National Park Service
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Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Fort Necessity National Battlefield

Natural Resource Report NPS/FONE/NRR—2018/1780





ON THIS PAGE
View of Fort Necessity as visitors approach from the Visitor's Center. Credit: NPS.

ON THE COVER
Fort Necessity, Pennsylvania. Credit: NPS.

Natural Resource Condition Assessment

Fort Necessity National Battlefield

Natural Resource Report NPS/FONE/NRR—2018/1780

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Contents

Page

Figures....vii

Tables....xi

Appendices....xiii

Executive Summary....xv

Background and Context....xv

Approach....xv

Threats to FONE....xvi

Current Condition of Natural Resources in FONE....xvi

Air Quality....xvi

Water Quality....xvi

Wetlands....xvii

Aquatic Species....xvii

Wildlife....xvii

Threatened and Endangered Species....xvii

Invasive Plants....xvii

Landscape....xvii

Soundscape....xvii

Lightscape....xviii

Visitor Usage....xviii

Acknowledgments....xix

1. NRCA Background Information....1

2. Introduction and Resource Setting....5

2.1. Introduction....5

2.1.1. Enabling Legislation....5

2.1.2. Geographic Setting....6

2.1.3. Park Mission....7

Contents (continued)

Page

2.1.4. Visitation Statistics 7

2.2. Natural Resources 10

2.2.1. Weather and Climate 10

2.2.2. Ecoregions and Watersheds 10

2.3. Resource Descriptions 14

2.3.1. Geology and Topography 14

2.3.2. Soils 15

2.3.3. Vegetation 16

2.3.4. Hydrology 21

2.3.5. Wildlife 23

2.3.6. Resource Issues Overview 23

2.3.7. Resource Stewardship 25

3. Study Scoping and Design 27

3.1. Preliminary Scoping 27

3.2. Study Design 27

3.2.1. Indicator Framework and Focal Study Resources 27

3.2.2. Reporting Areas 30

3.2.3. General Approach and Methods 30

4. Natural Resource Conditions 33

4.1. Air Quality 33

4.1.1. Ozone Status 33

4.1.2. Visibility 36

4.1.3. Atmospheric Deposition 39

4.2. Water Quality 43

4.3. Wetlands 48

4.4. Aquatic Species 52

Contents (continued)

Page

4.4.1. Macroinvertebrates 52

4.4.2. Fish Species 54

4.5. Wildlife 55

4.6. Threatened and Endangered Species 58

4.7. Invasive Plant Species 60

4.8. Landscape 65

4.9. Soundscape 67

4.10. Lightscape 70

4.11. Visitor Usage 72

5. Discussion 75

Literature Cited 79

Figures

Page

Figure 2.1. The location of Fort Necessity National Battlefield in relation to the rest of the ERMN units (Davey et al., 2006).....6

Figure 2.2. Location of all three units of Fort Necessity National Battlefield (NPS, 2013).....7

Figure 2.3. Ecoregions for the area surrounding Fort Necessity National Battlefield (FONE); FONE is shown by the dark circle (US EPA, 2017a).....11

Figure 2.4. Smaller HUC 8 sub-basins in the Monongahela sub-basin; the black dot is the approximate location of Fort Necessity National Battlefield (USACE, 2012).....12

Figure 2.5. Small watersheds at Fort Necessity National Battlefield (EPCAMR, 2014).....13

Figure 2.6. Physiographic provinces of Pennsylvania; the black circle shows the approximate location of Fort Necessity National Battlefield (Sevon, 2000).....14

Figure 2.7. Geologic map of Pennsylvania; the black circle shows the approximate location of Fort Necessity National Battlefield (BTGS, 2007).....15

Figure 2.8. Soils map of Fort Necessity National Battlefield's main unit (in pink); the soils shown are primarily Philo loam (Ph) along Great Meadows Run and the Brinkerton (B) and Gilpin (G) series (NCSS, 2017).....16

Figure 2.9. Fort Necessity National Battlefield land use-land cover map (PSU, 2000).....17

Figure 2.10. Vegetation types at Fort Necessity National Battlefield (Perles et al., 2006).....18

Figure 2.11. Surface water hydrology of Fort Necessity National Battlefield; black circle shows the approximate location of Great Meadows Run (USGS, 2004).....22

Figure 2.12. Historic and recent acid precipitation patterns in the US as reflected by sulfate deposition (US EPA, 2017b).....24

Figure 2.13. Ozone levels across the U.S. (Allen, 2002).....25

Figure 2.14. Average visibility due to haze across the U.S. from 1948-1983 (Corfidi, 2013).....25

Figure 4.1. Long-term ozone trends at Laurel Hill State Park, a CASTNET site located approximately 48 km (30 mi) northeast of Fort Necessity National Battlefield (US EPA, 2017d).....36

Figure 4.2. Location of IMPROVE monitoring stations within the U.S. and their average visual range (in kilometers) based on data collected from 2005-2007 (ARD, 2009).....37

Figures (continued)

Page

Figure 4.3. Total nitrogen deposition at Laurel Hill State Park, PA, the nearest NADP/NTN and CASTNET site to Fort Necessity National Battlefield (US EPA, 2017d). 42

Figure 4.4. Total sulfur deposition at Laurel Hill State Park, PA, the nearest NADP/NTN and CASTNET site to Fort Necessity National Battlefield (US EPA, 2017d). 43

Figure 4.5. Core water quality parameter sampling sites, shown by black lines, located in the main unit of Fort Necessity National Battlefield (Tzilkowski et al., 2015). 44

Figure 4.6. Fish and macroinvertebrate (MI) sampling sites at the Jumonville Glen and Braddock's Grave units at Fort Necessity National Battlefield (Tzilkowski and Sheeder, 2006). 45

Figure 4.7. Water quality sampling locations at Fort Necessity National Battlefield (Webber 2012). 46

Figure 4.8. Delineated wetlands in the main unit of Fort Necessity National Battlefield (Sharpe and Dammeyer, 2013). 49

Figure 4.9. Vegetation associations at Fort Necessity National Battlefield with wet meadows shown in light blue (Perles et al., 2006). 50

Figure 4.10. Wetlands surrounding the reconstructed Fort Necessity (Credit: P. Sharpe). 51

Figure 4.11. Simple linear regression of Bird Community Index (BCI) scores from 2011-2017 at two Fort Necessity National Battlefield sites (diamonds = Great Meadows Run; squares = unnamed tributary to Great Meadows Run). (Marshall et al., 2013; Marshall, unpublished data). 57

Figure 4.12. Average (± standard error) proportion of the total cover (blue bars) and species richness (brown bars) held by invasive exotic plant species as measured in monitoring quadrats in ERMN parks. The orange diamonds show the average number of invasive species/plot for each park, using all species data collected on each plot (Perles et al. 2014). 61

Figure 4.13. Average (± standard error) number of invasive plant species observed per plot in ERMN Forest Health monitoring plots (2008 – 2017). 63

Figure 4.14. Average (± standard error) proportion of groundstory cover in invasive plant species (2008 – 2017), from ERMN Forest Health Monitoring Data. 63

Figure 4.15. Average (± standard error) proportion of groundstory species richness in invasive plant species (2008-2017), from ERMN Forest Health Monitoring Data. 64

Figures (continued)

Page

Figure 4.16. Land use surrounding Fort Necessity National Battlefield (black circle) in 2011, with green representing deciduous forest and yellow representing hay pasture; Uniontown, PA is the urban area to the west, in red. (NPScape, 2016). 66

Figure 4.17. The forested landscape surrounding Fort Necessity National Battlefield (black circle), showing intact core forest in green (NPScape, 2016). 66

Figure 4.18. Ambient sound conditions for the United States; Fort Necessity National Battlefield is located within the black circle (NPS, 2017c). 69

Figure 4.19. Nighttime light conditions for Fort Necessity National Battlefield (white circle) (NPS NSNSD, 2016). 71

Figure 4.20. Annual visitation to Fort Necessity National Battlefield from 1935-2016 (NPS Stats, 2017). 73

Tables

Page

Table 2.1. Monthly and annual visitation to Fort Necessity National Battlefield from 1990-2016 (NPS Stats, 2017). 8

Table 2.2. ERMN Vital Signs (Marshall and Peikielek, 2007). 26

Table 3.1. List of the indicators selected for Fort Necessity National Battlefield after consulting with NPS personnel. 28

Table 3.2. Indicator symbols used to demonstrate condition, trend, and confidence in the assessment. 30

Table 3.3. Example indicator symbols and descriptions of how to interpret them. 31

Table 4.1. Benchmark ozone levels* for human health (Taylor, 2017). 34

Table 4.2. Benchmark ozone levels for plant health (Taylor, 2017). 34

Table 4.3. Status of ground-level ozone in Fort Necessity National Battlefield (ARD, 2017). 35

Table 4.4. The benchmark for visibility status (Taylor, 2017). 38

Table 4.5. Status of visibility at Fort Necessity National Battlefield (NPS ARD, 2017). 38

Table 4.6. Status of wet nitrogen and sulfur deposition at Fort Necessity National Battlefield. 41

Table 4.7. Water quality in two streams of Fort Necessity National Battlefield (Webber 2012). 47

Table 4.8. Water quality status at Fort Necessity National Battlefield; only temperature was considered as it was outside the bounds of recommended water quality standards. 47

Table 4.9. Status of wetlands within the area outlined by Sharpe and Dammeyer (2013). 52

Table 4.10. Status of aquatic macroinvertebrates at Fort Necessity National Battlefield. 53

Table 4.11. Fish that have been identified at Fort Necessity National Battlefield (Faulk and Weber 2017; NPSpecies, n.d.; Tzilkowski and Sheeder, 2006). FW=Faulk and Weber, NPS=NPSpecies, TS=Tzilkowski and Sheeder. 54

Table 4.12. Status of fish populations at Fort Necessity National Battlefield. 55

Table 4.13. Status of wildlife in Fort Necessity National Battlefield. 57

Table 4.14. Vulnerable species present, or probably present, in Fort Necessity National Battlefield (NPSpecies, n.d.). 58

Tables (continued)

Page

Table 4.15. Status of threatened and endangered species in Fort Necessity National Battlefield. 60

Table 4.16. Abundant and common non-native species documented by Zimmerman and Yoder (2006) in Fort Necessity National Battlefield. 62

Table 4.17. Status of invasive plant species in Fort Necessity National Battlefield. 64

Table 4.18. Status of landscape surrounding Fort Necessity National Battlefield. 67

Table 4.19. Status of soundscape in Fort Necessity National Battlefield. 69

Table 4.20. Status of lightscape in Fort Necessity National Battlefield. 71

Table 4.21. Status of visitor usage at Fort Necessity National Battlefield. 73

Table 5.1. Summary of natural resource status and trends at Fort Necessity National Battlefield. 75

Appendices

Page

Appendix A. Mammals present, or probably present (*), in Fort Necessity National Battlefield (NPSpecies, n.d.). 93

Appendix B. Amphibians present, or probably present (*), in Fort Necessity National Battlefield (NPSpecies, n.d.). 95

Appendix C. Reptiles present, or probably present (*), in Fort Necessity National Battlefield (NPSpecies, n.d.). 97

Appendix D. Birds present, or probably present (*), in Fort Necessity National Battlefield (eBird, 2018; NPSpecies, n.d.). 99

Executive Summary

Background and Context

As explained on the NPS website (2018), Fort Necessity National Battlefield (FONE) was established on March 4, 1931 to commemorate the French and Indian War and is the only national park unit in America dedicated to the conflict. It was at Fort Necessity, built by George Washington and his troops, that the first battle of the war took place. On the morning of July 3, 1754, the British forces were attacked by French soldiers and a group of Native Americans; after a daylong skirmish with many casualties, Washington surrendered his command and Fort Necessity was burned. Despite this initial loss, the British returned to southwestern Pennsylvania throughout the war, eventually emerging victorious. Presently, Fort Necessity National Battlefield covers approximately 360 ha (900 acres) over three units and is located about 18 km (11 miles) from Uniontown, Fayette County, Pennsylvania along the historic National Road, U.S. Route 40.

The mission of FONE is "*... to preserve and maintain both the natural and cultural resources of the Battlefield and to interpret these resources to the visiting public as well as the scientific and scholarly community*" (Interpretive Solutions, Inc., 2009).

As a small park focused primarily on cultural resources, background information on associated environmental resources is not widely available. Furthermore, the data that do exist are fragmented, making assessment of the natural resource statuses and trends within the park a difficult task. This Natural Resource Condition Assessment (NRCA) seeks to gather all available information on the natural resources of the park and provide an evaluation of their current state, as well as offer recommendations for action by the National Park Service to improve environmental resources in the park.

Approach

We used vital signs created by the NPS Eastern Rivers and Mountains Network (ERMN) and NPS soundscape and lightscape assessments as a baseline for our evaluation, characterized by local data sets. The majority of natural resource data was collected for the main unit, with a lesser quantity of data available for Braddock's Grave and Jumonville Glen. For each evaluated natural resource in this NRCA, we began with a brief description of the relevance of the resource to the environment in general and FONE in particular. We then documented the data and methods used to assess the resource and justified the condition categories by discussing reference conditions or threshold values utilized. The reference conditions and threshold values were based on federal or state agency regulations and criteria, peer-reviewed research, estimates of biotic integrity, established NPS ERMN vital signs, or NPS Air Resources Division (ARD) and NPS Natural Sounds and Night Sky condition (NSNSD) categories for natural resources. Best professional judgment was used to assign condition categories when other options were not available. We assigned each natural resource metric to a condition category for current state and temporal trend based on the available. Condition category language for current state included three categories: *resource is in good condition, resource warrants moderate concern*, and *resource warrants significant concern.* We assigned temporal trend categories of *condition is improving*, *condition is deteriorating*, or *condition is unchanging* after

assessment of historic and current data. We discussed data gaps and confidence in our assessment after each metric was evaluated. Confidence in the assessment and trend was identified as *high*, *medium*, *low*, or *not applicable*. *High* confidence ratings signify that extensive spatial or temporal quantitative data were available for review; *medium* ratings indicate that data were from studies that were quantitative and/or qualitative in nature but not usually spatially explicit; *low* ratings represent data were sourced from limited studies that collected generally qualitative information; and *not applicable* means that no reliable assessment or trend analysis was possible with the data available. Finally, the authors recommend in Chapter 5 potential indicators that may be useful for monitoring natural resource conditions in FONE in addition to those analyzed in this report.

Threats to FONE

Fort Necessity National Battlefield is primarily a cultural park, but it includes a variety of natural resources. Indeed, the fort itself sits in the midst of a wetland-dominated meadow known as the Great Meadows. Regrettably, this area has been ditched, drained, turned into pasture, and had roads and other infrastructure built on it; the NPS is restoring the Great Meadows to the best of its ability, but the effects of anthropogenic action are still visible. While internal and external development of this kind are no longer an immediate threat—indeed, the park sits within a relatively stable matrix of forested and agricultural lands—humans continue to affect FONE in other, often more indirect, ways. Excessive populations of white-tailed deer, borne largely from the anthropogenic elimination of top predators, pose a threat to forest regeneration, as deer browse inhibits understory growth. The forest understory is also altered by an assortment of non-native plants that, like other invasive species, immigrated due to prior development, anthropogenic transmittal, and changes in climate patterns. Invasive vegetation is a threat to native plant communities within the park, and efforts are underway in some spots to control or remove the non-native species. Additionally, foreign airborne contaminants enter FONE from urban areas in the west, leading to elevated nitrogen and sulfur concentrations; though these have declined somewhat over the years, ozone levels are high. Expansion of nearby cities, notably Pittsburgh and Uniontown, could cause air pollution in the park to worsen in the future; it is possible that associated light and noise pollution could also intrude, though thankfully FONE is somewhat shielded at the moment by its rural buffer.

Current Condition of Natural Resources in FONE

Air Quality

Air quality can affect visitor and wildlife well-being, plant health, water quality, and the lightscape in FONE. Parameters of interest for FONE's air quality include ozone, visibility, and wet deposition of nitrogen and sulfur. We rate the risk of ozone levels for both human and vegetative health as *resource warrants moderate concern*; based upon NPS guidance, we rate FONE's air quality for visibility and wet nitrogen and sulfur deposition as *resource warrants significant concern*. Because FONE is located in an ozone nonattainment area according to the EPA, overall air quality for the park automatically receives a *resource warrants significant concern* rating.

Water Quality

Water quality is not degraded within FONE, but because the streams are classified as High Quality – Cold Water Fishery by the Commonwealth of Pennsylvania, they are held to strict standards. Since

current water temperatures exceed the permissible maximum, we rate this issue as *resource warrants moderate concern*.

