, etc. (see Vogt et al. 2009) using the software GUIDOS. We then assessed regional forest connectivity in terms of connectedness of large core forests surrounding the FRSP units (i.e. within the same 30-km Area of Analysis [AOA] of the NPScape program). We used the results of the MSPA to identify areas of concern for future connectivity. This was augmented by assessing generalized zoning classifications for counties surrounding the FRSP units as well as the independent City of Fredericksburg using data from county GIS databases (provided by FRSP staff, 2013).

The results of this analysis show that, in spite of the intense landscape development along the I-95 corridor, there are still large areas of core forest in the region surrounding the FRSP units (as defined by the NPScape 30-km AOA, Figure 40), and the regional landscape connectivity is “good”. However, upon closer inspection of the area immediately surrounding the FRSP units (e.g. the 3-km NPScape AOA), it becomes apparent that there is a significant area of core forest that is disconnected from the larger regional core forest, having been fragmented by the development along I-95, and state highways 17 and 3 (Figure 41). While all of the FRSP units are still connected to the regional core forest, the Fredericksburg unit is of concern for loss of future core forest connectivity. While still connected to the large regional block of core forest, the connectivity is currently tenuous and exists due to a small “bridge” forested feature (Figure 42). Examination of generalized zoning classifications for lands surrounding the Fredericksburg unit reveals that all of the surrounding parcels are zoned for either residential or commercial land uses (Figure 43). Should all of these surrounding parcels be developed, this would pose a conservation concern as the Fredericksburg unit could become completely disconnected from the surrounding core forest. Numerous theoretical and empirical studies attest to the “island biogeographic” effect and subsequent loss of population viability in small, disconnected forest patches.

The largest and most intact forest occurs in the Hamilton thicket (Figure 24) in the Wilderness unit of the park. The surrounding forest (not in FRSP ownership) makes this location even more important from an ecological perspective. The integrity of this forest parcel is supported by the presence of a variety of forest dependent species including birds and amphibians and globally rare vegetation community types.

Landscape Dynamics

Wilderness Battle landscape

Aside from cultural meadows, early successional oak, coppice forests were a major landscape feature during the time of the Civil War battles, especially at the Wilderness battlefield (Young et al. 2005). For example, Auwaerter and Harris (2010) state

"Much of the fighting took place in the rolling, dense second-growth woods south, west, and northwest of the Ellwood fields [in the Wilderness battlefield]. The battlefield became notorious for its arduous and deadly conditions created by the scrubby oaks and pines with thick, tangled undergrowth that made movement difficult and visibility poor."

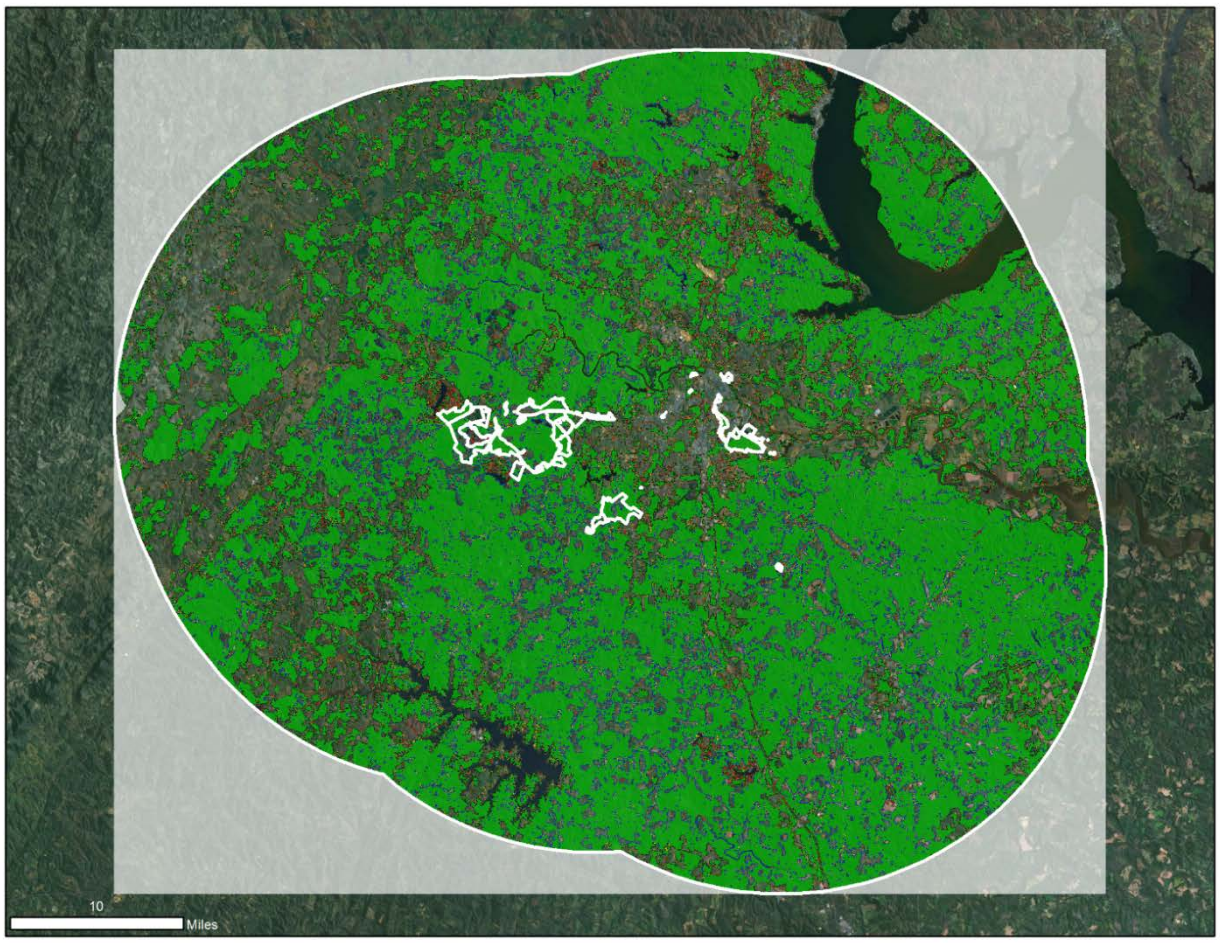

Figure 40. Forest landscape connectivity in 30-km NPScape buffer area at and around Fredericksburg and Spotsylvania National Military Park, 2013.