Wetlands

Wetlands in the park also receive a rating of *resource warrants moderate concern*, especially the Great Meadows area, due to human impact; ongoing efforts to restore the Great Meadows might eventually improve this rating.

Aquatic Species

Two types of aquatic organisms were evaluated: aquatic macroinvertebrates and fish. Using an index of biotic integrity (IBI), the status of aquatic macroinvertebrates is *resource warrants moderate concern*, although it should be noted that the IBI used for this assessment was not developed for this type of stream, and it is therefore possible that quality might be lower. The fish species present, however, were those representative of high quality streams. A high-quality habitat leads us to assign fish diversity a rating of *resource is in good condition*.

Wildlife

The wildlife assessment considered mammals, amphibians, reptiles, and birds throughout the park. Diversity was high for all groups and therefore received a status of *resource is in good condition*.

Threatened and Endangered Species

While there are some species of concern within the park, none are federally threatened or endangered. Only one plant, bushy St. John's wort (*Hypericum densiflorum*), is listed as threatened in Pennsylvania by the state government, and one bird, the yellow-bellied flycatcher (*Empidonax flaviventris*), is endangered. Therefore, we consider the state of threatened and endangered species to be *resource is in good condition*.

Invasive Plants

Non-native and invasive vegetation are established within FONE as a result of past and present anthropogenic activities and environmental factors. We assigned this issue a status of *resource warrants significant concern* since invasive plants can take over the understory of a forest and crowd out native plants, thus compromising the cultural integrity of the park by eliminating the vegetation that was present during the time period of interest. Three of the most abundant and widespread invasive plants were Japanese barberry (*Berberis thunbergii*), Morrow's honeysuckle (*Lonicera morrowi*), and multiflora rose (*Rosa multiflora*).

Landscape

FONE is generally surrounded by deciduous forest and agriculture, with little change since 2001. Most of the forest is intact and regarded as core forest. As a result of these current conditions, land use is given a rating of *resource is in good condition*.

Soundscape

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 therefore require the NPS to preserve the park's natural soundscape and restore deteriorated soundscapes to original conditions wherever possible. Additionally, NPS is required to prevent or minimize degradation of

the natural soundscape from noise (i.e., inappropriate or undesirable anthropogenic sound). Noises that impair the soundscape in FONE can originate from a number of sources, including motorized equipment in the park, such as vehicles or maintenance tools, nearby highway traffic, aircrafts, and visitors. There are no baseline measurements of sound at FONE, but the overall map from the NPS Natural Sounds and Night Skies Division indicates a status of *resource is in good condition*.

Lightscape

Natural lightscapes are important for nighttime scenery and star-gazing but are also critical for maintaining nocturnal habitat; adding artificial light to ecosystems may substantially impact certain species. Lightscapes can be culturally important as well and may be integral to the historical content of a park. Based upon a night sky map, we assign a status of *resource is in good condition*.

Visitor Usage

Since 1990, the average visitation rate has been greater than 160,000 people per year. For a small cultural park, this is a substantial number of visitors. Heavy human traffic creates the potential for negative effects on the park's cultural and natural resources, such as discarded trash or trampled vegetation. While there has not been an official investigation of the subject, rangers have not reported observing any such repercussions. Given the steadily increasing visitation rates, we assign usage a rating of *resource warrants moderate concern*, not due to an existing issue, but as a caution for the future.

Acknowledgments

The authors thank personnel of Fort Necessity National Battlefield and the Eastern Rivers and Mountains Network for discussions of and access to natural resource reports and documents. A special thank you is extended to reviewers who graciously offered constructive comments on the draft document. This study was funded by the National Park Service and administered by The Pennsylvania State University at University Park, PA.

1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs Strive to Provide…

- *Credible condition reporting for a subset of important park natural resources and indicators*
- *Useful condition summaries by broader resource categories or topics, and by park areas*

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

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.
Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data 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. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

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

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management

targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

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

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

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[6] An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

2. Introduction and Resource Setting

2.1. Introduction

Fort Necessity National Battlefield (FONE) was established on March 4, 1931 to commemorate the French and Indian War and is the only national park unit in America dedicated to that conflict (Interpretive Solutions, Inc. 2009; NPS 1991, 2013). It was at Fort Necessity, built by George Washington and his troops, that the first battle of the war took place. On the morning of July 3, 1754, the British forces were attacked by French soldiers and a group of Native Americans; after a daylong skirmish with many casualties, Washington surrendered his command and Fort Necessity was burned (Thomas and DeLaura 1996). Despite this initial loss, the British returned to southwestern Pennsylvania throughout the war, eventually emerging victorious. In 1966, the fort was added to the National Register of Historic Places. Presently, Fort Necessity National Battlefield covers approximately 360 ha (900 acres) over three units and is located about 18 km (11 miles) from Uniontown, Fayette County, Pennsylvania along the historic National Road, U.S. Route 40.

As a small park focused primarily on cultural resources, background information on associated environmental resources is not widely available. Furthermore, the data that do exist are fragmented, making assessment of the natural resource statuses and trends within the park a difficult task. This Natural Resource Condition Assessment (NRCA) seeks to gather all available information on the natural resources of the park and provide an evaluation of their current state, as well as offer recommendations for action by the National Park Service to improve environmental resources in the park.

2.1.1. Enabling Legislation

Fort Necessity was established on March 4, 1931 (46 Stat. 1522) to commemorate the Battle of Fort Necessity that took place on July 3, 1754. (NPS, 2013). This initial legislation only covered the battlefield itself; in 1961, additional acreage was obtained:

> *"In furtherance of the purposes of the Act of March 4, 1931 (46 Stat. 1522), the Secretary of the Interior is authorized to acquire by purchase, exchange, donation, with donated funds or otherwise by such means as he may deem to be in the public interest, lands and interests in lands adjoining or near the Fort Necessity National Battlefield site which in his discretion are necessary to preserve the historic battleground, together with not to exceed 25 acres at the detached Braddock Monument: Provided, That the total area acquired pursuant to sections 430pp to 430tt of this title shall not exceed 500 acres, except that in order to avoid the undesirable severance of parcels in private ownership such parcels may be purchased in the entirety."* (Pub. L. 87–134, § 1, Aug. 10, 1961, 75 Stat. 336.)

In addition to the main unit of the park, located where Washington and his troops unsuccessfully defended Fort Necessity against the French and Native Americans, FONE now includes Jumonville Glen, the site of a short skirmish between the British and French that ultimately led to war, and Braddock's Grave, mentioned above, where British General Edward Braddock died after retreating from a loss at the Battle of the Monongahela.

2.1.2. Geographic Setting

Fort Necessity National Battlefield is in the southwestern corner of Pennsylvania (Figure 2.1) and is included within the Eastern Rivers and Mountains Network (ERMN). FONE covers approximately 360 ha (900 acres) over three units and is located about 18 km (11 miles) from Uniontown, Fayette County, Pennsylvania along the historic National Road, U.S. Route 40. The park is situated in the Allegheny Mountain section within the Appalachian Plateau physiographic region and is positioned between the Youghiogheny and Monongahela rivers (Perles et al., 2006). Laurel Hill and Chestnut Ridge are the most conspicuous geologic features of the park (Shultz, 1999). FONE consists of three management units: The main unit, Braddock's Grave, and Jumonville Glen (Figure 2.2). The region is generally rural and not highly populated, with mixed land use of forest, agriculture, and small towns.

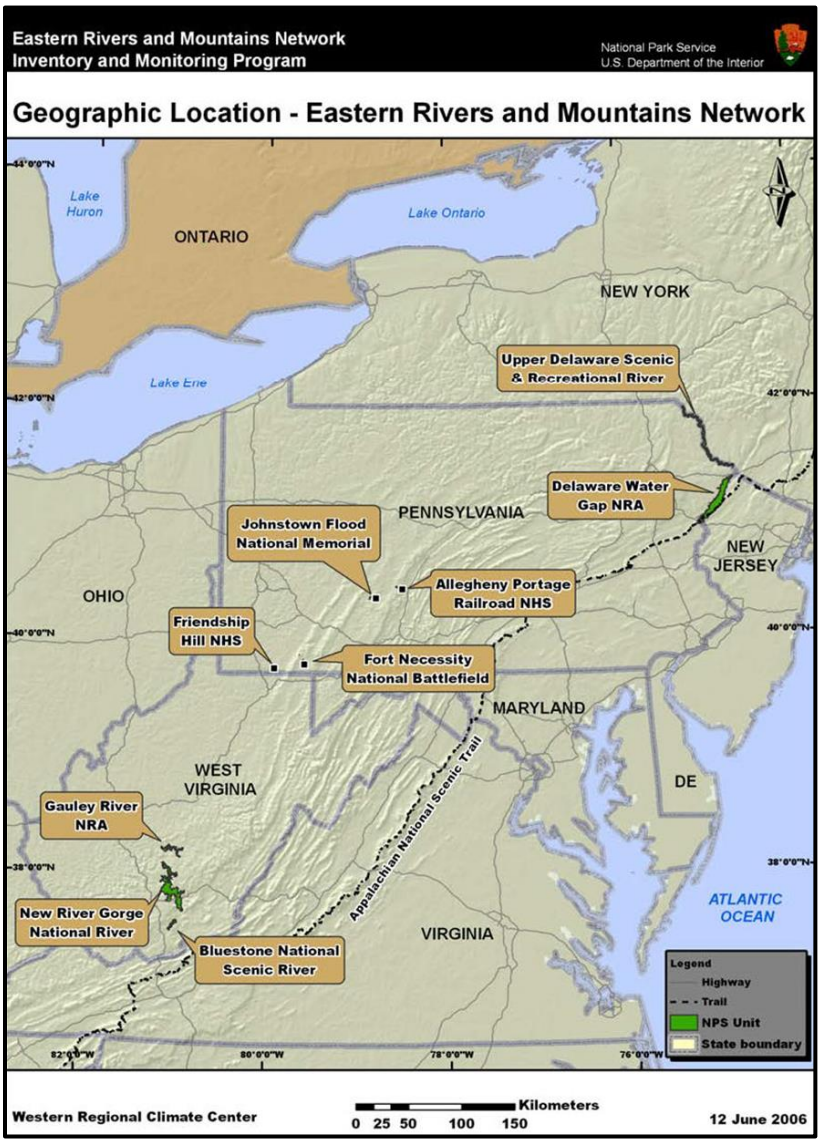


Figure 2.1. The location of Fort Necessity National Battlefield in relation to the rest of the ERMN units (Davey et al., 2006).

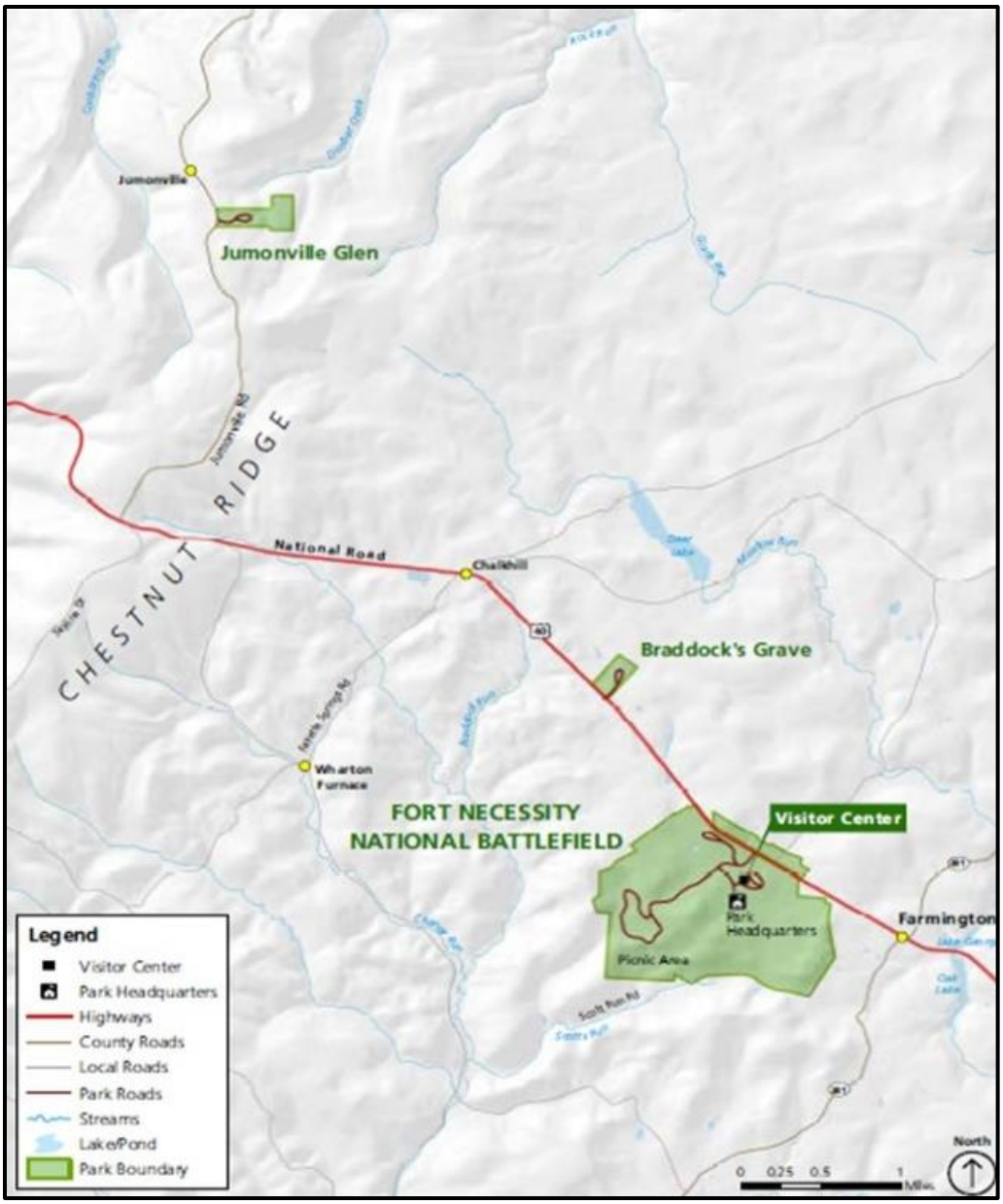


Figure 2.2. Location of all three units of Fort Necessity National Battlefield (NPS, 2013).

2.1.3. Park Mission

"The mission of Fort Necessity National Battlefield is to preserve and maintain both the natural and cultural resources of the Battlefield and to interpret these resources to the visiting public as well as the scientific and scholarly community" (Interpretive Solutions, Inc., 2009).

2.1.4. Visitation Statistics

Monthly visitor statistics from 1990-2016 (Table 2.1) show that the month of July is the busiest month for recreational visits at FONE, averaging more than 31,000 visitors (NPS Stats, 2017). The winter months (November-March) are the slowest visitation periods, averaging less than 7,000 visits per month. Mean annual visitation over the last 27 years is nearly 162,000 people per year.

Table 2.1. Monthly and annual visitation to Fort Necessity National Battlefield from 1990-2016 (NPS Stats, 2017).