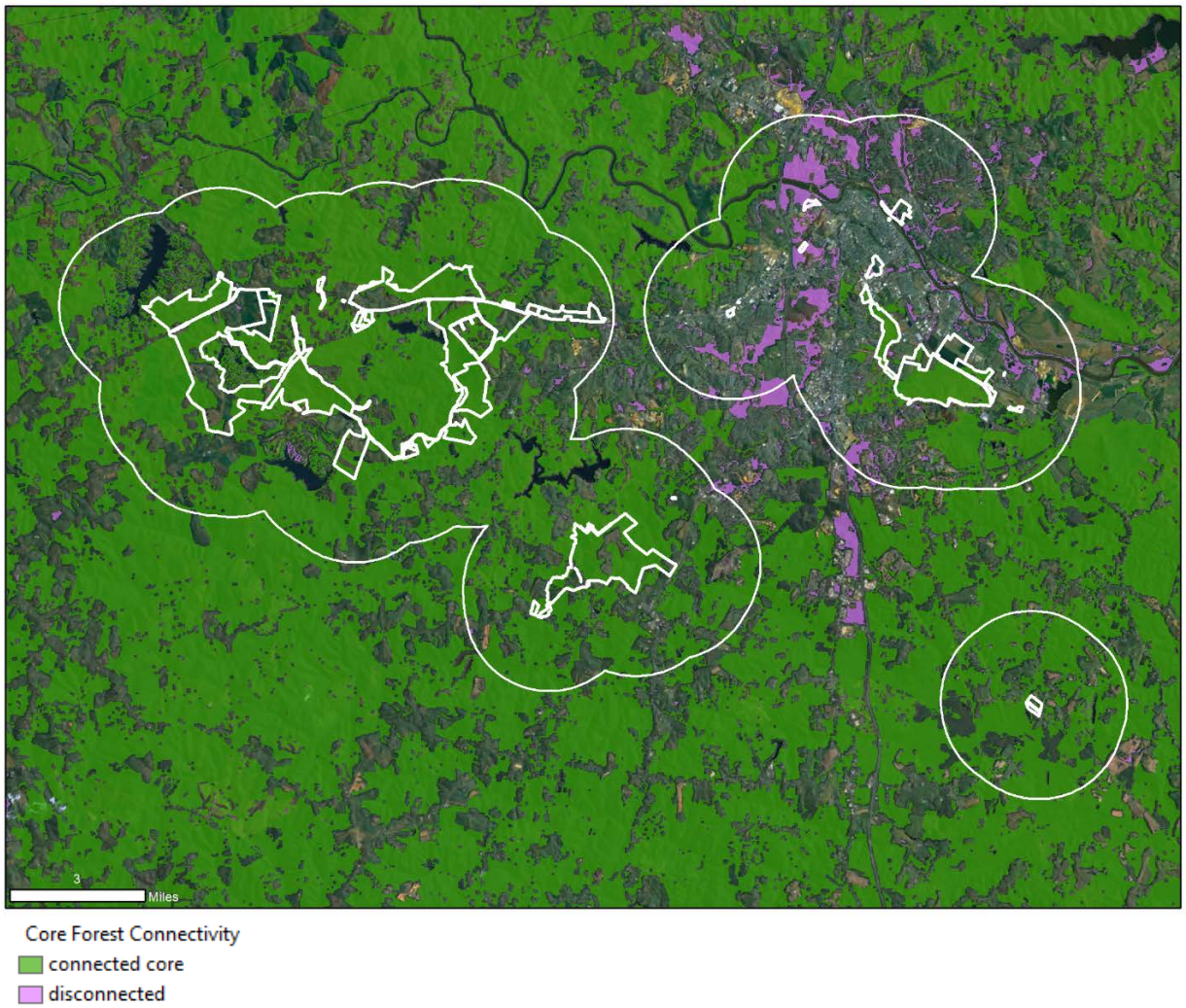

Figure 41. Core forest connectivity in 3-km NPScape buffer in and around Fredericksburg and Spotsylvania National Military Park. [Data from National Land Cover Database circa 2006]

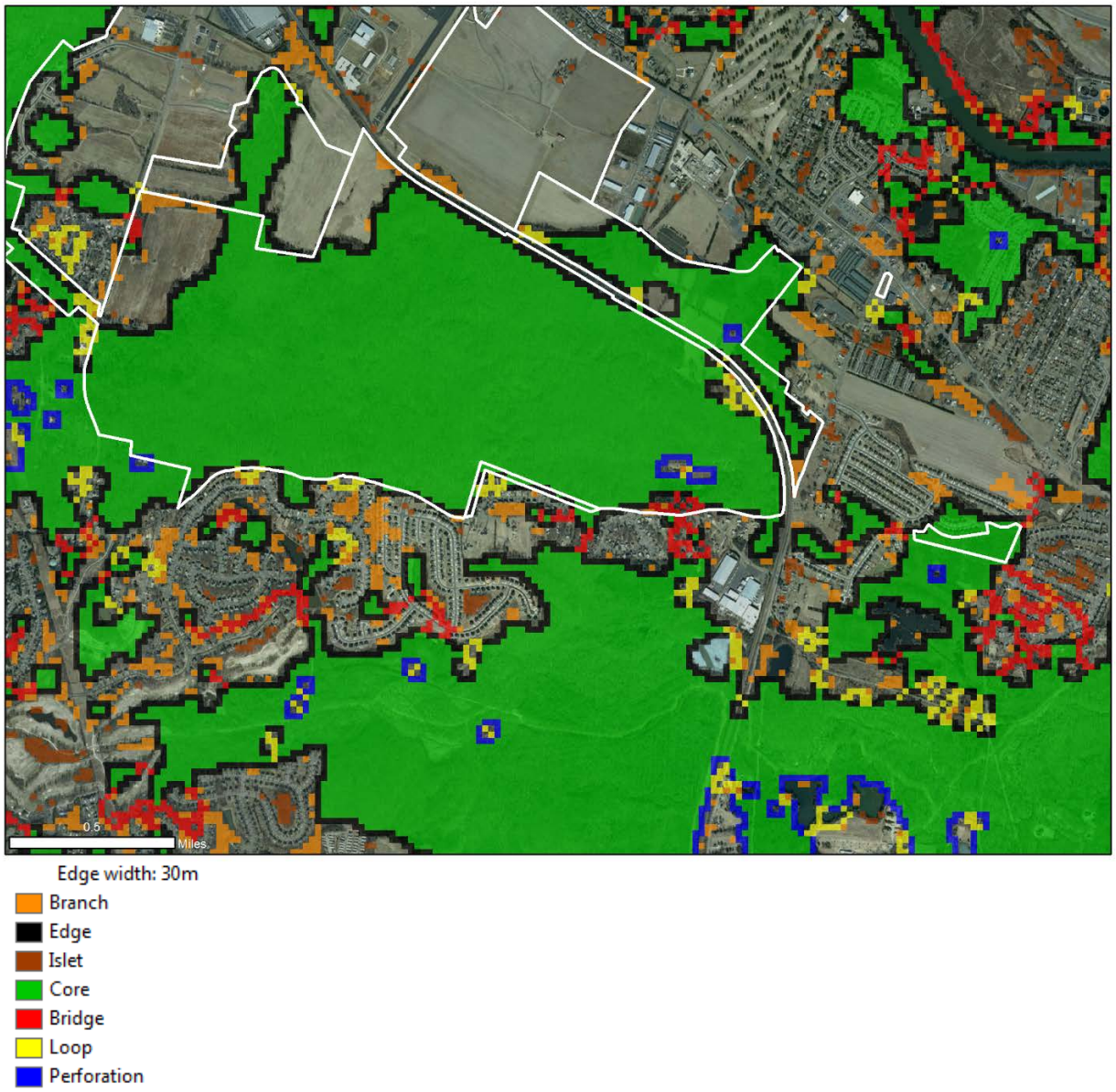

Figure 42. Detail of 2006 forest connectivity from the Fredericksburg unit at Fredericksburg and Spotsylvania National Military Park.

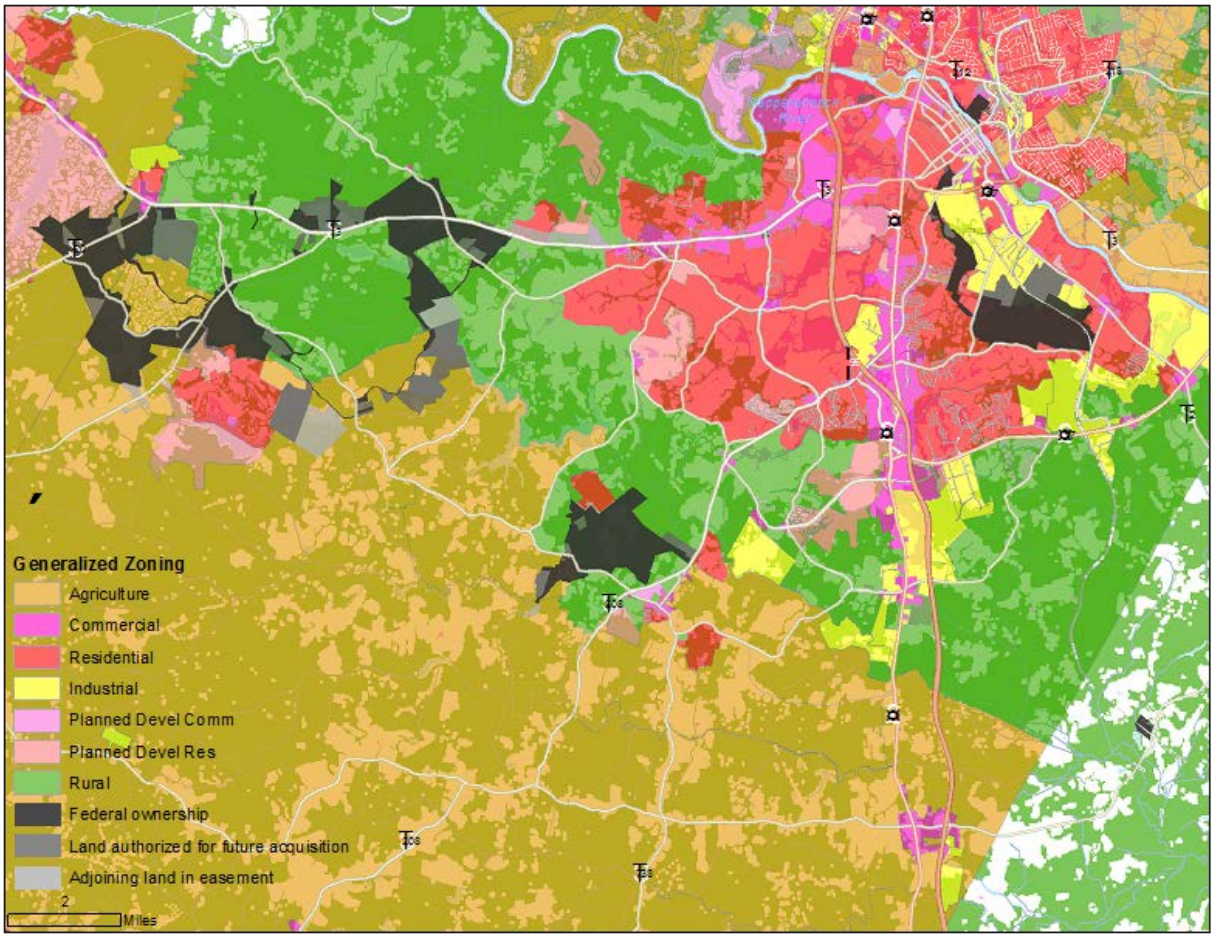

Figure 43. Generalized zoning in proximity to Fredericksburg and Spotsylvania Military Park units, 2013. [source: county GIS databases]