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
2016	2,531	3,422	5,181	8,875	30,419	24,262	80,454	56,142	25,514	37,846	10,315	5,060	290,021
2015	4,547	1,316	6,200	9,314	16,345	56,206	60,373	59,607	30,623	19,441	9,510	7,223	280,705
2014	860	1,142	2,595	7,768	22,017	45,539	44,607	43,523	19,510	24,223	5,247	2,515	219,546
2013	2,566	2,313	6,519	11,319	9,749	14,823	47,397	33,742	24,455	8,770	2,080	1,426	165,159
2012	5,682	4,550	12,833	17,891	26,926	27,942	20,135	27,475	15,592	21,661	5,323	1,883	187,893
2011	3,434	2,037	2,647	14,969	19,744	45,780	19,719	21,700	16,761	34,579	7,486	4,623	193,479
2010	2,544	935	5,100	46,800	48,745	49,727	46,739	22,644	18,093	17,029	3,867	2,227	264,450
2009	4,555	3,243	23,796	24,154	35,323	25,127	26,220	11,076	10,020	24,473	7,309	1,975	197,271
2008	1,362	621	13,444	15,204	10,378	12,092	14,001	12,855	20,196	19,668	4,183	3,668	127,672
2007	1,693	1,130	6,333	5,589	53,069	84,637	86,247	17,863	9,278	23,023	37,146	27,288	353,296
2006	619	243	6,795	5,564	31,412	26,473	71,552	24,343	17,265	23,491	7,661	7,693	223,111
2005	33	8	2,188	5,541	13,982	12,431	26,482	15,557	8,458	13,893	2,339	1,092	102,004
2004	351	1,001	2,313	5,622	14,730	13,546	19,717	16,762	9,935	11,590	7,820	2,301	105,688
2003	2,636	3,887	2,364	6,286	8,736	10,511	19,266	10,937	11,743	11,635	5,015	2,941	95,957
2002	1,423	1,954	5,402	4,553	10,705	10,198	16,215	13,194	8,476	10,310	3,949	3,028	89,407
2001	1,769	1,707	2,476	4,840	11,052	11,182	17,149	14,678	6,590	11,469	4,088	2,133	89,133
2000	1,025	1,793	2,439	6,507	12,952	13,517	13,299	8,273	9,681	12,883	8,257	3,234	93,860
1999	933	1,812	3,203	5,554	10,953	10,725	15,723	13,269	8,139	10,478	2,938	1,711	85,438
1998	1,796	2,130	3,722	6,296	12,393	10,339	18,383	16,178	9,646	12,238	3,351	1,325	97,797
1997	1,776	1,932	4,020	5,600	12,461	11,252	15,820	13,371	6,785	11,005	3,100	1,185	88,307
1996	1,814	2,969	3,746	7,629	10,606	12,323	17,962	14,008	9,871	11,990	1,920	1,265	96,103
1995	3,161	4,123	3,934	6,230	13,202	14,831	16,294	16,724	10,682	12,872	5,006	844	107,903
1994	3,629	2,836	4,960	5,429	10,881	11,645	17,101	15,034	9,374	14,294	4,209	2,658	102,050
1993	8,039	4,518	5,427	6,577	17,818	20,988	22,764	21,363	13,295	16,810	3,757	3,945	145,301
1992	4,064	7,978	5,470	10,067	17,903	37,112	25,575	28,345	15,311	11,884	7,162	3,098	173,969
1991	4,246	6,877	9,104	9,341	16,256	38,264	34,927	29,698	19,219	25,165	9,613	6,650	209,360

Table 2.1 (continued). Monthly and annual visitation to Fort Necessity National Battlefield from 1990-2016 (NPS Stats, 2017).

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1990	3,686	7,426	7,366	8,299	17,718	30,928	27,414	25,077	17,673	21,016	9,109	6,392	182,104
Avg.	2,621	2,737	5,910	10,067	19,129	25,274	31,168	22,350	14,155	17,546	6,732	4,051	161,740

2.2. Natural Resources

2.2.1. Weather and Climate

Weather and climate are important determinants for the condition of terrestrial and aquatic ecosystems (Chapin et al., 1996; Schlesinger, 1997; Jacobson et al., 2000; Bonan, 2015). Climatic variability influences ecosystem function and can alter geomorphic and biogeochemical processes (Davey et al., 2006). Because of the importance of climate in driving ecosystem processes, the Eastern Rivers and Mountain Networks (ERMN) has identified it as a high priority in the assessment of park conditions throughout the ERMN. Our report is largely dependent on the 2015 weather data report for the ERMN (Imhoff and Person, 2016), the Weather and Climate Inventory of ERMN by Davey et al. (2006) and data from the Pennsylvania State Climatologist for data from Uniontown (2018).

Temperature reaches an average low of -1^{o} C (30^{o} F) during January and peaks at an average of 23^{o} C (73^{o} F) in July. Approximately 107 cm (42 inches) of precipitation occurs annually, relatively evenly spread across the year (Pennsylvania State Climatologist, 2018). The natural systems of the ERMN are vulnerable to damage by extreme storm events (Marshall and Piekielek, 2005). Tropical storms have impacted these parks on a regular basis (Lugo, 2000; Lugo and Scatena, 1996), primarily due to flooding. During colder months, ice-storms are known to harm forest communities.

2.2.2. Ecoregions and Watersheds

Ecoregions represent areas of general similarity in the type, quality, and quantity of environmental resources. These general regions are intended to provide a spatial framework for ecosystem assessment, research, inventory, monitoring, and management for different resources within similar geographical areas. The approach used to compile these regions is based on the premise that ecological regions can be identified through the analysis of patterns of geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. FONE is found within the Level II Ozark, Ouachita-Appalachian Forests ecoregion, and, more specifically, within the Level III Central Appalachian ecoregion (Omernik, 1995, 2004). Woods et al. (1999) classified the areas surrounding FONE as either “Forested Hill and Mountains” or “Uplands and Valleys of Mixed Land Use” (Figure 2.3). These areas are rugged with substantially varied topography and are a mix of large forest tracts and agriculture. The two regions are distinguished by differences in land use and geology, with the “Forested Hills and Mountains” underlain by sandstone and sedimentary rocks, and the “Uplands and Valleys” underlain by shale and siltstone with some sandstone. In both cases, the predominant forest is the Appalachian Oak forest (Woods et al., 1999).

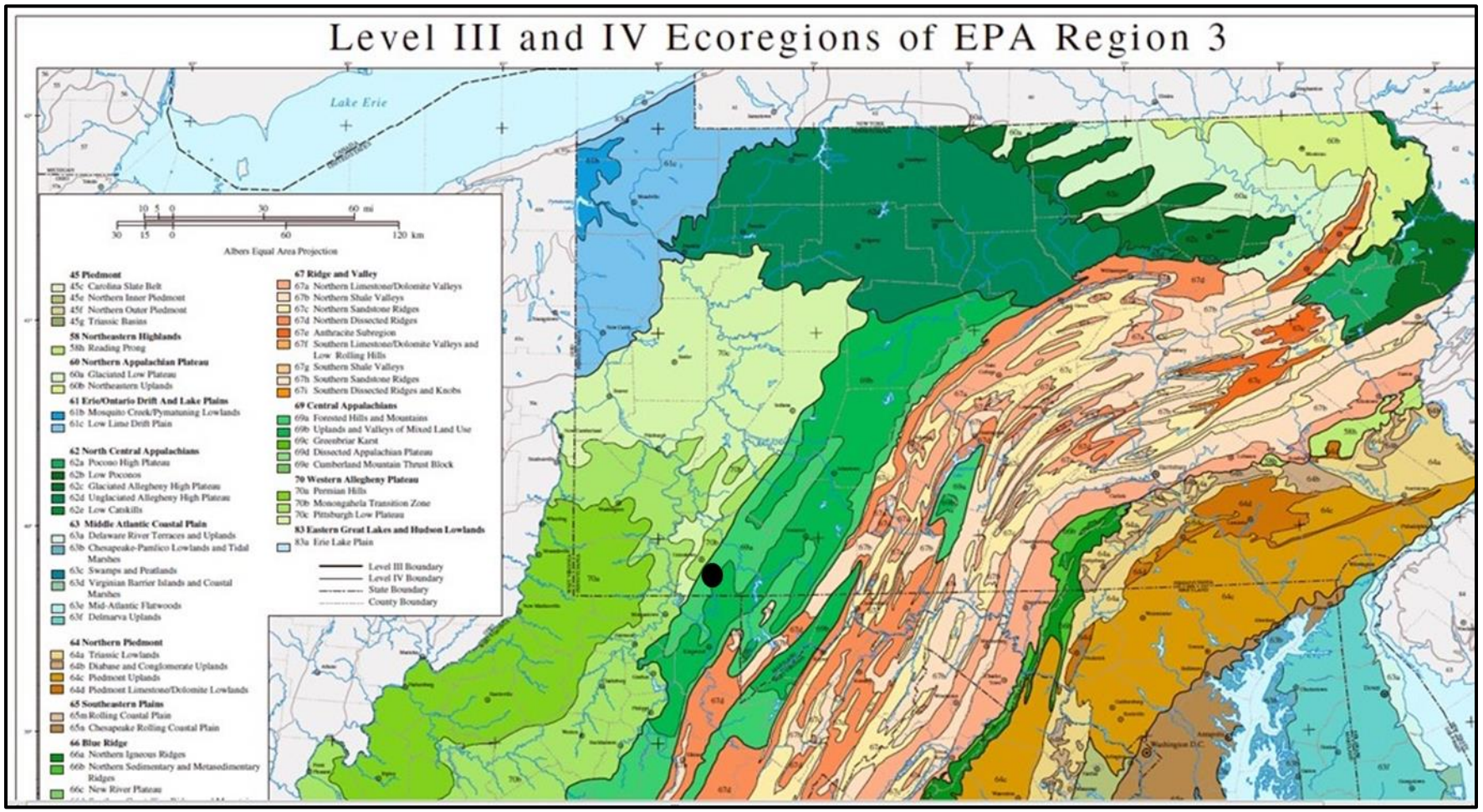


Figure 2.3. Ecoregions for the area surrounding Fort Necessity National Battlefield (FONE); FONE is shown by the dark circle (US EPA, 2017a).

The entirety of Fort Necessity National Battlefield lies in the Monongahela sub-basin, one of the five sub-basins within the larger Ohio River basin (FCCD, 2016). The Monongahela sub-basin itself comprises six lesser sub-basins, three of which, the Lower Monongahela, Youghiogheny, and Cheat sub-basins, cover the three units of FONE (USACE, 2012; BucknellGIS, 2016) (Figure 2.4). Each of these lesser sub-basins is further divided into smaller watersheds (Figure 2.5). The main unit of FONE, which straddles the border between the Cheat and Youghiogheny sub-basins, has portions inside both the Scott's Run and Meadow Run watersheds; Braddock's Grave, within the Cheat sub-basin, is wholly located in the Braddock Run watershed; and Jumonville Glen, largely in the Youghiogheny sub-basin with a small area in the Lower Monongahela sub-basin, is mostly inside the Dunbar Creek watershed with a small area inside the Coolspring Run watershed (BucknellGIS, 2016; EPCAMR, 2014).

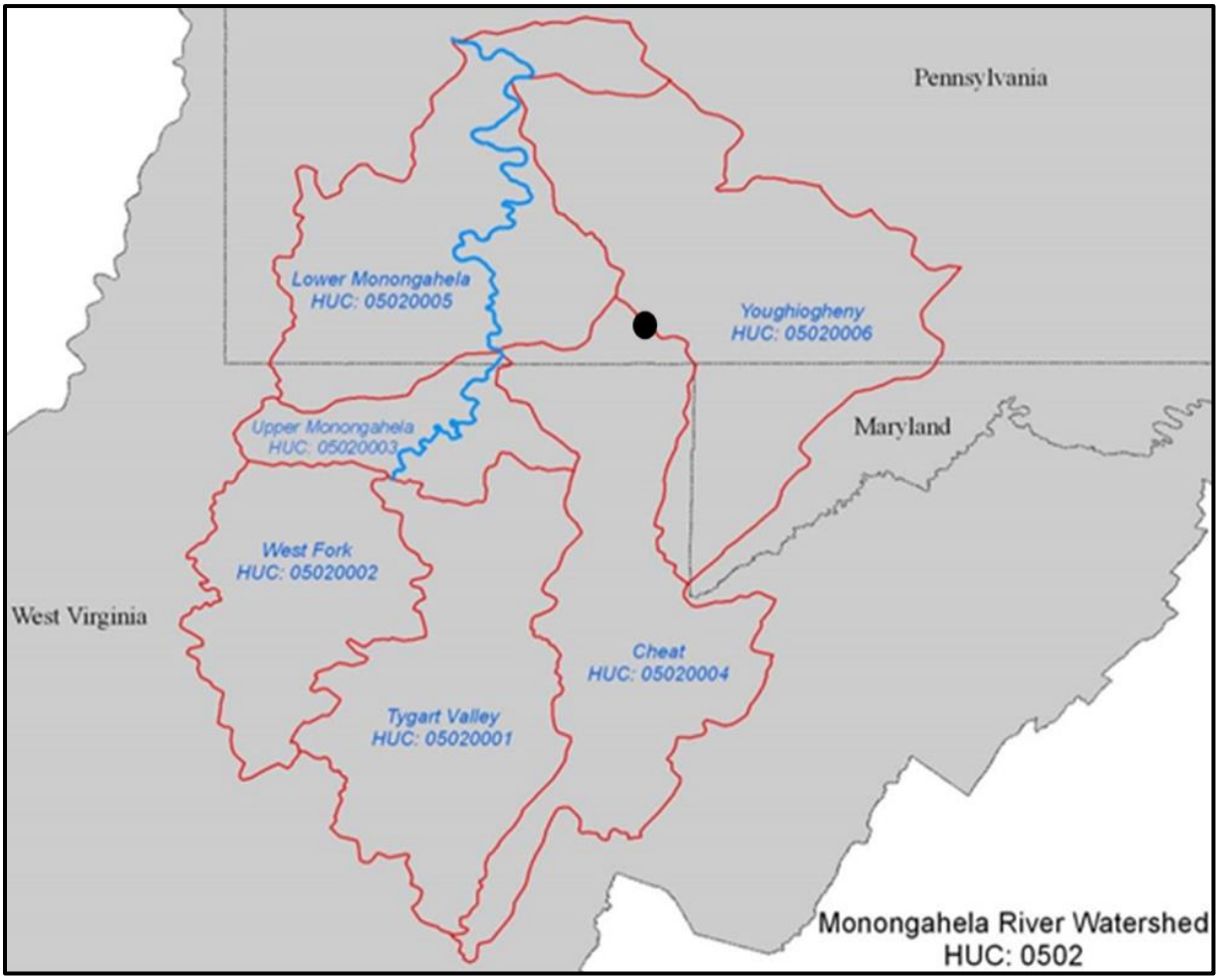


Figure 2.4. Smaller HUC 8 sub-basins in the Monongahela sub-basin; the black dot is the approximate location of Fort Necessity National Battlefield (USACE, 2012).

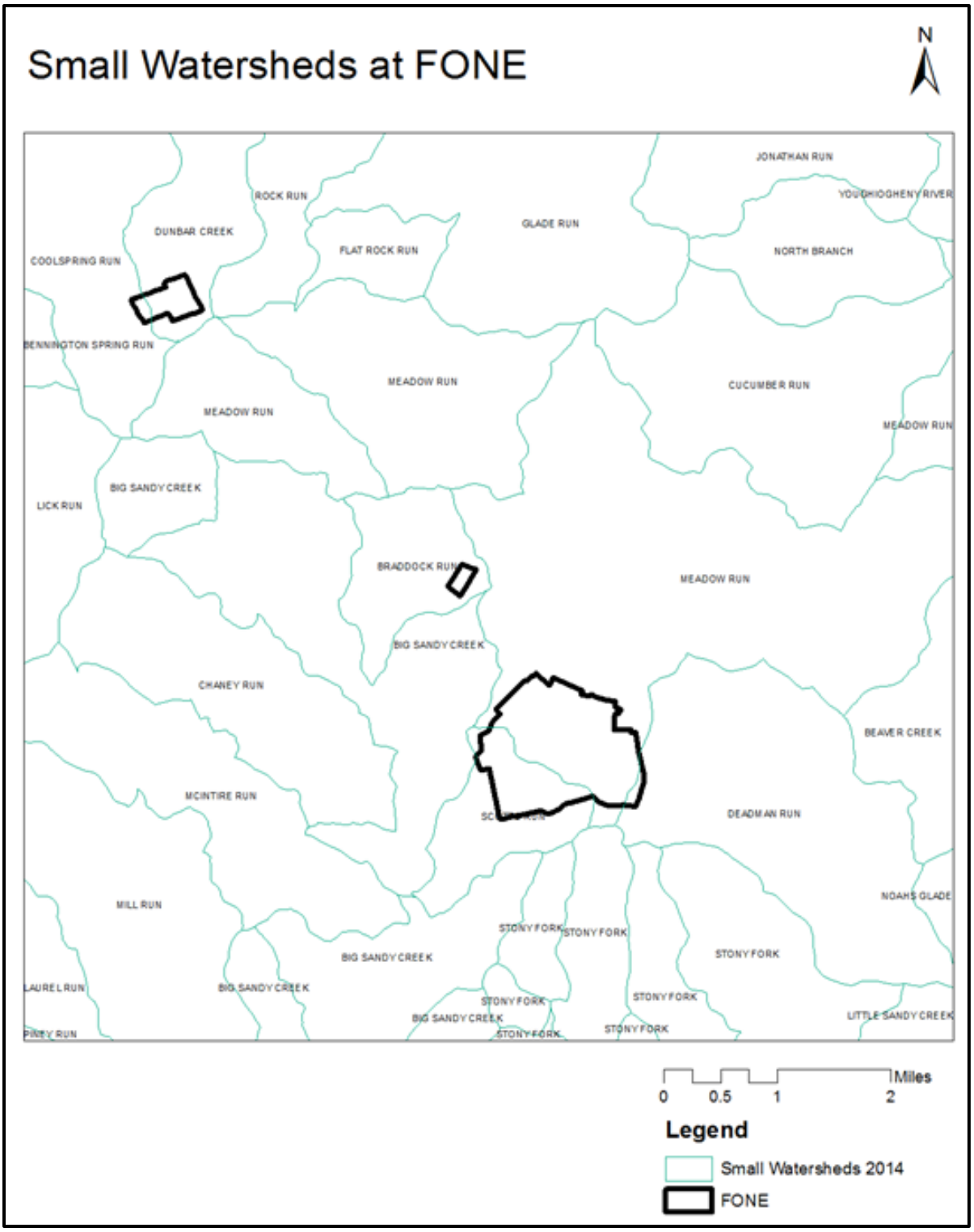


Figure 2.5. Small watersheds at Fort Necessity National Battlefield (EPCAMR, 2014).