Today, most of the woods have matured to the extent that they no longer exhibit the dense and tangled underbrush that made fighting in the Battle of the Wilderness so difficult in 1864. However, there are opportunities to recreate this historic landscape at the park. For example, the "Cultural Landscape Report for Ellwood," a plantation within the Wilderness battlefield, recommends the *"creation of small vegetative areas or plots in various stages of re-growth to allow visitors to walk through the types of vegetation that characterized the Wilderness of 1864. Woods that have ecological value or block views of modern development should be retained. This managed plot should feature an accessible area where visitors could view the character of the woods, and a rough path that visitors could take to experience the character firsthand. To perpetuate the exhibit, a plan of rotation will be required to maintain the desired successional character"* (Auwaerter and Harris 2010).

Rotation forest plots have been implemented within the mid-Atlantic to provide habitat structure for wildlife (e.g., see Yahner 1991, 1992). An area of 10 hectares (24.7 ac) with rotating 2.5 hectares (6.2 ac) patches of various ages would provide habitat for early successional bird species while creating an interpretative landscape within the Wilderness battlefield. Such a demonstration area or

areas should be placed at the interface of an existing cultural meadow and away from large forest blocks to minimize its potential effects on forest fragmentation (Figure 44). Suggested locations are adjacent to the Wilderness Battlefield Exhibit shelter or adjacent to Elwood Manor as suggested by Auwaeter and Harris (2010).

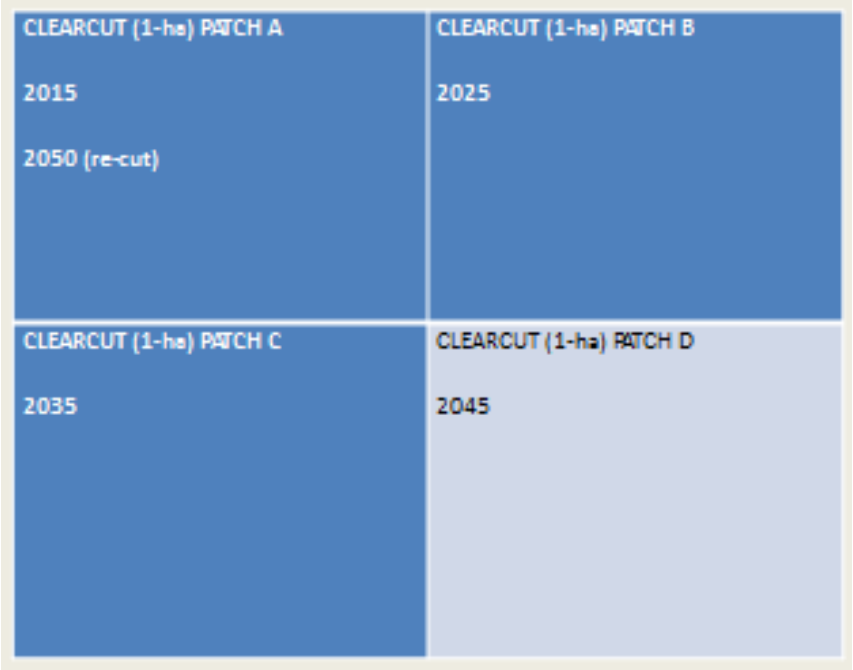

Figure 44. Proposed vegetation rotation demonstration site. Suggested locations are at forest edge adjacent to the Wilderness Battlefield Exhibit shelter or adjacent to Elwood Manor as suggested by Auwaerter and Harris (2010).

Non-native, Invasive Plant Species

As of 2008, 335 species of vascular plants have been identified at FRSP. At FRSP, 14 (4%) species of vascular plants are considered non-native and invasive in Virginia. A list of 29 invasive exotic indicator species and taxa is targeted for monitoring at FRSP as part of the Mid-Atlantic Inventory and Monitoring network. Indicator species include garlic mustard, Japanese barberry, Japenese honeysuckle, Japanese stiltgrass, multiflora rose among others (for a complete list see Comiskey and Wakamiya 2012). At FRSP, 5% of the forest vegetation monitoring plots contained exotic, invasive indicator plant species (Comiskey and Wakamiya 2012). For comparison, in the NPS MIDN parks, 25-30% of all vegetation monitoring plots contained exotic invasive indicator plant species (Comiskey and Wakamiya 2012). The most commonly occurring non-native invasive species at the park are Japanese honeysuckle and Japanese stiltgrass. Both of these species have negative ecological effects. Japanese honeysuckle is viewed by some as an “ecological trap” for nesting birds as it provides low-quality food for nestlings (e.g., Lionel and Rodewald 2006). Japanese stiltgrass is shade tolerant and out-competes native herbaceous understory vegetation. It is one of the fastest spreading non-native species in the mid-Atlantic (Judge et al. 2005). Both species are best controlled through direct application of herbicide in late summer.

Due to the presence of non-native species at the park (although relatively low), management activities that involve landscape changes (e.g., mowing, fire, logging) should be conducted with care and carefully monitored pre- and post- treatment for the presence of non-native species (Alpert et al. 2000, Hansen et al. 2005).

Threatened and Endangered Species

Except for occasional transient species, no federally listed or proposed endangered or threatened species (50 CFR 17.11, 10/01/05) are known to be endemic to FRSP except for the federally-threatened small whorled pogonia last seen in the park in 2006. From 1989 to 1991, the Virginia Department of Conservation and Recreation's Division of Natural Heritage conducted an inventory for "Natural Heritage Resources" in FRSP. Natural Heritage Resources include "the habitat of rare, threatened, or endangered plant and animal species, rare or state significant natural communities or geologic sites, and similar features of scientific interest." Two populations of the rare plant, red milkweed were found at the Spotsylvania unit in the early 1990s (G. Kneipp, FRSP, pers. comm. 2012). Additional surveys for the plant should be conducted in cooperation with the Virginia Department of Natural Heritage staff to avoid negative impacts to the rare plant should land use or management practices change.

Conclusions

Despite a history of disturbance, increasing human population, and concomitant residential/commercial development in and around the park, FRSP supports a diverse assemblage of plant communities, aquatic resources, and wildlife including globally-rare plant associations and bird communities. These natural resources of global, regional, and local significance persist within a landscape that preserves the history of several significant Civil War battles. Despite these findings, much is still unknown about many natural resources at the park. For example, information about terrestrial invertebrates, aquatic invertebrates (with the exception of macroinvertebrates), and bats is lacking. In addition, breeding and dispersal behavior of animals within the park have not been studied. However, based on information currently available and synthesized herein, we suggest several high-priority management approaches to ensure the persistence and, in some cases, restoration of natural resources of significance in the park.

- Maintain current cultural grassland management and expand where culturally appropriate.
- Create a cultural, early successional forest demonstration site at Wilderness battlefield to better interpret the landscape condition that occurred during the 1864 conflict while creating additional habitat for early successional bird species.
- Maintain Virginia pine plantations at Spotsylvania through the use of prescribed fire as presented in the park's fire management plan.
- Protect wetland habitat at Stonewall Jackson Shrine and continue to monitor species of special concern found at this site.
- Examine land ownership and zoning around areas of conservation interest (e.g., Hamilton's thicket, Stonewall Jackson Shrine wetland, Spotsylvania's Virginia pine stands, cultural meadows) and work with local conservancies, land owners, and municipalities to assist in their protection.
- Consider restoring more cultural meadows in the park, especially those adjacent to the Ellwood farm and in the Chancellorsville and Spotsylvania portions of the park.
- Where needed, create forested riparian buffers along all streams within the park.
- Establish non-native plant removal plans for Japanese honeysuckle and Japanese stiltgrass (with concurrent native plant replacement).
- Maintain connectivity between and among park parcels via conservation easements, re-forestation efforts, and re-zoning suggestions. In addition, maintaining forested connections to the Rappahannock River could have long-term conservation and cultural benefits, especially if the park lands can be linked to historic river crossings used by Union and/or Confederate troops.

Finally, FRSP must continue to steward its natural and cultural resources from within its boundaries. As 150 years of landscape management has shown, cultural use of the park is compatible with good natural resource management. Proper design, restoration, and maintenance of cultural meadows, trails, and park structures will ensure that the significant natural resources of FRSP are protected and experienced by visitors.