2.3. Resource Descriptions

2.3.1. Geology and Topography

The elevation of the park ranges from 640 m (2100 ft.) at the Main Unit down to 557 m (1830 ft.) at the Braddock Grave site and up to 732 m (2400 ft.) at Jumonville Glen as visitors travel northwest through FONE (Thornberry-Ehrlich 2009).

The geology of FONE has left the area with varying topography caused by erosion and downcutting of rivers and streams through horizontal layers, not unusual for the Appalachian Plateaus physiographic province (Figure 2.6). FONE is positioned close to the intersection of two physiographic sub-provinces – the Pittsburgh Low Plateau and the Allegheny Mountains (Sevon, 2000; Thornberry-Ehrlich, 2009). The rough topographic relief of the Allegheny Mountains is located to the west of the park. To the east, several valleys rise sharply towards Chestnut Ridge; this ridge is capped by Mississippi to Devonian sandstone (Thornberry-Ehrlich, 2009). The basic geology of the Fort Necessity region includes conglomerate, sandstone, shale, claystone, limestone, and dolomite (Figure 2.7). Within these formations are fossils and some coal deposits (Thornberry-Ehrlich, 2009).

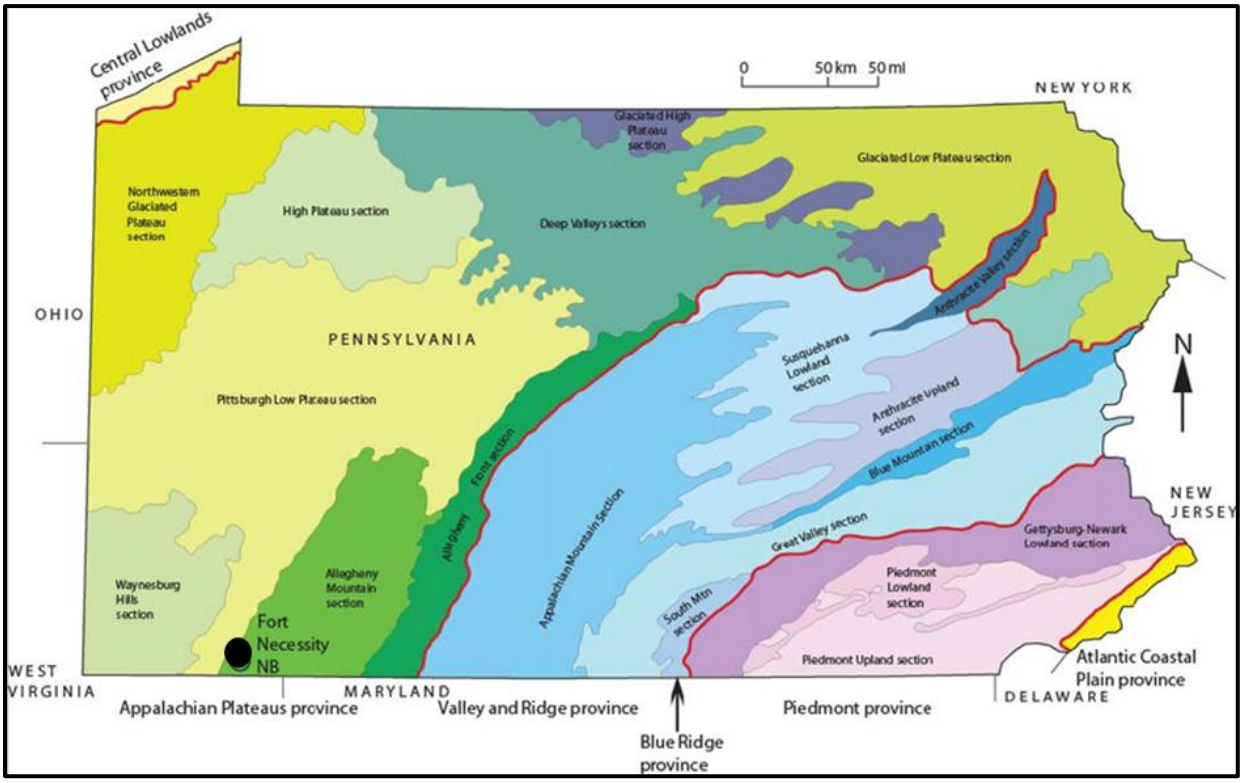


Figure 2.6. Physiographic provinces of Pennsylvania; the black circle shows the approximate location of Fort Necessity National Battlefield (Sevon, 2000).

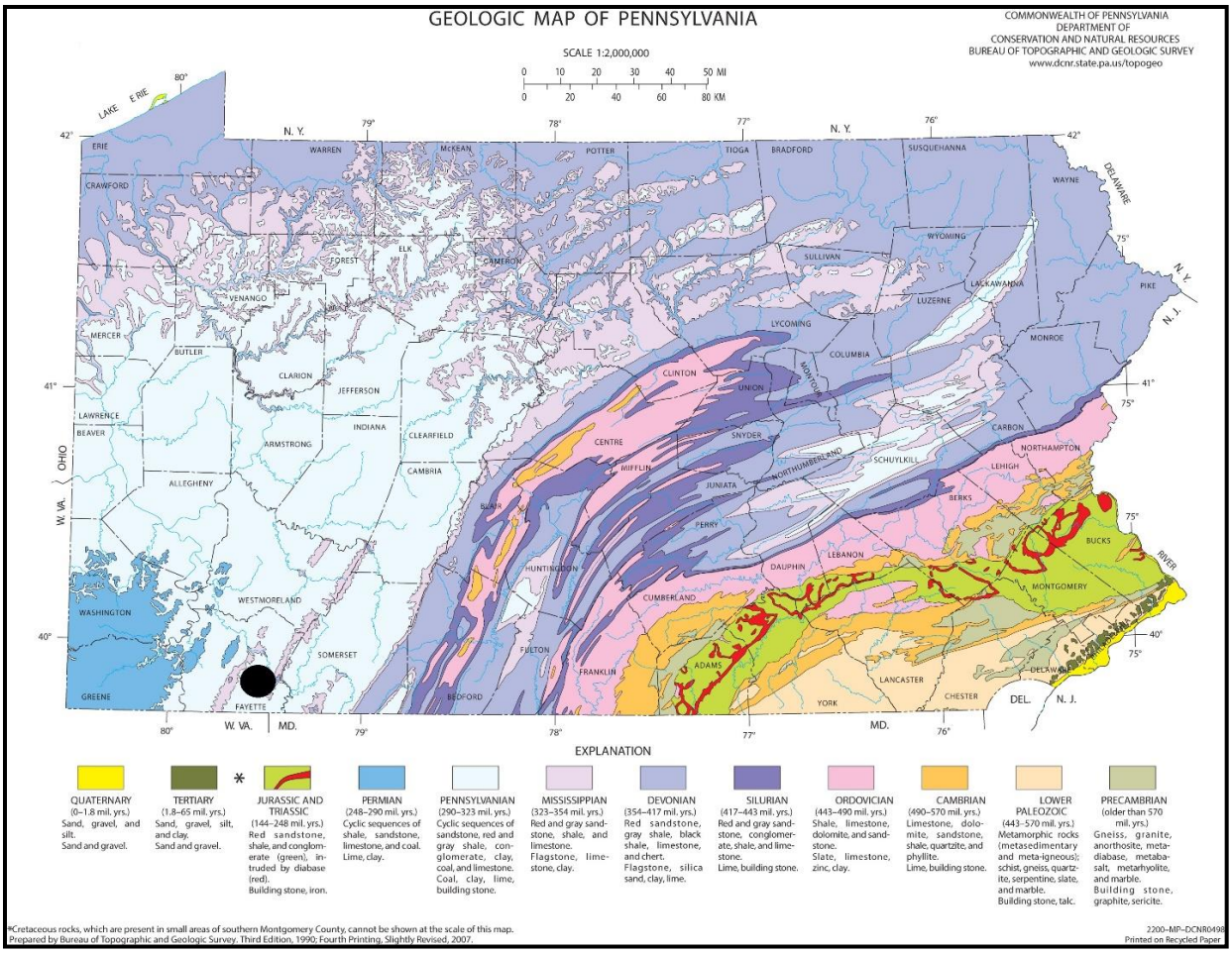


Figure 2.7. Geologic map of Pennsylvania; the black circle shows the approximate location of Fort Necessity National Battlefield (BTGS, 2007).

2.3.2. Soils

The main unit and Braddock's Grave are characterized by silt loams, primarily of the Gilpin-Wharton-Ernest association in low areas and the Dekalb-Hazelton-Cookport association at higher elevations (Figure 2.8). The Gilpin series is well drained and formed on siltstone, sandstone, and shale. The Hazelton series is very well drained and formed from a variety of sandstones. The Cookport loam is deep and moderately well drained, formed primarily from sandstone. Poorly drained sections are typically underlain by Brinkerton, Ernest, and Armagh silt loams. The Brinkerton and Ernest series are moderate to poorly drained and formed on mixed shales, siltstone, and some sandstone. Permeability is moderate in the upper zones but becomes poor deeper down. The Armagh series is deep and poorly drained, with very low permeability. At Jumonville Glen, Hazelton-channery loam predominates (Kopas, 1991; Perles et al., 2006; NRCS, n.d.).

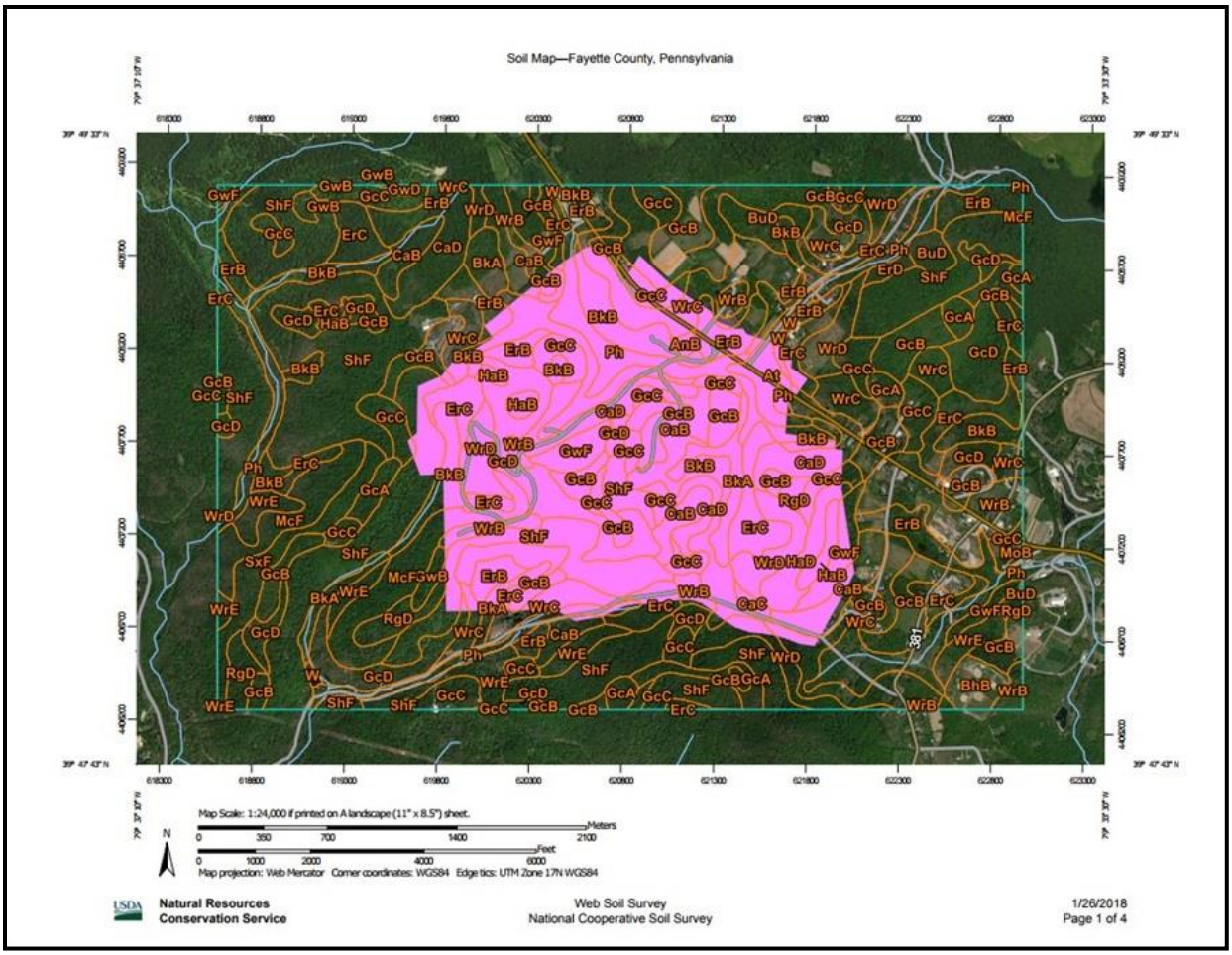


Figure 2.8. Soils map of Fort Necessity National Battlefield's main unit (in pink); the soils shown are primarily Philo loam (Ph) along Great Meadows Run and the Brinkerton (B) and Gilpin (G) series (NCSS, 2017).

2.3.3. Vegetation

FONE is primarily forested with some minor agriculture mixed in (Figures 2.9 and 2.10). According to NPSpecies (n.d.), there are 451 vascular plant species present, or probably present, within FONE's borders. Perles et al. (2006) conducted a vegetation classification and mapping effort at FONE and identified eight vegetation associations: Northern Red Oak-Mixed Hardwood Forest, White Oak-Mixed Hardwood Forest, Sugar Maple-Basswood Forest, Tuliptree Forest, Red Maple-Black Cherry Successional Forest, Conifer Plantation, Successional Old Field, and Wet Meadow. The Sugar Maple-Basswood Forest is confined to a small area in the Jumonville Glen due to the underlying limestone geology and resulting soil conditions. The Successional Old Field and Wet Meadow associations in the main unit of the battlefield provide visitors with the contextual landscape from the times of the historic battles as well as provide habitat for a variety of wildlife (Perles et al., 2006).

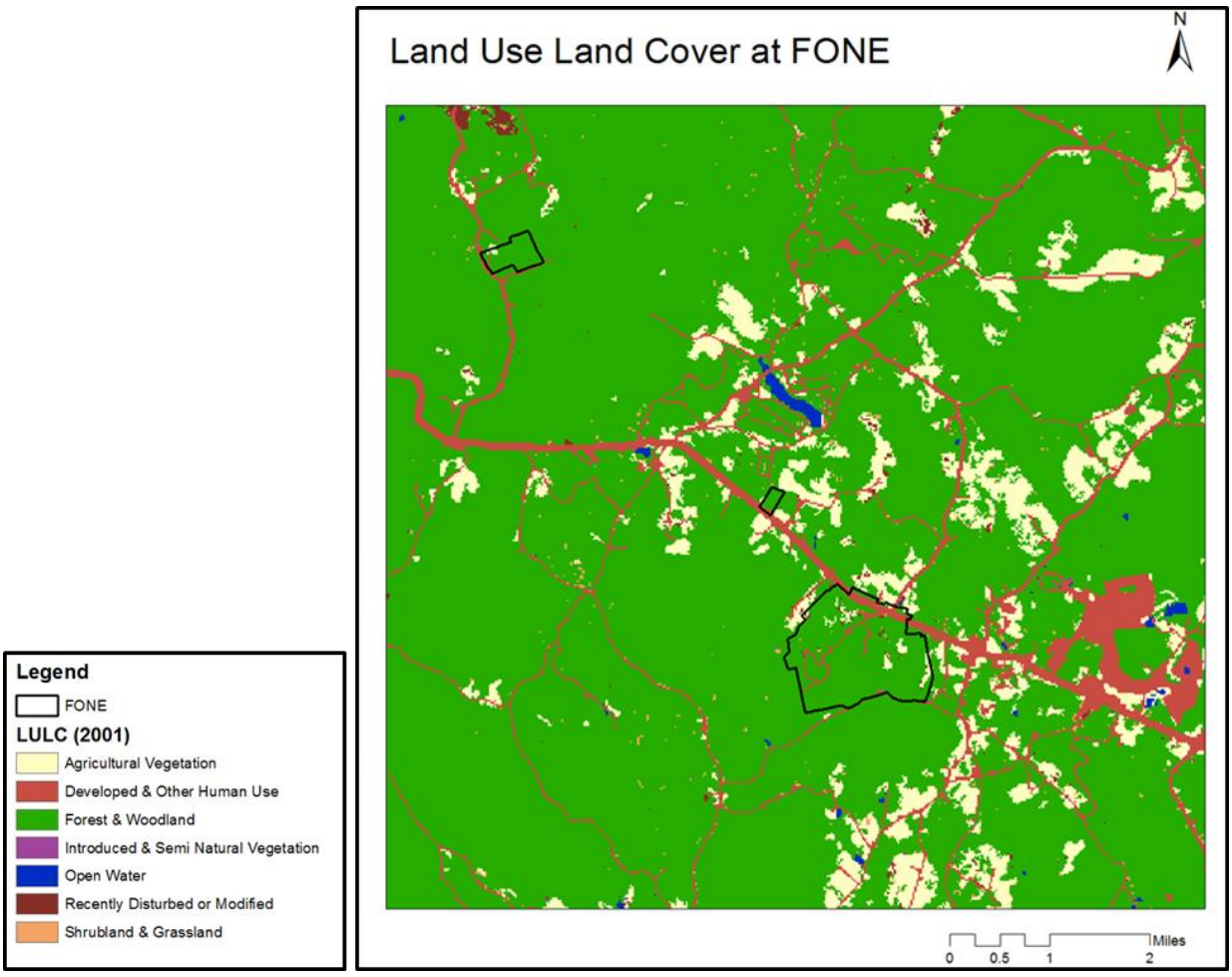


Figure 2.9. Fort Necessity National Battlefield land use-land cover map (PSU, 2000).

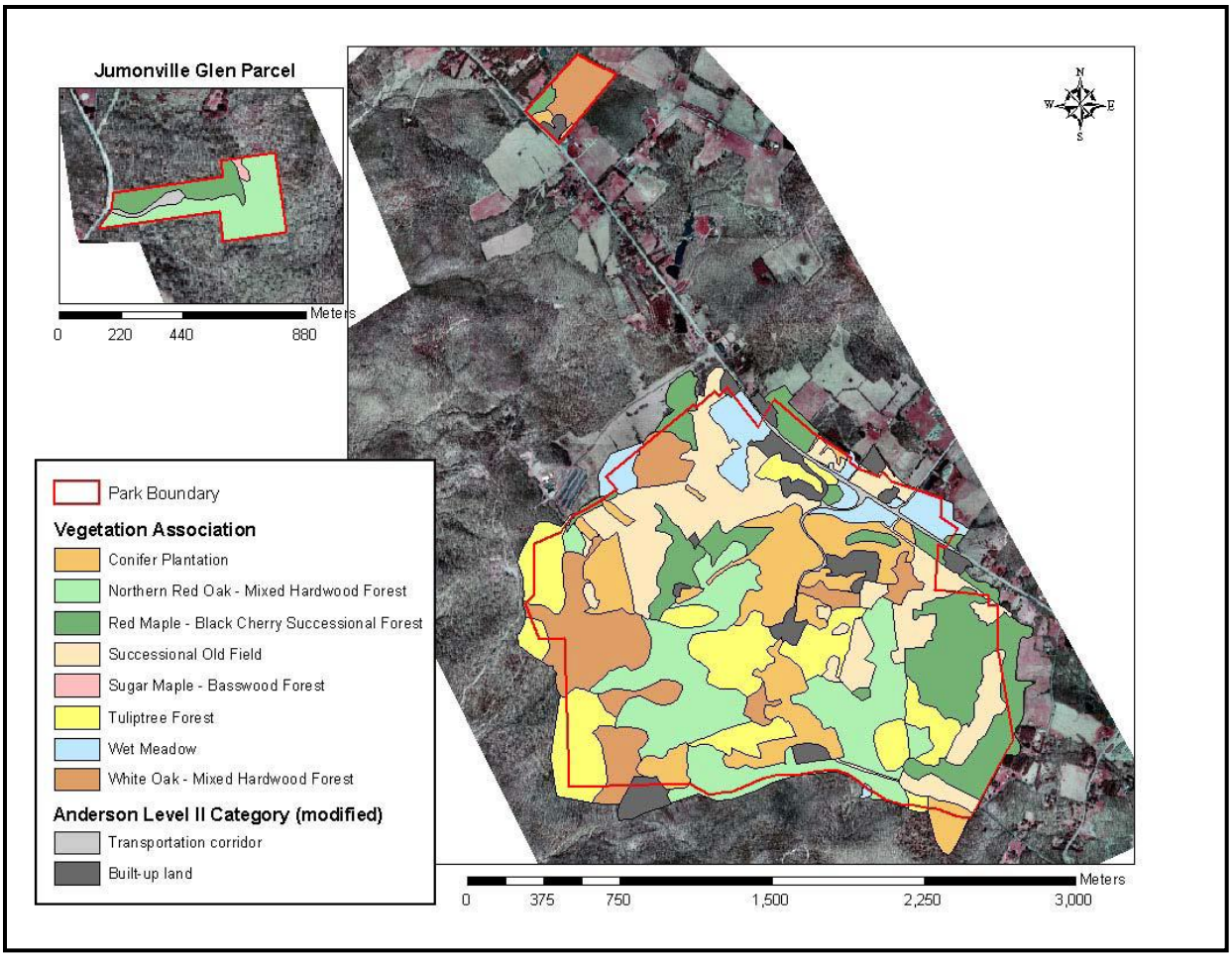


Figure 2.10. Vegetation types at Fort Necessity National Battlefield (Perles et al., 2006).

In Fayette County, the region surrounding FONE, the ridgelines of Laurel Hill and Chestnut Ridge support large contiguous blocks of forest (Wagner and Coxe, 2000). American chestnuts (*Castanea dentata*) dominated these forests until the 1930s, at which time they were decimated by the chestnut blight and replaced by oak throughout eastern North America. The oaks have since suffered from gypsy moth infestations, which were most prevalent in the late 1980s and early 1990s. In addition to disease and pests, significant loss of forest can be attributed to mining, agriculture, development, and several rounds of logging over the past two centuries. Currently, the primary stressors to forest ecosystems in FONE are invasive plants and both native and introduced forest pests and pathogens; through personal communication, FONE personnel described significant damage done by the emerald ash borer (*Agrilus planipennis*). Other threats to forest conditions include unsustainable timber harvesting, browse by white-tailed deer, acidic deposition, changes in regional land use, and climate change (Rentch and Anderson, 2006). The vegetation types found in FONE, as described by Perles et al. (2006) are summarized below.

White Oak-Mixed Hardwood Forest

Found on FONE's upper slopes, White Oak-Mixed Hardwood Forest type is dominated by white oak (*Quercus alba*) and northern red oak (*Quercus rubra*). Other co-dominants include red maple (*Acer*

rubrum), shadbush (*Amelanchier arborea*), shagbark hickory (*Carya ovata*), white ash (*Fraxinus americana*), tuliptree (*Liriodendron tulipifera*), and black cherry (*Prunus serotina*). The understory generally includes American hornbeam (*Carpinus caroliniana*), northern spicebush (*Lindera benzoin*), and cucumber magnolia (*Magnolia acuminata*). The herbaceous layer has deertongue grass (*Dichanthelium clandestinum*), partridgeberry (*Mitchella repens*), and New York fern (*Thelypteris noveboracensis*) among other species, especially ferns. Seeps and springs are quite common in this forest type, as well as occasional vernal pools (Perles et al., 2006). The NatureServe Global Conservation Status of this forest type is G4/G5, indicating that this plant community is relatively secure throughout its range (NatureServe, 2018).

Northern Red Oak-Mixed Hardwood Forest

Northern Red Oak-Mixed Hardwood forests grow lower on the slopes than the white oak dominated forests, where the soil tends to be drier. Besides northern red oak, common species in this forest type include red maple and cucumber magnolia (Perles et al., 2006). Other prevalent species are sugar maple (*Acer saccharum*), pignut hickory (*Carya glabra*), white ash, tulip tree, white oak, chestnut oak (*Quercus montana*), and black oak (*Quercus velutina*). Understory shrubs species include sweet birch (*Betula lenta*), American hornbeam, mountain laurel (*Kalmia latifolia*), cucumber magnolia, hophornbeam (*Ostrya virginiana*), chokecherry (*Prunus virginiana*), and sprouts of American chestnut. The herbaceous layer contains eastern hay-scented fern (*Dennstaedtia punctilobula*), intermediate wood fern (*Dryopteris intermedia*), New York fern, and others. Virginia creeper (*Parthenocissus quinquefolia*) and poison ivy (*Toxicodendron radicans*) are two common vines (Perles et al., 2006). The NatureServe Global Conservation Status of this forest type is G4, indicating that this plant community is relatively secure throughout its range (NatureServe, 2018).

Sugar Maple-Basswood Forest

Jumonville Glen is the only unit of FONE that contains Sugar Maple-Basswood Forest. The bedrock composition in the glen is calcareous, a property that is reflected in the soils and likely has a strong influence on the vegetation growing there. Sugar maple and American basswood (*Tilia americana*) prevail; other co-dominants include cucumber magnolia and northern red oak. Northern spicebush is the most common shrub along with shadbush, sweet birch, American witch hazel (*Hamamelis virginiana*), and black cherry. The herbaceous layer is composed primarily of ferns, and includes spinulose wood fern (*Dryopteris carthusiana*), intermediate wood fern, cinnamon fern (*Osmunda cinnamomea*), and New York fern. Virginia creeper and greenbriar (*Smilax* spp.) are also frequently found (Perles et al., 2006). The NatureServe Global Conservation Status of this forest type is G4, indicating that this plant community is relatively secure throughout its range (NatureServe, 2018).

Tuliptree Forest

This Tuliptree Forest type is found on lower slopes and abandoned agricultural fields. Along with tuliptree, red maple, black cherry, and northern red oak co-dominate the canopy and subcanopy. Other tall shrubs include shadbush, sweet birch, American chestnut, white ash, American elm (*Ulmus americana*), and southern arrowwood (*Viburnum dentatum* var. *lucidum*). Shorter shrubs include Morrow's honeysuckle (*Lonicera morrowii*), multiflora rose (*Rosa multiflora*), and a variety of *Rubus* species. White snakeroot (*Ageratina altissima*), eastern hay-scented fern, Virginia creeper,

spotted ladysthumb (*Polygonum persicaria*), greenbriar, New York fern, and poison ivy make up the understory (Perles et al., 2006). Tuliptree Forests are widespread throughout the Appalachians, leading to a G5 conservation status, indicative of secure conditions (Perles et al., 2006).

Red Maple-Black Cherry Successional Forest

Red Maple-Black Cherry Successional Forests typically occur on former agricultural sites and areas where oak has been harvested. In addition to red maple and black cherry, sugar maple, tuliptree, white oak, and black locust (*Robinia pseudoacacia*) can occasionally be found. The shrub layer consists of shadbush, sweet birch, American hornbeam, northern spicebush, and southern arrowwood, with small stands of hawthorn (*Crataegus* spp.) and apples (*Malus* spp.). The understory is dominated by Japanese barberry (*Berberis thunbergii*), Morrow's honeysuckle, multiflora rose, and several *Rubus* species. The herbaceous layer includes white snakeroot, eastern hay-scented fern, deertongue grass, spotted ladysthumb, and New York fern, among others (Perles et al., 2006). This forest type has been heavily modified by human activity and has therefore been assigned a conservation status of GNA, meaning not applicable (NatureServe, 2018).

Conifer Plantations

There are several conifer plantations within FONE, characterized by Japanese larch (*Larix kaempferi*), Norway spruce (*Picea abies*), red pine (*Pinus resinosa*), and white pine (*Pinus strobus*). In pine plantations, hardwoods such as red maple, American hornbeam, hawthorn, white ash, and black cherry mingle in the canopy and subcanopy with the pines. The canopies of spruce plantations are typically overstocked, creating dense shade in the understory. Common shrubs include invasive species such as Japanese barberry, Morrow's honeysuckle, and multiflora rose, in addition to native species such as American witch hazel, northern spicebush, several *Rubus* species, and southern arrowwood. In drier areas, the herbaceous layer includes white snakeroot, spinulose woodfern, rough bedstraw (*Galium asprellum*), and partridgeberry, while common rush (*Juncus effusus*), whitegrass (*Leersia virginica*), and reed canarygrass (*Phalaris arundinacea*) are more common in wetter areas (Perles et al., 2006). Like Red Maple-Black Cherry Successional Forest, Conifer Plantations are heavily modified by human activity, and therefore have also been assigned a conservation status of GNA (NatureServe, 2018).

Successional Old Field

Successional Old Field habitats are common in FONE in abandoned agricultural areas and fields that are periodically mowed. The community composition of Successional Old Field is variable, ranging from grasslands to woodlots comprising hawthorn, black cherry, and apple. Common shrubs include dogwood (*Cornus* spp.), Morrow's honeysuckle, several *Rubus* species, and southern arrowwood. The herbaceous layer is frequently dominated by a variety of goldenrods including flat-top goldenrod (*Euthamia graminifolia*), early goldenrod (*Solidago juncea*), and wrinkleleaf goldenrod (*Solidago rugosa*). Other species found throughout Successional Old Fields include yarrow (*Achillea millefolium*), Japanese barberry, sedges (*Carex* spp.), crown vetch (*Coronilla varia*), deertongue grass, timothy (*Phleum pretense*), cinquefoil (*Potentilla simplex*), and poison ivy (Perles et al., 2006). Because these sites are primarily old farm fields and the vegetation is often non-native, it has been assigned a conservation status of GNA (NatureServe, 2018).

Wet Meadow

In FONE, Wet Meadow habitat occurs in the Great Meadows in the main unit, where the ground is seasonally wet. Common shrub species are dewberry (*Rubus hispidus*) and white meadowsweet (*Spiraea alba*). Herbaceous species include creeping bentgrass (*Agrostis stolonifera*), tussock sedge (*Carex stricta*), common rush, rice cutgrass (*Leersia oryzoides*), sensitive fern (*Onoclea sensibilis*) green bulrush (*Scirpus atrovirens*), and asters (*Symphotrichum* spp.) (Perles et al., 2006). The NatureServe Global Conservation Status of this vegetation type is G4/G5, indicating that this plant community is relatively secure throughout its range (NatureServe, 2018).

Invasive Species

There are many invasive plant species in FONE. Perles et al. (2010) discovered invasive species in 73% of observed plots. Zimmerman and Yoder (2006) documented 64 non-native species within the park, eighteen of which were considered to be invasive; they also found that successional habitats were more likely to have higher numbers of non-native plants than oak forest types. The three most abundant and widespread invasive species were Japanese barberry, Morrow's honeysuckle, and multiflora rose. Morrow's honeysuckle is a major concern, as it produces prolific seed whose fruit is widely eaten and dispersed by wildlife (Perles et al., 2006). As a result, it generally outcompetes native plants in the region and grows in high density populations (176,000 stems/ha) (Love and Anderson, 2009). Morrow's honeysuckle is particularly a problem in the Great Meadows, thereby threatening a significant cultural resource in the park. The Great Meadows also contain other problematic species such as Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), crown vetch, teasel (*Dipsacus fullonum*), and multiflora rose (Perles et al., 2006). In the forests, Japanese stiltgrass (*Microstegium vimineum*) poses a considerable threat; Perles et al. (2006) recommended mechanical control as well as herbicide to keep it in check. Zimmerman and Yoder (2006) also suggested the removal of non-native conifers such as blue spruce (*Picea pungens*) to improve FONE's forests. The recent Forest Health Assessment conducted by the US Forest Service (Sykes and Hill, 2017) provides additional species-specific management plans for six of the park's most abundant invasive plant species.

2.3.4. Hydrology

There are nine streams and eight ponds located within FONE (Tzilkowski and Sheeder, 2006) (Figure 2.11). The largest stream is Great Meadow Run, a 3rd order stream that empties into the Youghiogheny River and, eventually, the Ohio River system in Pittsburgh (Thornberry-Ehrlich, 2009). There are several, unnamed, intermittent streams; three of these drain Scott's Run to the Monongahela River and another drains Dunbar Creek to the Youghiogheny River. Braddock's Run is notable as a headwater tributary of the Monongahela River.