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Appendix A. Status and trend in condition of natural resources for Fredericksburg and Spotsylvania National Military Park, January 2014.

Key for Symbols Used to Determine the Condition of Natural Resources:

Condition Status		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Unchanging		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low

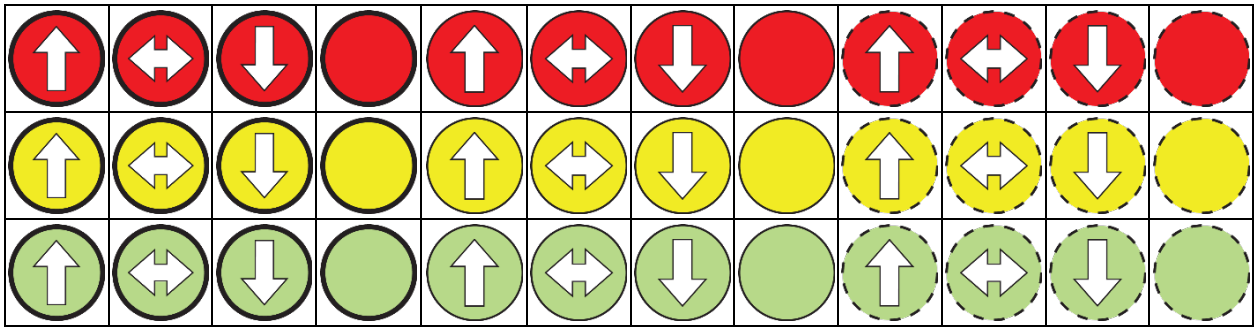
Examples of how to Interpret the Symbols:

Resource is in good condition, its condition is improving, high confidence in the assessment.

Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.

Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.

Possible Conditions of Natural Resources:



Summary of the Condition of Each General Natural Resource Category:

Air/Visibility/Sound	Water; Including Macroinvertebrates	Plants	Terrestrial Vertebrates	Fish	Landscape Connectivity	Historical Landscapes
↑	↓	↔	↔	↔	↓	↔

Detailed Description of the Condition of Each Natural Resource:

RESOURCE	STATUS	TREND	EVIDENCE	
AIR RESOURCES (OVERALL)	**CAUTION**	**IMPROVING**		↑
Ground level ozone	Caution	Unchanged	From the period 2005-2009, the average ozone exposure indices at FRSP were 12.01 ppm/hr (moderate ranking) and 15.46 ppm/hr (high ranking) in winter and summer, respectively.	↔
Acid deposition	Caution	Improving	Although the park is exposed to acid pollution, ecosystems within the park are not sensitive to acidification due to a combination of high acid neutralizing capacity in several park areas and the relatively flat topography of the park. In general, airborn sulfur (SOX) and nitrogen (NOx), both contributors to acid deposition, are declining in the mid-Atlantic due to pollution control measures.	↑
Visibility	Significant concern	Improving	The Interagency Monitoring of Protected Visual Environments (IMPROVE) estimates that ambient haze in and around the park is very high (23.11; haze index [deciview; dv]). This value contrasts with the estimated natural or background haze for the park of 8.24 dv (NPS 2014). However, recent air quality management programs (e.g., Burns et al. 2011) appear to be having an effect on decreasing haze throughout the mid-Atlantic. For example, a recent analysis conducted by the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) indicates that ambient haze has decline at FRSP from 2005 to 2009.	↑

RESOURCE	STATUS	TREND	EVIDENCE	
Dark night skies	Caution	Unknown	The NPS is obligated to preserve the natural lightscape and dark night skies of parks (Albers and Duriscoe 2001). Recent studies have indicated that light pollution may have adverse effects on water quality, salamander foraging, migratory birds, and turtle breeding (Harder 2004). Artificial light in and around the park associated with roads, buildings, and signage is a potential threat to the dark night skies of FRSP as evidenced by NOAA night-time photography. Although the visual environment of dark night skies has not been directly measured at FRSP, the NPS Natural Sounds and Night Sky Division (NSNSD) modeled the visual environment for FRSP. For level 2 parks, FRSP models in the amber range (Moderate Condition).	
Natural sounds	Caution	Unknown	Noise from traffic along major highways adjacent to the park are the major potential contributors to deterioration in the natural sounds of FRSP. No monitoring of the acoustical environment of FRSP has been conducted, but using modeled impact results, FRSP is assessed in amber or moderate condition threshold.	
WATER RESOURCES (Including Macroinvertebrates)	**SIGNIFICANT CONCERN**	**DETERIORATING**		
Fecal coliform pollution	Significant concern	Unknown	The Virginia Department of Environmental Quality (DEQ) designated sections of Hazel Run and the Rappahannock River as impaired due to high fecal coliform bacteria in 2004.	
Macro-invertebrates as indicators of water quality	Significant concern	Unknown	All macroinvertebrate monitoring sites had Virginia Stream Condition indices lower than the threshold level of 60, indicating impairment of park streams.	
PCBs	Significant concern	Unchanged	Sections of Hazel Run and the Rappahannock River in and around FRSP were designated as impaired due to the presence polychlorinated biphenyls (PCBs) in fish tissue that surpassed 54 parts per billion. Therefore, fish consumption was not supported in these waters. In Hazel Run the fish species with high levels of PCBs was American eel. In the Rappahannock River, gizzard shad, channel catfish, carp, and blue	

RESOURCE	STATUS	TREND	EVIDENCE	
			catfish had PCB levels that exceeded accepted limits.	
Dissolved oxygen	Caution	Unknown	Dissolved oxygen (DO) levels below the 4.0 mg/l threshold were noted in August at Lewis Run (FRSP 1, 2, 3), the lower reaches of Brock Run (FRSP 4) and the unnamed tributary of the Rappahannock River along Lee Drive (FRSP 7). The average water temperature at these sites was not significantly higher (24.6 C) than that of other sites (24.2 C), indicating that a combination of surrounding land use and, perhaps, water flow (which also effects waters' ability to hold oxygen) may be affecting DO levels during late summer. In addition, several sites with low DO (FRSP 2, 3, 4) are associated with impounded streams. Stream impoundments affect water flow and may result in lower DO levels (Kittrell 1959).	
pH	Caution	Unknown	Water sampling locations along Lee Drive in the Fredericksburg unit and in Brock Run in the Wilderness unit of the park had pH readings that were below threshold levels of 6.0. However, these low pH readings may be due to surrounding vegetation communities and soil types rather than water pollutants.	
Chloride and potassium	Good	Unknown	Chloride and Potassium measured well below or within thresholds set by the EPA, CBF, VA DEQ, mid-Atlantic streams assessment, and/or MD biological stream survey.	
PLANT RESOURCES (OVERALL)	**CAUTION**	**VARIABLE**		
Mature, upland forests	Good	Improving	Mature, upland forest associations at FRSP include Oak/Heath Forest; Acidic Oak-Hickory Forest, Mesic Mixed Hardwood Forest, and Eastern White-Pine Hardwood Forest. These forests are fully-stocked (average basal area/ha = 65 m^2) with intact forest canopies (Comiskey and Wakamiya 2012). The dominant cover type in mature forests at the park is oak—due to the well-drained, acidic soils present in much of the park as well as the disturbance land use history. Since the time of the battles, there has been some mesofication of these forests with shade-tolerant species such as American Beech and Red Maple dominating the	

RESOURCE	STATUS	TREND	EVIDENCE	
			understory at many of these stands. Recruitment of these mesic species out-pacing that of successional forest species such as Virginia pine (Comiskey and Wakamiya 2012). The number of snags (< 10/ha) and woody debris present is relatively low and of concern for forests of this age (Comiskey and Wakamiya 2012).	
Early successional Virginia pine communities	Caution	Deteriorating	Regeneration data indicates that early successional pine forests are rapidly succeeding to hardwood forest with American beech, American ash, and American holly dominating the understory (Comiskey and Wakamiya 2012). Due to their cultural and ecological significance (supporting rare populations of birds and mammals), management intervention should be adopted in these stands to maintain Virginia Pine - as proposed in the park's Fire Management plan (FRSP 2012).	
Early successional woodland/coppice forest	Significant concern	Declined since time of the battles	A coppice forest was the dominant covertype at the Wilderness battlefield in 1864. This dense, shrub-like forest was due to the mining and charcoal industries during the mid-1800s. After the battle, these early-successional forests matured to the well-stocked late successional forest communities present at much of the park today.	
Cultural/historic grasslands	Caution	Declined and/or changed since time of the battles	Based on 1867 maps, it appears there were many parts of the park that were historically open and have reverted to forest today. Similarly, based on 1937aerial photographs, some cultural meadows that are open today had reverted to forest between 1867 and 1937.	
Wetlands	Good	Unknown	The Chancellorsville unit has the largest concentration of both palustrine emergent and palustrine forested wetlands. The Fredericksburg unit has the second highest concetration of palustrine forested wetlands, including an additional 54 acres mapped by Sharpe et al. (2013). Both the Spotsylvania Courthouse and Wilderness units have significant acreage of palustrine forested and palustrine emergent wetlands. Palustrine emergent wetland acreage at the Stonewall Jackson Srine is small, but not insignificant due to the vegetation communities and wildlife species found at that site. Potential vernal pools exist in all of the major park units based on observations of amphibian breeding patterns. Coastal Plain / Piedmont Floodplain Swamp forest has a conservation	