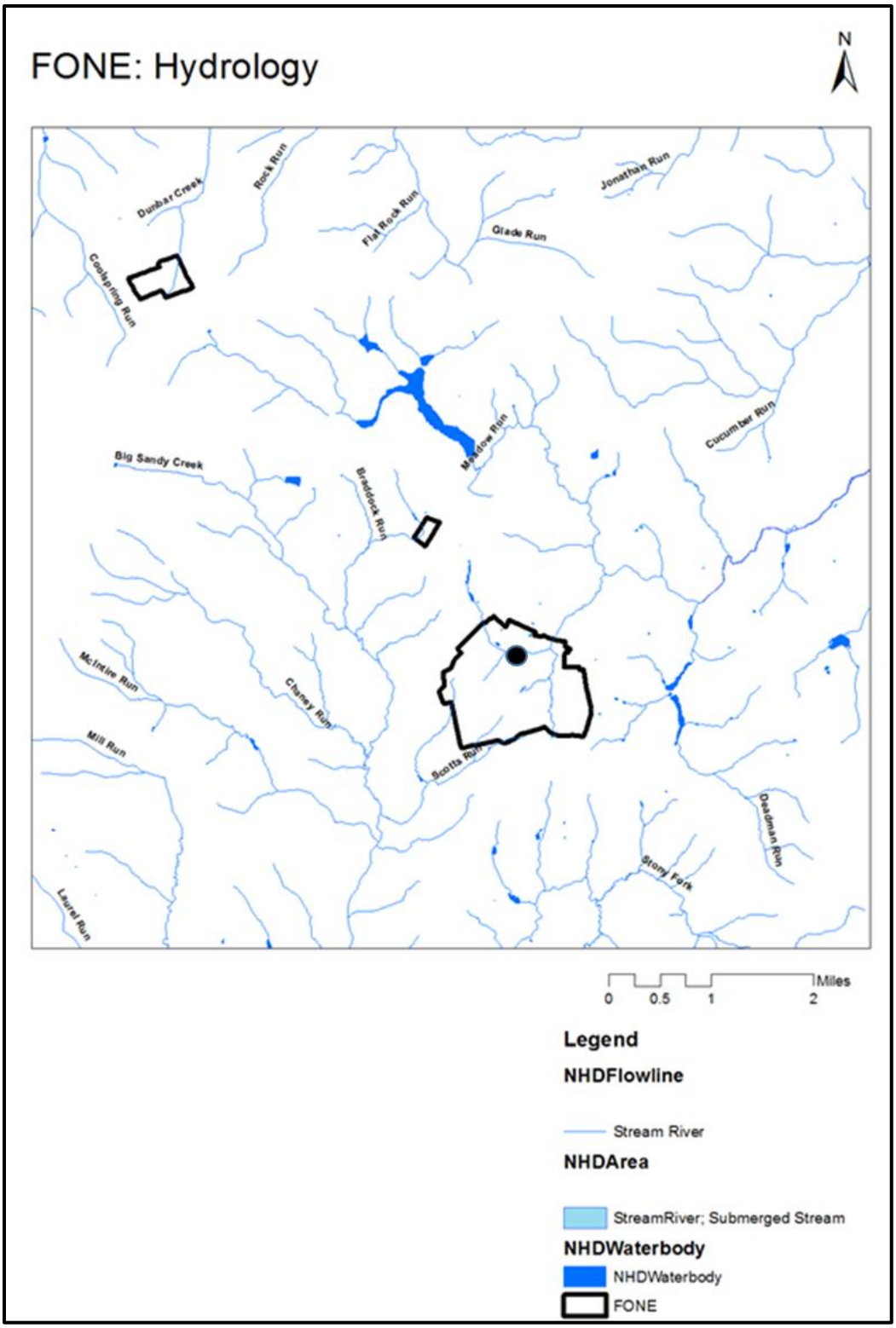


Figure 2.11. Surface water hydrology of Fort Necessity National Battlefield; black circle shows the approximate location of Great Meadows Run (USGS, 2004).

FONE's wetland, the Great Meadows, comprises approximately 50 acres of open area, including roughly 2 acres of breeding habitat for the American Woodcock (*Scolopax minor*). However, it has been modified in many ways over the years, necessitating the development of a restoration plan (Ranson, 2006; NPS, 2017). Several studies indicate that there used to be extensive wetlands adjacent to the fort, as well as along both sides of Great Meadows Run (Lewis, 1816; Blackford, 1931; Harrington, 1957; Ranson 2006). Since, the area has been ditched, drained, and filled, leaving the Great Meadow substantially changed compared to original conditions. The site has also been subjected to pasturing and the introduction of non-native vegetation such as Morrow's honeysuckle and multiflora rose. Over the past decade, there have been several projects aimed at the removal of these invasive species, as well as Japanese barberry, burning bush (*Euonymus alatus*), privet (*Ligustrum* spp.), autumn olive (*Elaeagnus umbellata*), teasel, and crown vetch (NPS, 2017). The tree line that historically bounded the area has also been altered over time (Foster and Smith 2016).

2.3.5. Wildlife

According to NPSpecies (n.d. and no longer updated by the NPS), there are 4 species of fish, 32 species of mammals, 22 species of amphibians, 14 species of reptiles, and 145 species of birds present, or probably present, in FONE (Appendices A, B, C, and D). Tzilkowski and Sheeder (2006) list 7 species of fish present. One bird species in the park, the yellow-bellied flycatcher (*Empidonax flaviventris*), is listed by the state government as endangered in Pennsylvania (NPSpecies, n.d.).

2.3.6. Resource Issues Overview

Fayette County is not experiencing rapid growth; in fact, the county's 2016 population of 132,733 people is roughly a 10% decrease compared to the 2000 population of 148,644 people (City-Data.com, 2018). Additionally, the area is rural and distant from development pressures in urban centers such as Pittsburgh. Nonetheless, there are issues that have affected the region in the past and continue to influence the park today.

The area surrounding Fort Necessity has a long history of mining coal, limestone, iron, and other minerals (Thornberry-Ehrlich, 2009). In fact, in 1992, Bogovich and Member found that more than 15% of all abandoned coal mines in the state at the time were in southwestern Pennsylvania. Today, out of over 9,000 mines in the state, approximately 70 mines are within a 16 km (10 mile) radius of FONE's main unit (PA DEP 2018a, PA DEP, 2018b). Though there are no active or abandoned mines within FONE's boundaries, acid mine drainage affects an unnamed tributary of Dunbar Creek and could pose a threat to groundwater resources (Kimmel and Clark, 2000).

Numerous other anthropogenic activities have impacted natural resources inside FONE's borders. Humans have ditched streams, logged forests, tilled fields and introduced grazing livestock, built roads and parking lots, and removed brush from the Great Meadows (Whitehead and Ford, 2016). While some artifacts of human influence will remain, such as the parking lots that facilitate visitation, other consequences are being addressed, as evidenced by the restoration underway in the Great Meadows.

Based on discussions with NPS personnel, the following topics are the principal issues of concern for FONE.

- Air quality – FONE sits in a region of Pennsylvania that used to be subjected to high levels of acid deposition, though the problem has been greatly alleviated in recent years (Figure 2.12). However, Fayette County still suffers from higher than recommended ozone levels (Figure 2.13). Furthermore, the Appalachian Mountains experience hazy summer conditions that have intensified over the years, and visibility is, therefore, a concern (Figure 2.14).
- Water chemistry – Surface water chemistry is also altered by acid deposition, thereby becoming a concern for FONE. Acid mine drainage already affects one stream within the park, the aforementioned unnamed tributary to Dunbar Creek, in Jumonville Glen (Kimmel and Clark, 2000).
- Biological integrity – Invasive plant species are prevalent throughout the park, posing a threat to ecosystem function. Additionally, the Great Meadows wetland area has been physically altered in past decades and is in the process of being restored.
- Soundscape and lightscape – The NPS has become increasingly concerned that noise and light levels in their parks have risen to a level that detracts from the visitor experience and visitation rates.
- Human use – To accommodate increasing visitation, NPS personnel will be considering additional facilities and parking areas in FONE, which may then affect the park' natural resources.

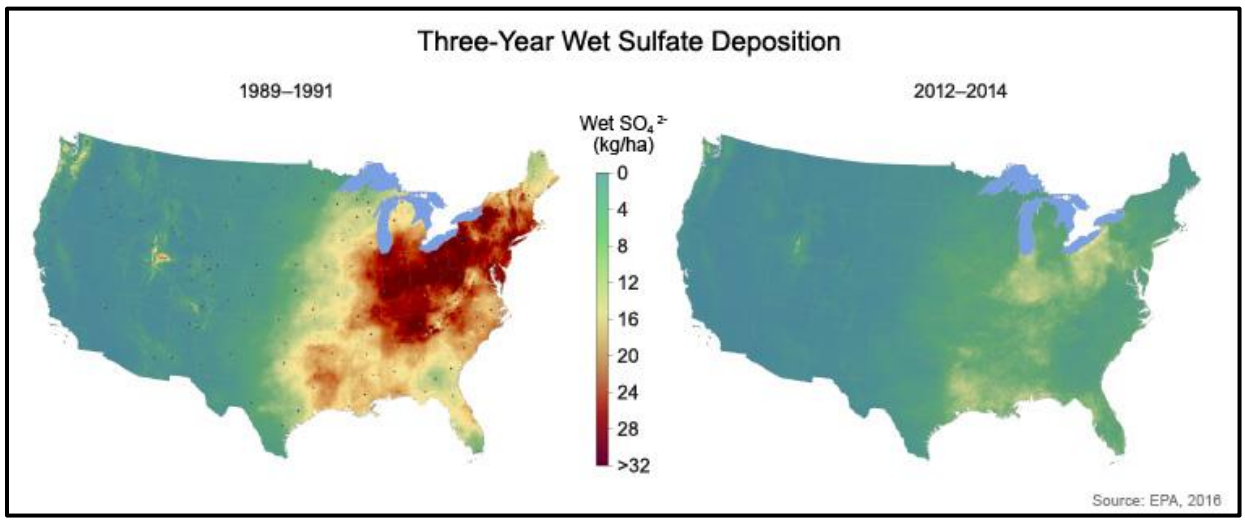


Figure 2.12. Historic and recent acid precipitation patterns in the US as reflected by sulfate deposition (US EPA, 2017b).

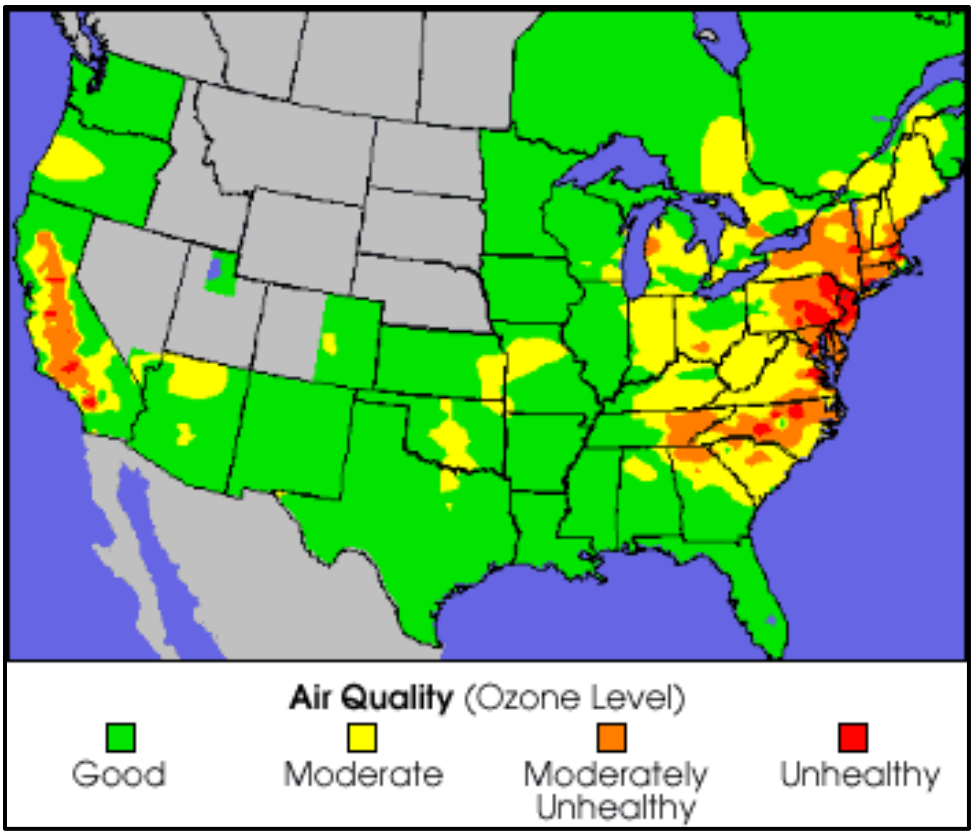


Figure 2.13. Ozone levels across the U.S. (Allen, 2002).

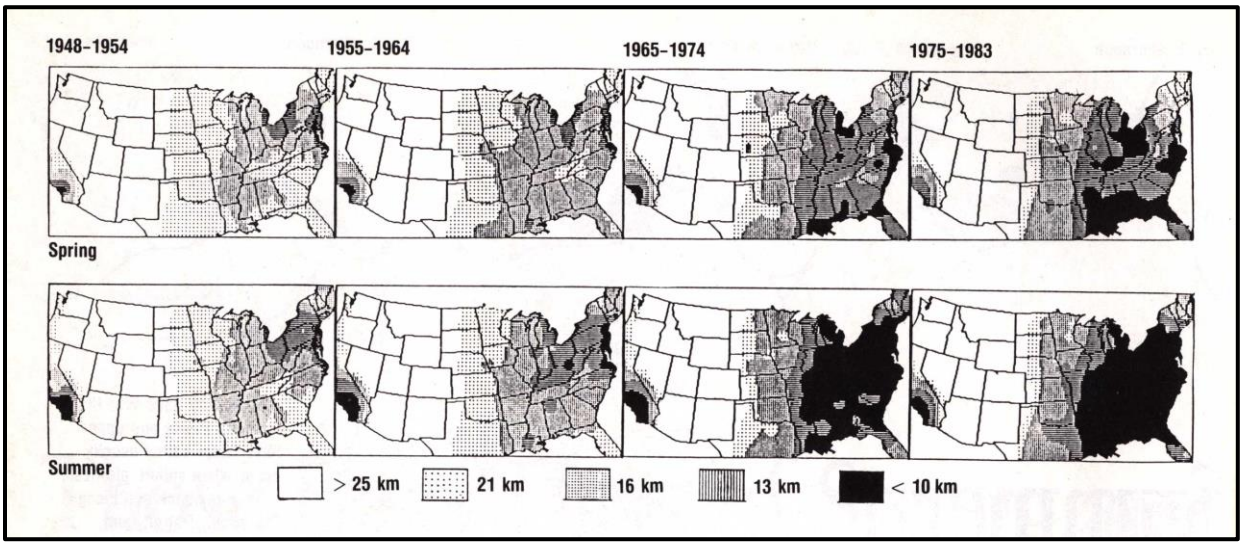


Figure 2.14. Average visibility due to haze across the U.S. from 1948-1983 (Corfidi, 2013).

2.3.7. Resource Stewardship

Management Directives and Planning Guidance

The units that form FONE are cultural landscapes within which important natural resources exist; as stated in the park's General Management Plan, the environment is critical to the interpretation of

FONE's cultural resources (NPS, 1990). To protect the historic significance of the park, the NPS developed a Foundation Document (FD) that helps guide park actions (NPS, 2013). The FD describes FONE's purpose and significance, values, interpretive themes, and fundamental resources. The FD also describes special mandates, defines administrative commitments, and provides an assessment of planning and data needs. As an example of the comprehensive nature of the FD, it notes the Great Meadows for both its historic importance and for data needs relative to hydrology and archaeology (NPS, 2013).

Status of the Supporting Science

Our approach to a natural resources assessment for FONE was based on indicators developed by the Eastern Rivers and Mountains Network (ERMN) as part of the Inventory and Monitoring Vital Signs program. The Vital Signs program provides long-term monitoring protocols for important natural resources in more than 270 parks, nine of which, including FONE, are in the ERMN (Fancy et al., 2009). These vital signs are generally intended to be information-rich indicators of the overall health of park ecosystems. Table 2.2 lists the high priority vital signs defined by the ERMN (Marshall and Piekielek, 2007).

Table 2.2. ERMN Vital Signs (Marshall and Peikielek, 2007).

Level 1 Category	Level 2 Category	Level 3 Category	ERMN Vital Sign Name
Air and climate	Air quality	Wet deposition	Air quality
	Weather and climate	Weather and climate	Weather and climate
Geology and soils	Soil quality	Soil function and dynamics	Soil function and dynamics
Water	Hydrology	Surface water dynamics	Surface water hydrology
	Water quality	Water chemistry – core	Water chemistry – core
	Water quality	Water chemistry – expanded	Water chemistry – expanded
	Water quality	Aquatic macroinvertebrates	Aquatic macroinvertebrates
Biological integrity	Invasive species	Invasive/exotic plants and animals	Invasive/exotic plants, animals, and diseases – Status and trends
	Invasive species	Invasive/exotic plants and animals	Invasive/exotic plants, animals, and diseases – Early detection
	Focal species or communities	Shrubland, forest, and woodland communities	Forest, woodland, shrubland, and riparian plant communities
	Focal species or communities	Riparian communities	Rare, riparian plant communities
	Focal species or communities	Birds – riparian communities	Louisiana waterthrush
Landscapes (ecosystem pattern and process)	Landscape dynamics	Land cover and use	Landscape dynamics
	Landscape dynamics	Landscape pattern	Landscape dynamics

3. Study Scoping and Design

3.1. Preliminary Scoping

Preliminary scoping efforts for the NRCA of FONE began in 2014 with a meeting of FONE's park staff and NPS coordinators for discussion and a tour of the park's grounds. Within a few months, there was a substantial personnel change at The Pennsylvania State University (PSU), forcing a long delay before the project resumed. Historical reports, photographs, geospatial data, and data from current sampling efforts were gathered with the help of FONE staff and the NPS Eastern Rivers and Mountains Network (ERMN) team. Additionally, PSU collected data from other federal and state agency databases such as the USGS and PGC. Through conference calls and e-mail exchanges, the NPS staff continued to assist the authors of this report by providing information on environmental issues in FONE and the surrounding area, current data collection efforts and protocols for the park, and vital signs metric development. These communications were essential to understanding the natural resources in FONE, as the NPS staff invests significant time inventorying, monitoring, and interpreting data for the region and the park.

3.2. Study Design

3.2.1. Indicator Framework and Focal Study Resources

FONE is a small, historic park, and information regarding the natural resources there and in the surrounding vicinity was not abundant for most metrics. The framework used for FONE's assessment is organized by broad ecosystem resources as designed for the ERMN's vital signs approach. Since the vital signs program is a framework for long-term monitoring of park resources, using these indicators in this report allows the NPS to utilize NRCA results in future studies. However, the compiled data for FONE's natural resources were limited in terms of quantitative measures or spatial and temporal sample sizes. Thus, the availability of historic and present data collected for FONE helped determine which vital sign metrics could be included in this assessment, as well as establish the framework for the condition categories used. After consultation with NPS personnel, we settled on a modified list of the ERMN vital signs with additional indicators (Table 3.1)

Table 3.1. List of the indicators selected for Fort Necessity National Battlefield after consulting with NPS personnel.

Level 1	Level 2	Level 3	Vital Sign	Period of data for condition assessment and/or trend analysis	Main reference/source
Air & Climate	Air Quality	Weather & Climate	Weather & Climate	2007-20015	ERMN reports
	Air Quality	Ozone	Ozone	2011-2015	NPS Air Resources Division
	Air Quality	Wet & Dry Deposition	Atmospheric Deposition & Stress	1990-2015	NPS Air Resources Division; NADP database; Sullivan et al. (2001a,b)
	Air Quality	Wet & Dry Deposition	Visibility	2011-2015	NPS Air Resources Division
Geology & Soils	Soil Quality	Soil Function & Dynamics	Forest Soil Condition	2006-2014	ERMN Forest dynamics reports
Water	Water Chemistry	Water Chemistry	Water Chemistry	1926-2000	NPS WRD report
	Wetlands	Wetlands	Wetlands	2013	FONE, Sharpe reports
Biological Integrity	Invasive Species	Invasive/Exotic Plants	Invasive/Exotic Plants-Early detection	2008-2015	ERMN monitoring reports
	Invasive Species	Invasive/Exotic Animals	Invasive/Exotic Animals-Early detection	2008-2015	ERMN monitoring reports
	Invasive Species	Fishes	Fishes	2006, 2017	Faulk and Weber 2017; NPSpecies, n.d.; Tzilkowski and Sheeder, 2006;
	Invasive Species	Birds	Streamside Birds	2007-2012	ERMN reports
	Invasive Species	Stream benthic macroinvertebrates	Stream benthic macroinvertebrates	2009-2013	ERMN reports
Human Use	Visitor & Recreational Use	Visitor Usage	Visitor Usage	1935-2015 (visitation); 1992-2016 (traffic counts)	NPS STATS
Landscapes	Landscape Dynamics	Landscape Dynamics	Landscapes	Historical data collection and projected models for landscape variables from 1950-2030.	NPScape historical and projected data; NLCD data 1992-2006; US Census data (2010)

Table 3.1 (continued). List of the indicators selected for Fort Necessity National Battlefield after consulting with NPS personnel.

Level 1	Level 2	Level 3	Vital Sign	Period of data for condition assessment and/or trend analysis	Main reference/source
Landscapes (continued)	Landscape Dynamics	Landscape Dynamics	Soundscape	Geospatial sound model	NPS Natural Sounds Program
	Landscape Dynamics	Landscape Dynamics	Lightscape	Anthropogenic Light Ratio with US Census data (2010)	NPS Night Sky Program

3.2.2. Reporting Areas

Fort Necessity National Battlefield is a small park of about 364 ha (900 ac) spread across multiple units. Limited data availability made individual, unit-level assessments difficult, and therefore results will be presented as a broad evaluation of the park as a whole.

3.2.3. General Approach and Methods

Discussion of the background, approach, and rationale for all assessments is provided in Chapter 4. The description of each metric begins with a brief explanation of its relevance to human and environmental health, both in general and at FONE in particular. Then, we review the methods followed and the data used to evaluate the resource, including the reference conditions or threshold values utilized. This is followed by condition, trend, and confidence assessments with justification. The reference conditions and threshold values were based on federal or state agency regulations and criteria, peer-reviewed research, estimates of biotic integrity, established ERMN vital signs condition categories, NPS Air Resource Division categories, or NPS Natural Sounds and Night Sky Division categories. In cases where data were lacking or qualitative in nature, best professional judgment was used to assign a condition category.

Each resource was given one of the following condition category ratings: *resource is in good condition*, *resource warrants moderate concern*, or *resource warrants significant concern*. The temporal trend of the resource's condition was then assigned one of the following trend category ratings: *condition is improving*, *condition is deteriorating*, or *condition is unchanging*. Finally, confidence in the condition and trend assessments were identified as *high*, *medium*, *low*, or *not applicable* based on available data (Tables 3.2 and 3.3). *High* confidence ratings required extensive spatial and temporal quantitative data; *medium* ratings indicated data were from studies that were quantitative and/or qualitative in nature but not usually spatially explicit; *low* ratings indicated data were from limited studies that collected generally qualitative data; and *not applicable* indicated no reliable assessment or trend analysis was possible given the data available.

Table 3.2. Indicator symbols used to demonstrate condition, trend, and confidence in the assessment.

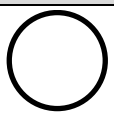
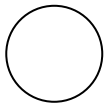
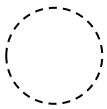
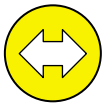
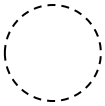
Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table 3.3. Example indicator symbols and descriptions of how to interpret them.

Symbol Example	Description of Symbol
	Resource is in good condition; condition is improving; high confidence in the assessment.
	Resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Resource warrants significant concern; condition is deteriorating; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

4. Natural Resource Conditions

4.1. Air Quality

Very little air pollution in national parks is generated within NPS borders; most air pollution comes from sources external to park boundaries. The nearest likely source of air pollution to FONE is Pittsburgh, Pennsylvania, located approximately 97 km (60 mi) northeast of the park. Although air quality in Pittsburgh has drastically improved over the past few decades, pollutants originating there could still negatively affect FONE. Air quality parameters for FONE were collected from nearby stations and in conjunction with the NPS Air Resource Division (ARD), since the park itself does not have air quality monitoring capabilities. Three air quality categories have been individually assessed for FONE based on the approach developed by ARD: ozone; visibility; and atmospheric deposition of sulfur (S) and nitrogen (N) (ARD, 2017).

The ARD uses air quality monitoring data from national, state, and local stations averaged over five-year periods to generate interpolations to derive estimates of air quality parameters at all NPS units. Interpolation condition categories are then assigned to each air quality parameter. The creation of these categories is based on regulatory standards and peer-reviewed literature that investigated the effects of air quality parameters on ecological systems. However, temporal delays of the impact of air pollution on the environment exist and may cause us to underestimate the effects of these pollutants on the environment. Lovett et al. (2009) recommended that air quality impacts known to occur in the Northeast region be considered in any long-term environmental conservation strategy.

When a park sits within a region deemed by the EPA to have even one non-attainment air quality, the overall air quality for the park is regarded to be of significant concern (ARD, 2015). For FONE, ozone in the region does not meet EPA standards, and thus the overall air quality rating for the park is *resource warrants significant concern*. Individual measures are described below.

4.1.1. Ozone Status

Relevance

Ground-level ozone is a product of reactions between sunlight and volatile organic compounds (VOCs) generated primarily from vehicle exhaust and industrial emissions (US EPA, 2014). It is well-documented that inhaling ozone has negative consequences on respiratory and cardiovascular systems, especially for children, the elderly, and people with asthma (US EPA, 2014). Moreover, new research shows that the effects of ozone at concentrations below the federal standards may still lead to negative human health outcomes and harm to ecosystems (US EPA, 2009). Due to its detrimental effects, ozone is measured extensively throughout the northeastern US. To protect public health, the National Ambient Air Quality Standards (NAAQS) mandates that

> *"…the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm"* (US EPA, 2014).

Long-term exposure to ground-level ozone can also affect vegetative health. When ozone enters a plant's stomata during respiration, it oxidizes the surrounding tissues, causing damage and reducing

likelihood of plant survival; in trees, such foliar injury from ozone significantly slows growth (ARD n.d.; ARD, 2018).

Methods and Data

Current National Ambient Air Quality Standard (NAAQS) ozone guidelines for human health set by the US EPA (2014) are used as thresholds by ARD to assign condition categories, a practice followed in this report (Taylor, 2017) (Table 4.1). The current ozone level for a park in relation to public health is based on the estimated 5-year average of the 4th-highest daily maximum 8-hour average ozone concentration (Taylor, 2017). The data used in this NRCA to evaluate condition and trend for ozone levels as they influence human well-being was collected by ARD; the most recent interpolated ozone data was collected from 2011-2015.

Table 4.1. Benchmark ozone levels* for human health (Taylor, 2017).

Status Category	Ozone Concentration (ppb)
Warrants significant concern	≥ 76
Warrants moderate concern	61-75
Resource is in good condition	≤ 60

*Ozone level is estimated by 5-year average of annual 4th-highest daily maximum 8-hour mean concentration.

The benchmarks used here for ozone concentrations as they pertain to vegetative health are also ARD guidelines based on US EPA (2014) standards (Table 4.2). For plants, ozone levels are estimated by the W126 metric, which is a weighted, cumulative sum of all ozone present during daylight hours over the course of three months, with higher concentrations counted more heavily; the highest 3-month period that occurs during the growing season is reported in parts per million-hour (ppm-hr).

Table 4.2. Benchmark ozone levels for plant health (Taylor, 2017).

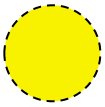
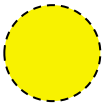
Status Category	W126* (ppm-hrs)
Warrants Significant Concern	> 13
Warrants Moderate Concern	7-13
Resource is in good condition	< 7

*W126 value is an estimated or measured 5-year average of the maximum 3-month 12-hour W126.

Condition Assessment

The estimated ozone concentration in FONE with regard to human health, bas ed on the interpolated data from 2011-2015, is 68.4 parts per billion (ppb) (NPS ARD, 2017). Using the benchmarks in Table 4.1, this condition is rated *resource warrants moderate concern* (Table 4.3).

Table 4.3. Status of ground-level ozone in Fort Necessity National Battlefield (ARD, 2017).

Air Quality Indicator	Specific Measure	Condition Status/Trend*	Rationale
Ozone	Human Health		**Condition:** Human health risk from ground-level ozone warrants moderate concern at FONE with a 2011–2015 estimated ozone concentration of 68.4 parts per billion (ppb). **Trend:** Trend information is not applicable because there are not sufficient on-site or nearby ozone monitoring data available. **Confidence:** The degree of confidence is low because estimates are based on interpolated data from more distant ozone monitors.
	Vegetative health		**Condition:** Vegetation health risk from ground-level ozone warrants moderate concern at FONE. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated W126 metric of 8.7 parts per million-hours (ppm-hr). The W126 metric relates plant response to ozone exposure. **Trend:** Trend information is not applicable because there are not sufficient on-site or nearby ozone monitoring data. **Confidence:** The degree of confidence at FONE is low because estimates are based on interpolated data from more distant ozone monitors.

* Condition assessments for contiguous U.S. parks use the Inverse Distance Weighted (IDW) interpolation method to estimate 5-year average (2011–2015) values. Trend analyses use 10 years (2006–2015) of data from on-site or nearby monitors.

The estimated ozone concentration in FONE with regard to plant health, based on 2011-2015 estimated W126 data, is 8.7 ppm-hr (NPS ARD, 2017). Using the benchmarks in Table 4.2, this condition is also rated *resource warrants moderate concern* (Table 4.3).

Trend Assessment

Based on long-term Clean Air Status and Trends Network (CASTNET) data from Laurel Hill State Park, located approximately 48 km (30 mi) northeast of FONE, there does not appear to be a significant upward or downward trend in ozone concentrations in the region over the last few decades (Figure 4.1). However, as stated above, we cannot be certain of the exact condition of ozone in FONE, given the distance to the monitoring station, and it seems irresponsible to appoint a temporal trend status to an undetermined spatial value. Therefore, while the trend appears to be stable for the region, we will not assign a trend rating for ozone in the park (Table 4.3).

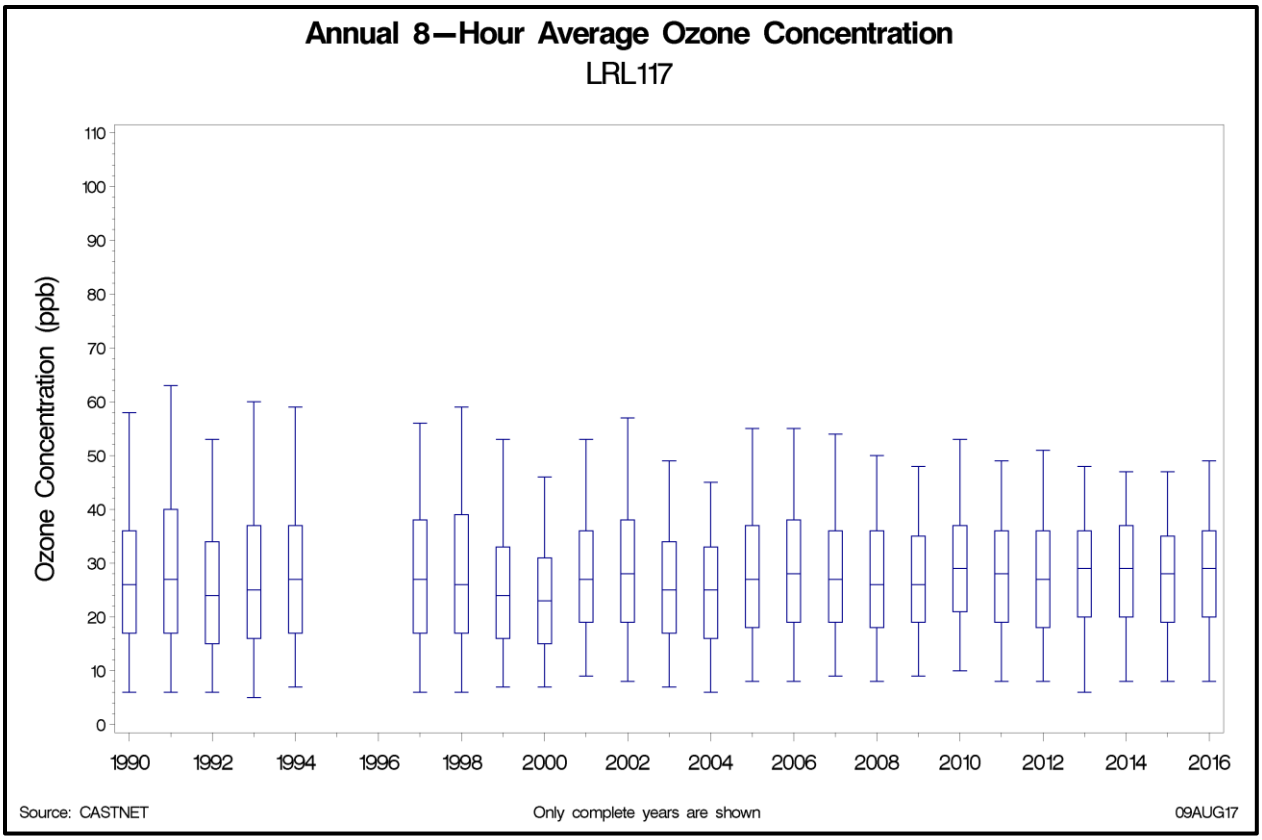


Figure 4.1. Long-term ozone trends at Laurel Hill State Park, a CASTNET site located approximately 48 km (30 mi) northeast of Fort Necessity National Battlefield (US EPA, 2017d).