RESOURCE	STATUS	TREND	EVIDENCE	
			rank of G3/G4 (vulnerable; rare or locally found within a restricted range) and is found only within the Chancellorsville section of the park. The Non-Riverine Saturated Forest which is a globally rare vegetation association (G2; imperiled; very vulnerable to elimination throughout its range) is found in the Fredericksburg Battlefield portion along Lee Drive - where the most extensive stand is located. The Coastal Plain / Piedmont Acidic Seepage Swamp is an uncommon (G3) wetland habitat throughout the mid-Atlantic. At FRSP, this wetland type is found in the Wilderness, Spotsylvania, and Fredericksburg portions of the park and has an average size of 2 ha (4.9 ac). Hamilton's thicket in the Wilderness portion of the park supports an exemplary occurrence of the Coastal Plain Depression Wetland.	
Wetland connectivity	Caution	Deteriorating	The riverine wetland connectivity in FRSP units is 78% and ranked as "good" (or "variegated" in the categorization of Klimas et al. 2004). Non-riverine wetland connectivity was 58% or "fair" (fragmented). Increasing development around the park threatens the hydrologic connectivity within and among wetlands.	
Riparian vegetated buffers	Caution	Unknown	Riparian buffers along streams (within 75 ft [22.9 m]) are 84% forested within the FRSP units.	
Forest/landscape connectivity and core forest	Caution	Deteriorating	In spite of the intense landscape development along the I-95 corridor, there are still large areas of core forest in the region surrounding the FRSP units (as defined by the NPScape 30-kKm Area of Analysis) and the regional landscape connectivity is "good". However, upon closer inspection of the area immediately surrounding the Fredericksburg unit (e.g. the 3-km NPScape Area of Analysis), it becomes apparent that there is a significant area of core forest that is disconnected from the larger regional core forest, having been fragmented by the development along I-95, and state highways 17 and 3. The largest and most intact forest occurs in Hamilton's thicket in the Wilderness unit of the park. The large tracts of surrounding forest (not in FRSP ownership) makes this location even more important from an ecological perspective.	

RESOURCE	STATUS	TREND	EVIDENCE	
Plant species of special concern	Caution	Unknown	The federally-threatened small whorled pogonia (Isotria medeoloides) persists in the understory of mature forests in the park. Two populations of the state-rare plant, red milkweed (Asclepias rubra) were found at the Spotsylvania unit in the early 1990s. Current distribution of this plant is unknown.	
Nonnative plants	Caution	Deteriorating (nonnative plants may be increasing at NERI)	At FRSP, 14 (4%) species of vascular plants are considered non-native and invasive in Virginia. In addition, 5% of the forest vegetation monitoring plots at FRSP contained non-native vegetation (Comiskey and Wakamiya 2012). For comparison, in the NPS Mid-Atlantic Network (MIDN) parks, 25-30% of all vascular plant species are non-native. The most commonly occurring non-native invasive species at FRSP are Japanese honeysuckle and Japanese stiltgrass.	
ANIMALS	**GOOD**	**UNCHANGED**		
Fish	Caution	Unknown	Forty-one species of fish were captured at inventory locations during the early-mid 2000s. Of the fish captured, 70% were native and 27% were non-native. FRSP has the highest number of fish species of any of the parks within the Mid-Atlantic Network (MIDN) of the NPS (Atkinson 2008). This relatively high species diversity probably is due to the fact that FRSP occupies two physiographic provinces (Piedmont and Coastal Plain), two drainages, and crosses a fall line. The mottled sculpin (found in Wilderness Run) and silverjaw minnow (found in Hazel Run) are particularly noteworthy findings within the park.	
Amphibians	Good	Unknown	NPSpecies (2013) lists 26 species of amphibians known from FRSP. These species represent 85% of the amphibian species known from the Piedmont and Coastal Plain of VA. One species of special concern, the carpenter frog, is found at FRSP.	
Reptiles	Good	Unchanged	Recent inventories documented that the eastern painted turtle was the most numerous species of reptile found at FRSP and it occupies both stream and impoundment habitat (Mitchell 2007). An additional 4	

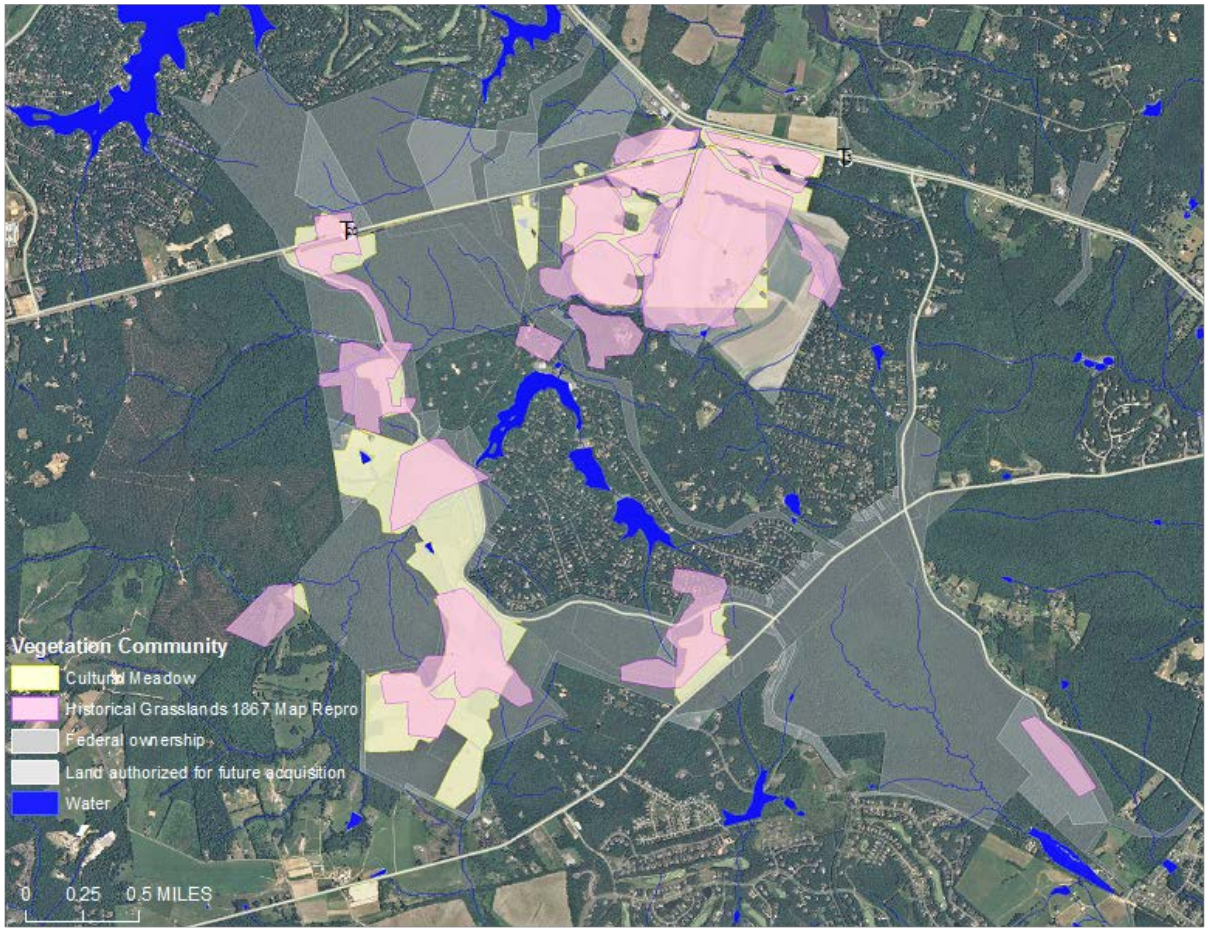
RESOURCE	STATUS	TREND	EVIDENCE	
			species of freshwater turtle including snapping turtle, red-bellied cooter, spotted turtle, and stinkpot are also found in FRSP. In addition, box turtles occur at FRSP, especially in the Spotsylvania portion of the park. Populations of fence lizards and five-lined skinks occur in old field habitat at FRSP. A variety of snakes also are found at FRSP including the northern watersnake, northern copperhead, ribbon snake, and eastern garter snake.	
Bats	Unknown	Unknown	Although no targeted survey has been conducted, at least two species of bats are known from FRSP. These bats, big brown and eastern red, forage in the park but their residency status is unknown. Big brown bats and little brown bats (not documented in park) probably use human structures at FRSP for roosting during the summer (Agosta 2002). Some cave and mine hibernating bat populations in the eastern United States have declined more than 90% in the past decade due to a fungal disease known as white-nose syndrome. Therefore, any bats located in FRSP should be monitored for its presence (Reichard and Kunz 2009).	
Small mammals	Good	Unknown	The white-footed mouse is the most abundant terrestrial mammal found at FRSP and occurs in all habitat types (Barry et al. 2008). Field (meadow) habitats at FRSP support populations of meadow voles, eastern harvest mouse (at very high densities), and northern short-tailed shrew. The eastern harvest mouse occurs at high density at FRSP, perhaps, due to meadow restoration programs. The American least shrew, an uncommon insectivore, was found adjacent to a pine stand at the Spotsylvania unit and may occur in low abundance. Virginia opossum and eastern cottontails are found along forest edges and in old-fields at FRSP. Two species of non-native mammals, house mouse and Norway rat, are found at the park and are closely associated with human structures.	
Squirrels	Good	Unknown	Four species of squirrels are known from FRSP including gray squirrel, southern flying squirrel, woodchuck, and eastern chipmunk. Red squirrel and eastern fox squirrel were not detected during recent mammals surveys although suitable habitat (e.g., pine stands) exist (Barry et al. 2008).	

RESOURCE	STATUS	TREND	EVIDENCE	
Wetland/riparian mammals	Good	Unchanged	Wetland and riparian areas at FRSP provide habitat for raccoons, beavers, and eastern moles. In addition, one specimen of rice rat was captured in 2005 at the Stonewall Jackson Shrine wetlands, which is at the extreme northwest of this species' geographic distribution (Barry et al. 2008).	
Canids	Good	Unchanged	The coyote is known to breed in the park and red and gray foxes are present but their residency status is unknown (NPSpecies 2013).	
White-tailed deer	Good	Unchanged overall	According to the Virginia Department of Game and Inland Fisheries (VDGIF), Spotsylvania county contains <15 deer/mi2 (6 deer/km2) in 2010. The white-tailed deer population index (antlered buck killed/mi2 of deer habitat) is 1.9 (0.6 antlered buck killed/km2) which is considered "low" but stable for modern times. These estimates differ from those found by natural resource managers at the park. Visual encounter surveys estimate the deer population at Chancellorsville to be 12.0 deer/mi2 (31 deer/km2), 12.7 (33), 15.1 (39), 7.7 (20), and 8.5 (22) in 2007, 2008, 2009, 2010, and 2011, respectively, representing the lowest deer density estimates for the park. Resource managers at FRSP estimate that deer densities were as high as 22.5 deer/mi2 (58.2 deer/km2) at the Wilderness unit in 2010 and approximately 17.4 deer/mi2 (45 deer/km2) at the Spotsylvania and Fredericksburg units in 2010 (G. Kneipp, FRSP, pers. comm., 2013).	
Forest birds	Good	Unchanged	Currently, 159 species of birds are known to occur in FRSP (NPSecies 2013). This represents 74.4% (125 of 168 species) of the species found in Virginia and 42% (25 of 59 species) of the species identified as state species of special concern or on the Partners in Flight (PIF) watchlist. Highest bird species richness was documented at Wilderness battlefield, probably due to the large expanse of mature, unfragmented forest that still persists in that park unit. At FRSP, six species of Parulida (worm-eating warbler, Kentucky warbler, northern parula, prothonotary warbler, Louisiana waterthrush, and hooded warbler) require mature forests along streams, swamps, and other bottomlands with well-developed shrub layers for breeding and foraging habitat. At FRSP, four pine-dependent bird species (pine warbler, yellow-	

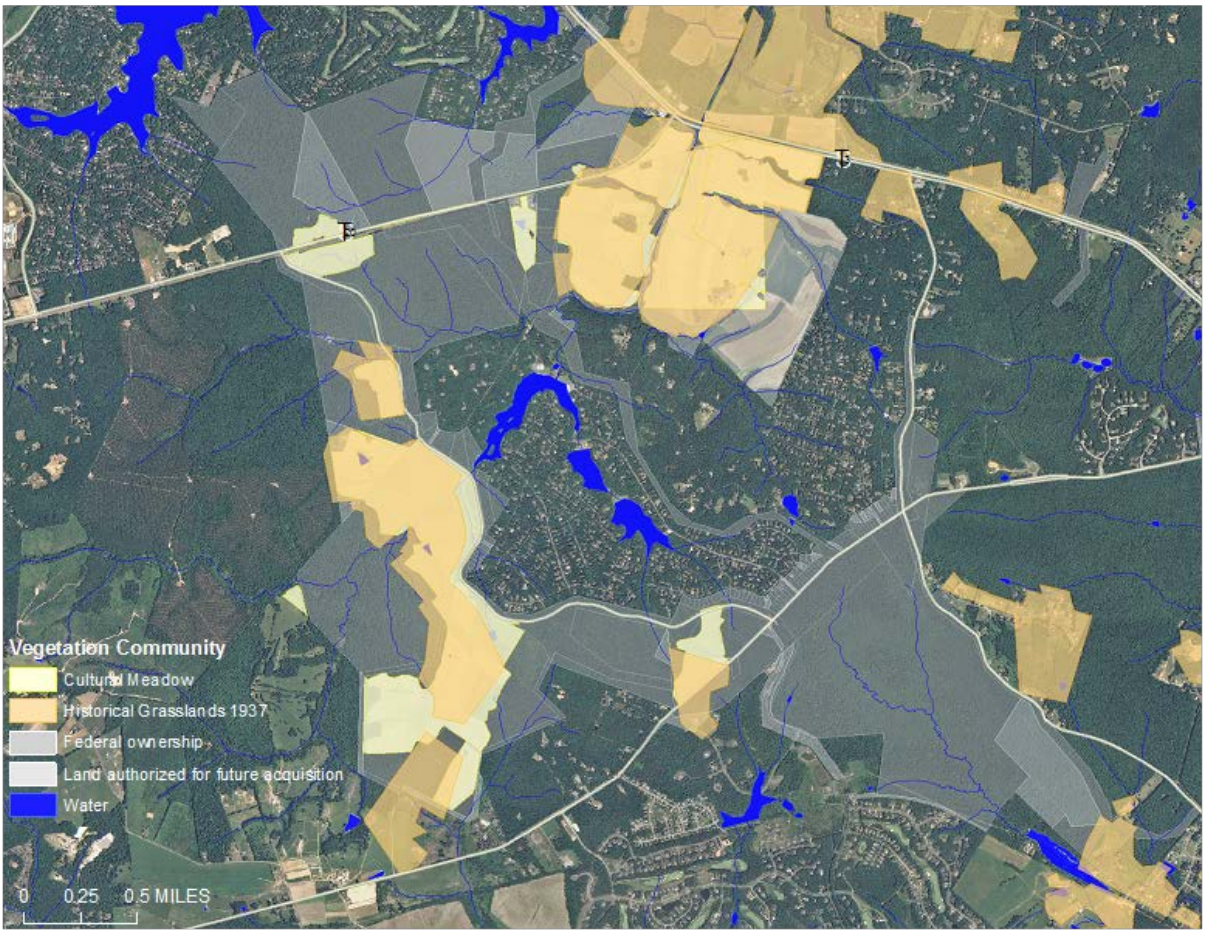
RESOURCE	STATUS	TREND	EVIDENCE	
			throated warbler, bobwhite quail, and red-breasted nuthatch) were detected in the Spotsylvania Courthouse unit within or adjacent to the successional Virginia Pine vegetation community. Mature forests at FRSP support 6 species of woodpeckers (Pileated Woodpecker, Red-bellied Woodpecker, Red-headed Woodpecker, Northern Flicker, Hairy Woodpecker, Downy Woodpecker) including all of the resident species found within the northern piedmont of Virginia.	
Waterbirds and waterfowl	Good	Unchanged	The waterways of FRSP support species of birds that depend on good water quality. For example, belted kingfisher and Louisiana waterthrush depend on clean streams (O'Connell et al. 2003). Other water-dependent species found in FRSP, such as green herons, great blue herons, spotted sandpipers, snipe, and various species of waterfowl (e.g., wood duck), use riparian corridors along streams and swamps for foraging habitat.	
Raptors	Good	Unchanged	Thirteen species of raptors are found in FRSP (NPSpecies 2013). Species of interest at the park include broad-winged hawk, northern harrier, and bald eagle which rely on forests, grasslands, and riparian corridors, respectively, for breeding.	
Shrubland birds	Caution	Deteriorating throughout their range	In the VA piedmont, shrubland species are declining as early successional habitat converts to older forests or are cleared for agriculture and/or development (Wolters et al. 2008). At FRSP, shrublands (represented by the successional vegetation community types) provide breeding habitat for Indigo Buntings, Common Yellowthroats, Orchard Orioles, Eastern Kingbirds, Whip-por-whil, Brown Thrashers, Eastern Towhees, and Yellow-breasted Chats.	
Grassland birds	Caution	Deteriorating throughout their range	The historic (cultural) meadows maintained at FRSP support a suite of breeding grassland birds including: Eastern Bluebirds, Blue Grosbeak, Field Sparrow, Grasshopper Sparrow, Eastern Meadowlark, and Bobolink. Like shrubland species, grassland bird species are declining in the eastern US and conservation of appropriate habitat for these species at FRSP is critical. Grassland birds are declining throughout the mid-Atlantic due to mowing practices, conversion of meadows to other	

RESOURCE	STATUS	TREND	EVIDENCE	
			habitat types, and urbanization (Brawn et al. 2001). At FRSP, cultural meadows at Wilderness, Chancellorsville, and Spotsylvania units support the highest diversity of breeding grassland bird species.	

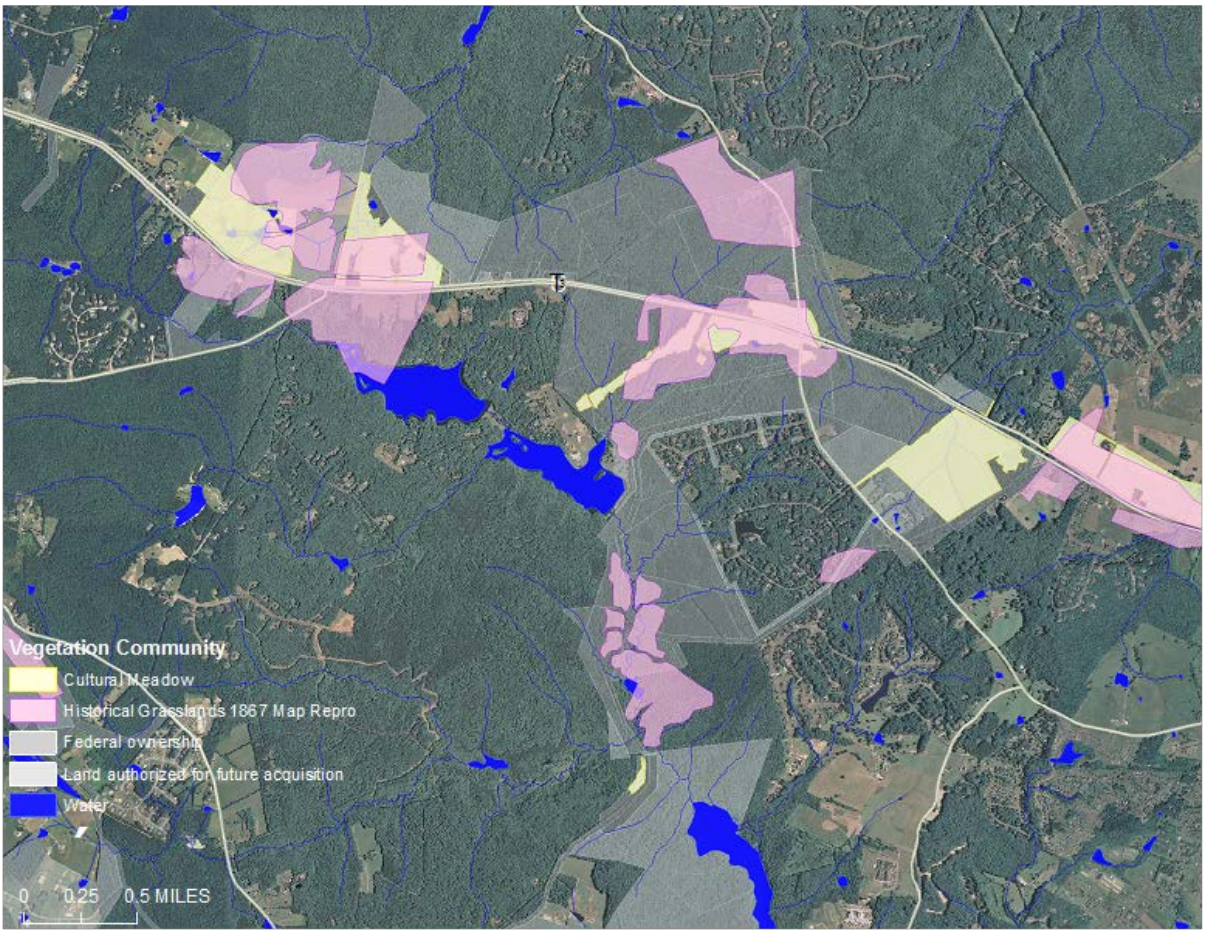
Appendix B. Areas of change in open meadow / grasslands mapped from 1867 map reproductions, 1937 aerial photos, and current conditions for the Wilderness, Chancellorsville, and Fredericksburg units at Fredericksburg and Spotsylvania National Military Park. Comparisons for the Spotsylvania Courthouse unit are located in Figures 38 and 39.



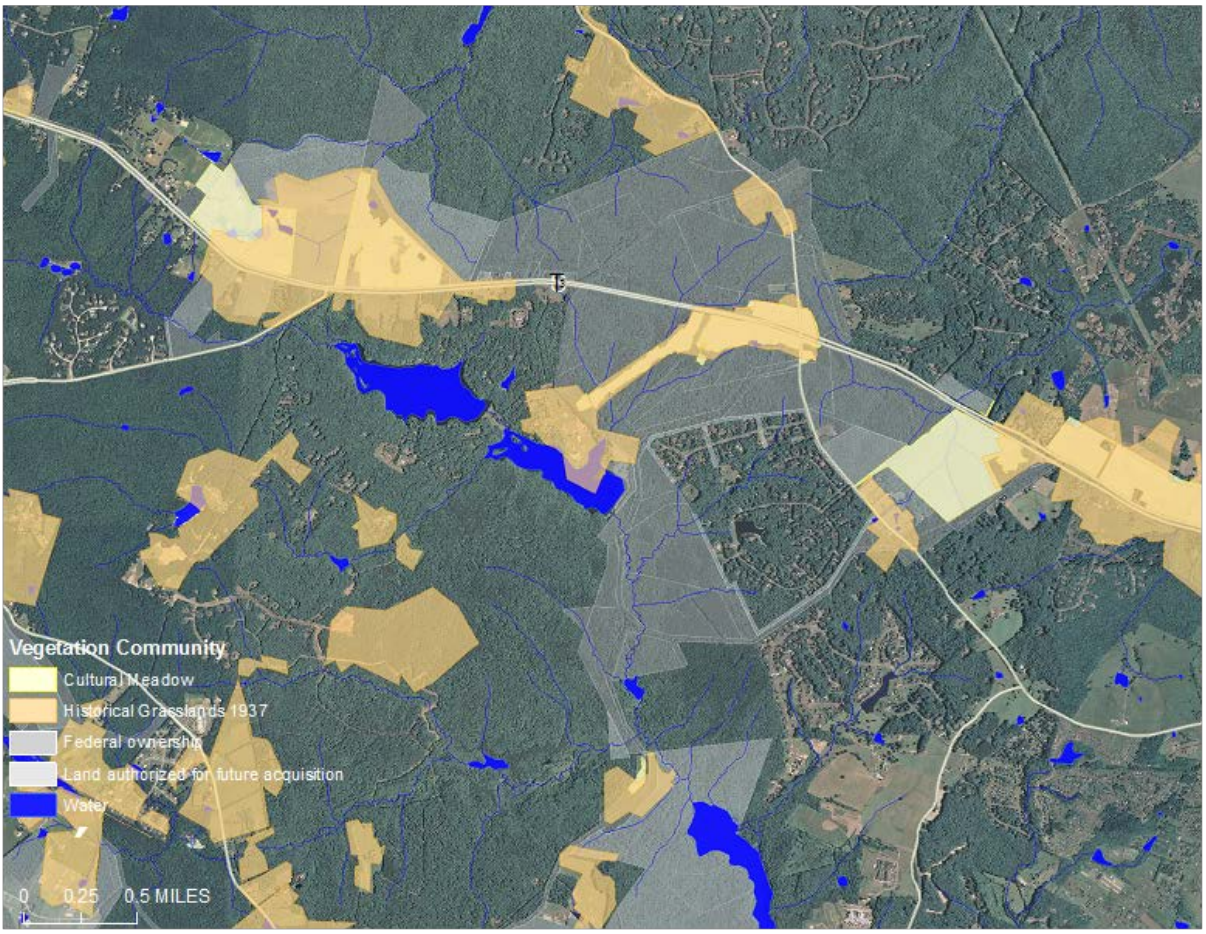
Areas of change in open meadow / grasslands (pink) mapped from 1867 map reproduction and current conditions (yellow) for the Wilderness unit at Fredericksburg and Spotsylvania National Military Park.



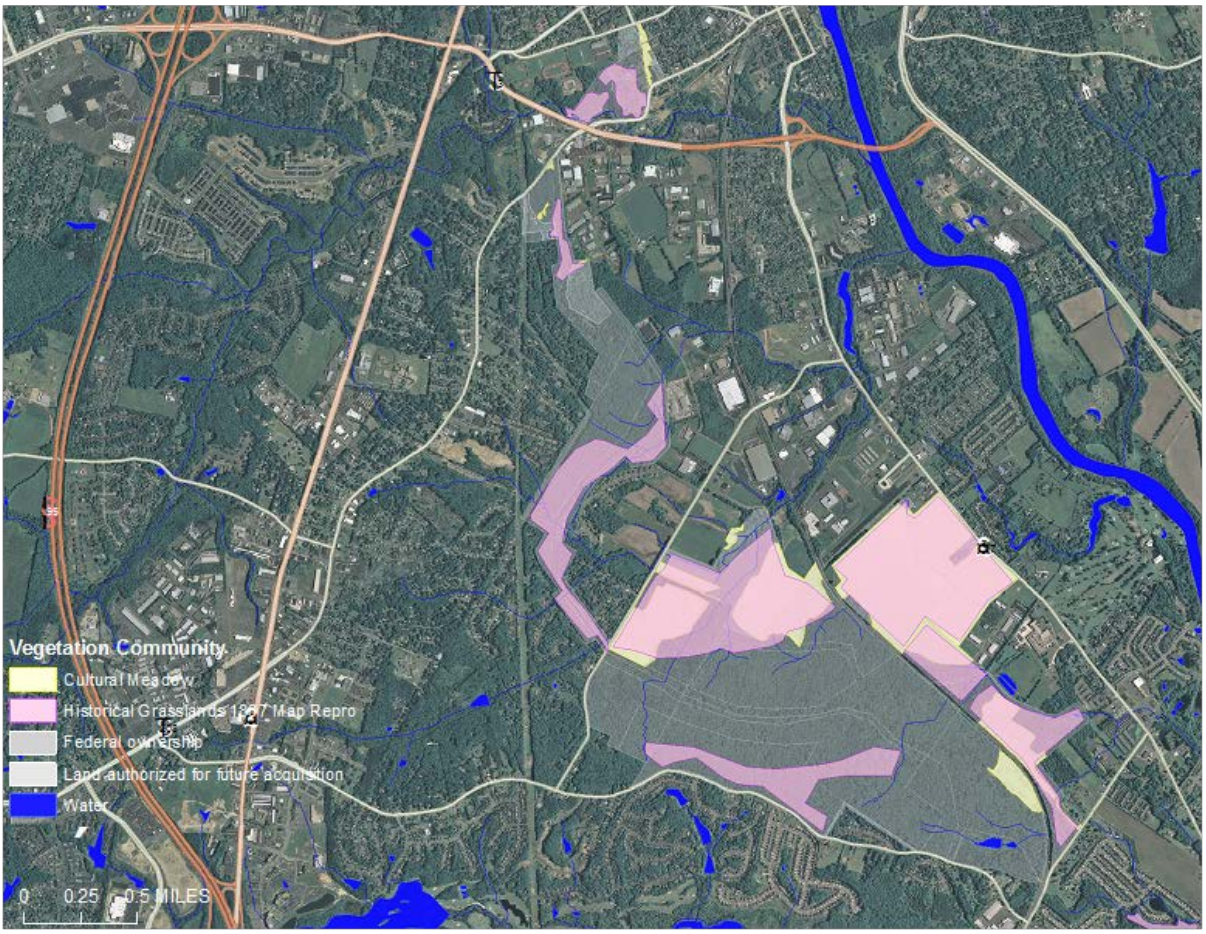
Areas of change in open meadow / grasslands (orange) mapped from 1937 aerial photos and current conditions (yellow) for the Wilderness unit at Fredericksburg and Spotsylvania National Military Park.



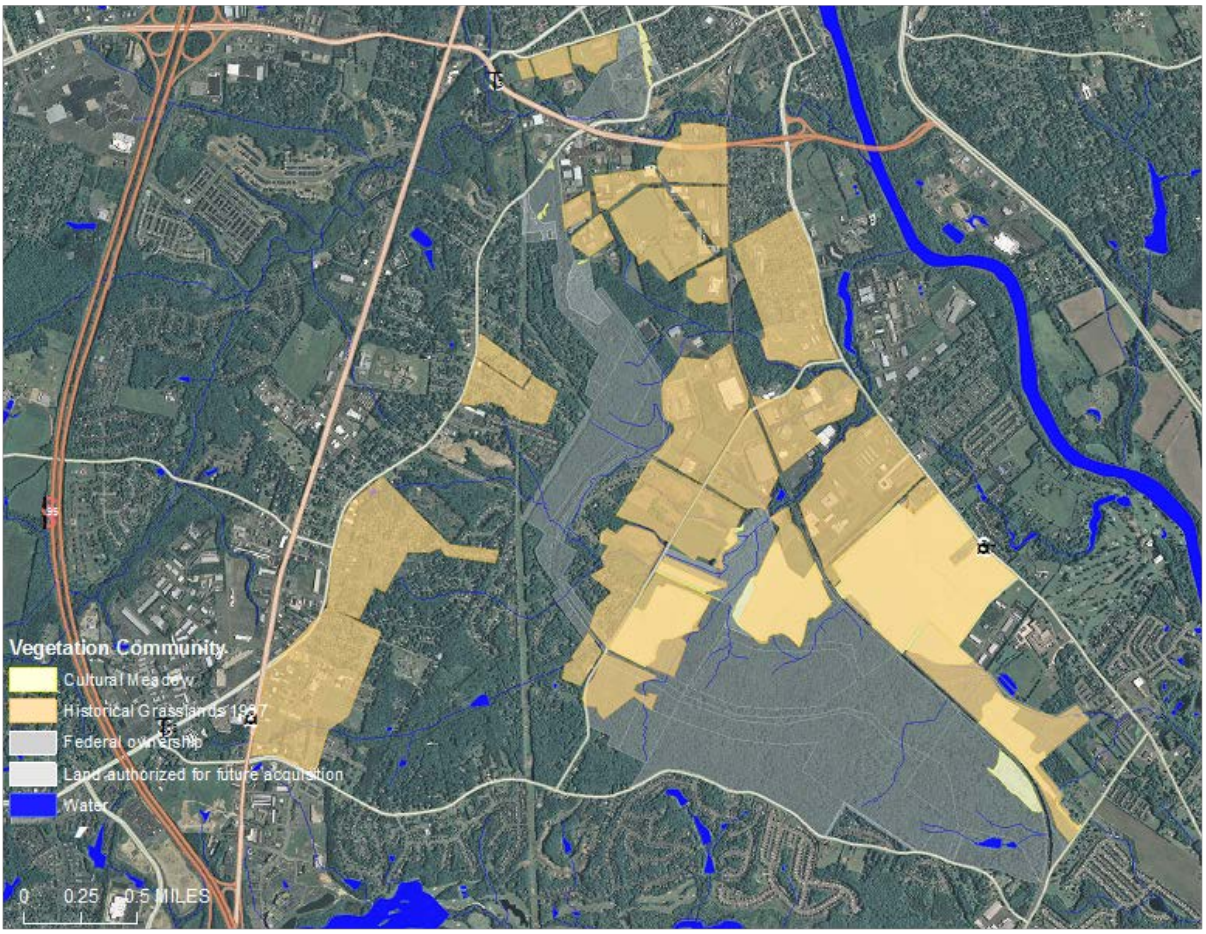
Areas of change in open meadow / grasslands (pink) mapped from 1867 map reproduction and current conditions (yellow) for the Chancellorsville unit at Fredericksburg and Spotsylvania National Military Park.



Areas of change in open meadow / grasslands (orange) mapped from 1937 aerial photos and current conditions (yellow) for the Chancellorsville unit at Fredericksburg and Spotsylvania National Military Park.



Areas of change in open meadow / grasslands (pink) mapped from 1867 map reproduction and current conditions (yellow) for the Fredericksburg unit at Fredericksburg and Spotsylvania National Military Park.



Areas of change in open meadow / grasslands (orange) mapped from 1937 aerial photos and current conditions (yellow) for the Fredericksburg unit at Fredericksburg and Spotsylvania National Military Park.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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