Confidence Assessment

Confidence with regard to both human and vegetative health risk is *low* because FONE lacks site-specific ozone data and field documentation of foliar injury (Table 4.3).

4.1.2. Visibility

Relevance

Scenic and historic views are central to the allure and character of a park, making visibility a critical measurement. Air pollutants can worsen visibility, thereby reducing visitor satisfaction in addition to degrading well-being, as described above. The interaction of sunlight and tiny air pollution particles creates haze that shortens visual range. Loss of visibility has led to monitoring at many national parks and wilderness areas, a program implemented with the aid of Interagency Monitoring of Protected Visual Environments (IMPROVE) (Figure 4.2).

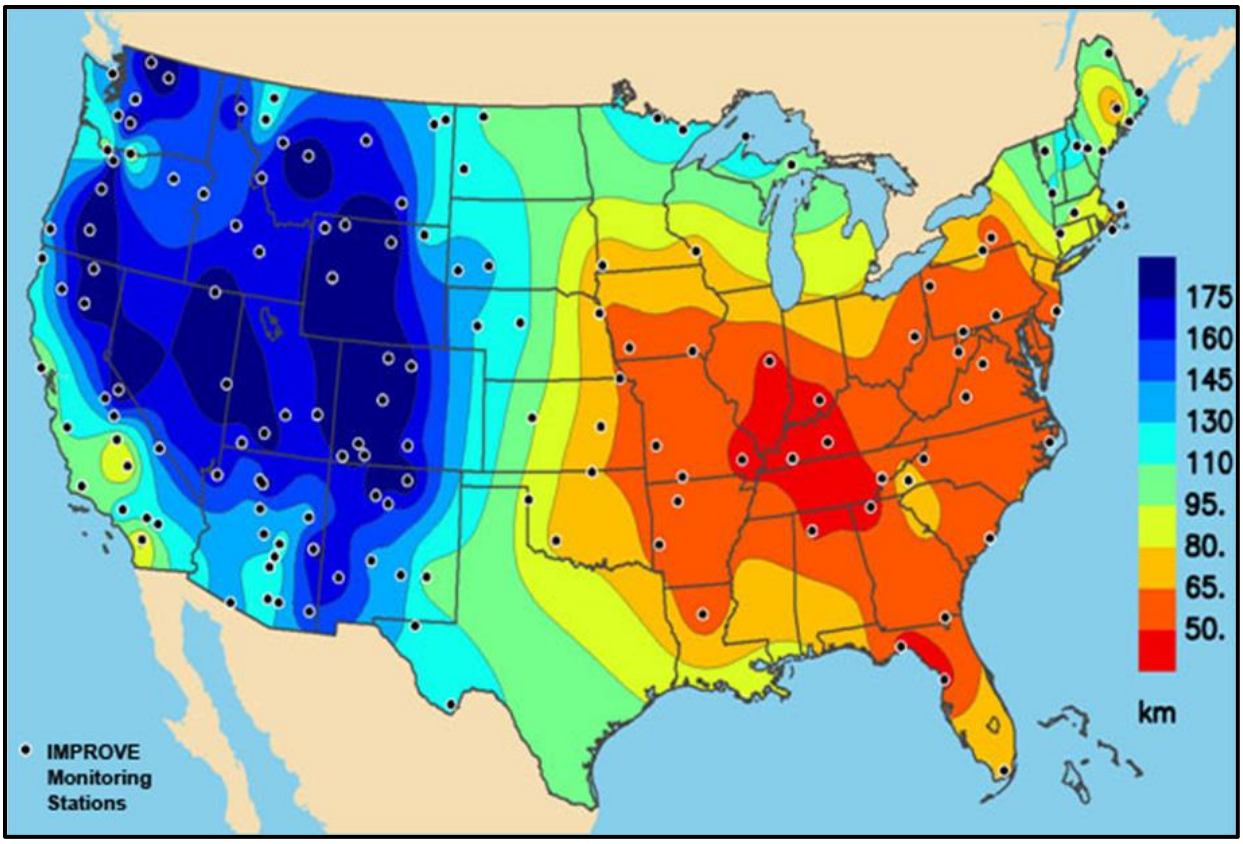


Figure 4.2. Location of IMPROVE monitoring stations within the U.S. and their average visual range (in kilometers) based on data collected from 2005-2007 (ARD, 2009).

Using data collected at IMPROVE sites, the NPS ARD compares the average recorded visibility to estimated natural visibility; the difference represents anthropogenic impact on visibility. It is recommended that this difference stay below 2 deciviews (dv) for all parks (2015).

Methods and Data

The evaluation of condition and trends for visibility was based on NPS ARD data and their established condition categories for assessing visibility. The NPS ARD evaluates visibility by

> *"… using the average haze index on the on mid-range days (40th to 60th percentile). Annual average measurements for visibility on mid-range days are averaged over a 5-year period and subtracted from the estimated natural visibility condition on mid-range days at each Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring site with at least 3-years of complete annual data. The difference between 5-year average visibility and natural visibility on mid-range days estimates the human contribution to visibility impairment on average days"* (NPS ARD, 2010).

Reference visibility levels are regulatory estimates based on natural background conditions for Class I parks and wilderness areas. Based on these estimates, the NPS ARD has established categories for assessing visibility condition; these categories were used in the condition assessment for FONE

(Table 4.4). The dv ranges for categories, while somewhat subjective, were chosen to reflect as nearly as possible the variation in visibility conditions across the monitoring network (NPS ARD, 2010).

Table 4.4. The benchmark for visibility status (Taylor, 2017).

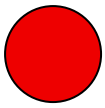
Status Category	Visibility (dv)*
Warrants significant concern	> 8
Warrants moderate concern	2-8
Resource in good condition	< 2

*The value for dv is estimated or measured 5-year average of visibility on mid-range days minus natural condition of mid-range days

Condition Assessment

The interpolated visibility value for FONE during the period from 2011-2015 was 8.5 dv above natural conditions, which are estimated to be 7.3 dv at FONE (ARD, 2017). Based on the NPS ARD condition categories above, FONE's air quality for visibility is assigned a rating of *resource warrants significant concern* (Table 4.5).

Table 4.5. Status of visibility at Fort Necessity National Battlefield (NPS ARD, 2017).

Air Quality Indicator	Specific Measure	Condition Status/Trend*	Rationale
Visibility	Haze Index**		**Condition:** Visibility warrants significant concern at FONE. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated visibility on mid-range days of 8.5 deciviews (dv) above estimated natural conditions*** **Trend:** No trend information is available for FONE because there are not sufficient on-site or nearby visibility monitoring data. **Confidence:** The degree of confidence at FONE is medium because estimates are based on interpolated data from more distant visibility monitors.

*Condition assessments for contiguous U.S. parks use the Inverse Distance Weighted (IDW) interpolation method is used to estimate 5-year average (2011–2015) values. Trend analyses use 10 years (2006–2015) of data from on-site or nearby monitors.

**Visibility trends and conditions are both expressed in terms of a Haze Index in deciviews (dv); however, the benchmark metrics are different. Condition assessments are based on estimated five-year average visibility on mid-range days (40^{th} to 60^{th} percentile) minus the estimated natural visibility condition on mid-range days. Visibility trends are computed from the haze index values on the 20% haziest days and the 20% clearest days.

***Natural visibility conditions are those estimated to exist in each area in the absence of human-caused visibility impairment. Estimated annual average natural condition on mid-range days equals 7.3 deciviews (dv) at FONE.

Trend Assessment

Trend assessment of visibility data based on the haziest days for national parks within the U.S. from 1999-2008 resulted in eastern U.S. parks showing 'no significant trend' or 'possible improvement' (NPS ARD, 2010). However, as with the ozone assessments, none of the monitoring stations are close enough to FONE to allow us to be certain of the visibility inside the park and estimating the temporal trend of an approximated spatial condition does not seem useful; therefore, we will not assign a trend rating (Table 4.5).

Confidence Assessment

Because visibility status for FONE is obtained from interpolated data from distant monitoring stations, the confidence in this assessment is *medium* (Table 4.5).

4.1.3. Atmospheric Deposition

Relevance

Burning fossil fuels to generate electricity, operating vehicles and heavy equipment, and industries such as manufacturing release nitrogen and sulfur into the atmosphere as nitrogen oxides and sulfur dioxide (US EPA, 2017c). Once there, nitrogen and sulfur can return to Earth as dust or precipitation, known as dry or wet deposition (US EPA, 2017c). Both forms affect aquatic and terrestrial ecosystems by altering soil and water composition through acidification and enrichment, thereby harming soil and water invertebrates, stressing vegetation, shifting community composition, increasing insect and disease outbreaks, and disrupting ecosystem processes such as nutrient cycling and fire regimes (Driscoll et al., 2001; Dupont et al., 2005; Horsley et al., 2002; Mitchell et al., 2001; Rusek and Marshall, 2000; Schindler, 1988; Schindler et al., 1989; Thormann, 2006; US EPA, 2017c; Wallace et al., 2007).

In the eastern U.S., the natural background deposition level for nitrogen and sulfur is approximately 0.50 kg/ha/yr, with wet deposition accounting for 0.25 kg/ha/yr—a higher rate than the rest of the U.S. (Driscoll et al., 2003; NPS ARD, 2010). While ecosystems are affected by both dry and wet deposition, the NPS ARD

> *"…selected a wet deposition threshold of 1.0 kg/ha/yr as the level below which natural ecosystems are likely protected from harm…*" (NPS ARD, 2015).

Therefore, this report uses wet deposition as a representative metric for atmospheric deposition.

Methods and Data

Data were collected from various monitoring stations near FONE in conjunction with NPS ARD sources; wet deposition conditions were assessed from 2011-2015 and wet deposition trends were assessed from 1990-2014. Since acidification and enrichment from nitrogen and sulfur inputs are the catalysts for other ecosystem-level changes, it was also imperative to include appraisals of the park's sensitivity to such developments.

Park resources' sensitivity to acidification was measured on a national scale based on a risk assessment by Sullivan et al. (2011a) and included acidification-related risk ratings for 271 parks,

including FONE. This risk assessment considered three factors that influence the magnitude of a park's reaction to acidification from nitrogen and sulfur deposition: pollutant exposure, ecosystem sensitivity, and park protection. National parks were ranked according to each of these factors and a summary risk rating was then calculated for each park based on an average of the three rankings. Each park was then classified into one of five categories representing risk of acidification: Very low, Low, Moderate, High, Very high; see Sullivan et al. (2011a) for further details on the variables included for each of the three factors and ranking assessment.

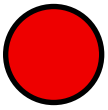
Sullivan et al. (2011b) conducted a second risk assessment to assess the relative sensitivity of NPS parks to nutrient enrichment caused by atmospheric nitrogen deposition. The assessment considered three factors that influence how affected park resources may be by nutrient enrichment from atmospheric nitrogen deposition: nitrogen pollutant exposure, ecosystem sensitivity, and park protection mandates. National parks were ranked according to each of these factors and an overall risk ranking was calculated based on averages of the three rankings. Results of quintile rankings of national parks throughout the U.S. were used to distinguish the risk levels of nutrient enrichment for a park; see Sullivan et al. (2011b) for further details on the variables included for each of the three factors and ranking assessment.

Relative risk assessments are especially useful because critical loads have not been established in the Clean Air Act for nitrogen and sulfur deposition. Consequently, the NPS is creating a critical load approach for wet deposition of nitrogen and sulfur to protect and manage its parks' ecosystems (NPS ARD, 2010). The NPS ARD has created a conditional assessment benchmark of 1.0 kg/ha/yr based on ecological responses documented in the scientific literature, as cited above. FONE's values for wet nitrogen and sulfur deposition were based on interpolated values over a five-year average from NADP/NTN data collected from a station in Laurel Hill State Park. Wet deposition was calculated by multiplying nitrogen or sulfur concentrations in precipitation by a normalized precipitation amount for sites within the continental U.S.; this normalized precipitation is calculated to minimize variation in data caused by interannual differences in precipitation.

Condition Assessment

Nitrogen deposition can lead to issues with both acid precipitation and nutrient enrichment and is thus a concern for FONE. The NPS ARD reports a wet deposition rate of 4.8 kg/ha/yr for 2011-2015—a rate well over the established benchmark (2017). With regard to nutrient enrichment, Sullivan et al. (2011b) considered FONE's ecosystems to be moderately sensitive compared to other parks' ecosystems. Overall, we rate the nitrogen deposition status at FONE as *resource warrants significant concern* (Table 4.6).

Table 4.6. Status of wet nitrogen and sulfur deposition at Fort Necessity National Battlefield.

Air Quality Indicator	Specific Measure	Condition Status/Trend*	Rationale
Nitrogen	Wet Deposition		**Condition:** Wet nitrogen deposition warrants significant concern at FONE. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet nitrogen deposition of 4.8 kilograms per hectare per year (kg/ha/yr). Ecosystems in the park were rated as having a moderate sensitivity to nutrient enrichment effects (Sullivan et al., 2011b) but are highly sensitive to acidification (NPS ARD, 2015). **Trend:** Total N deposition seems to be declining substantially in the region based on NADP/NTN and CASTNET data from Laurel Hill State Park, 48 km distant from FONE. **Confidence:** The degree of confidence at FONE is high because atmospheric deposition of nitrogen would not be expected to vary much over the 48 km divide between the NADP/NTN and CASTNET stations and FONE.
Sulfur	Wet Deposition		**Condition:** Wet sulfur deposition warrants significant concern at FONE. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet sulfur deposition of 3.9 kilograms per hectare per year (kg/ha/yr). Ecosystems in the park were rated as having very high sensitivity to acidification effects relative to all Inventory & Monitoring parks (Sullivan et al., 2011a). Plants sensitive to the effects of acidification in the park include sugar maple (*Acer saccharum*) and red spruce (*Picea rubens*). **Trend:** Data from the NADP/NTN and CASTNET site 48 km distant shows a declining trend over the past 25 years. **Confidence:** The degree of confidence at FONE is high because atmospheric deposition of sulfur would not be expected to vary much over the 48 km divide between the NADP/NTN and CASTNET stations and FONE.

*Condition assessments for contiguous U.S. parks use the Inverse Distance Weighted (IDW) interpolation method is used to estimate 5-year average (2011–2015) values. Trend analyses use 10 years (2006–2015) of data from on-site or nearby monitors. Reporting units for conditions and trends are different. Trends are evaluated using pollutant concentrations in precipitation (micro equivalents/liter) so that yearly variation in precipitation amounts do not influence trends analyses. Conditions are based on nitrogen and sulfur loading (kilograms per hectare per year) to ecosystems.

Sulfur deposition can also lead to acid precipitation, thereby damaging both water and soil resources (NPS ARD, 2015). The NPS ARD reports a wet deposition rate of 3.9 kg/ha/yr for 2011-2015—again, a rate well over the established benchmark (2017). Sullivan et al. (2011a) categorized FONE's sensitivity to acidification as Very high compared to other parks. The sulfur deposition status at FONE is therefore also *resource warrants significant concern* (Table 4.6).

Trend Assessment

While conditions are recorded in terms of kg/ha/yr, trends are documented using pollutant concentrations in terms of micro equivalents/liter to account for yearly variations in precipitation (NPS ARD, 2017). The nearest NADP/NTN and CASTNET stations to FONE are at Laurel Hill State Park, approximately 48 km (30 mi) northeast of FONE; using this site and interpolated NADP–NTN/PRISM/CMAQ data, we can estimate overall nitrogen and sulfur deposition trends (Figures 4.3 and 4.4). Atmospheric deposition is less variable across a region, and with more certainty that regional values reflect park conditions, we feel comfortable assigning a trend rating for this assessment. Based upon data from 1990-2014, there appears to be a substantial and continued decline in overall nitrogen and sulfur deposition in the region over the past 25 years, resulting in a rating of *condition is improving* (US EPA, 2017d) (Table 4.6).

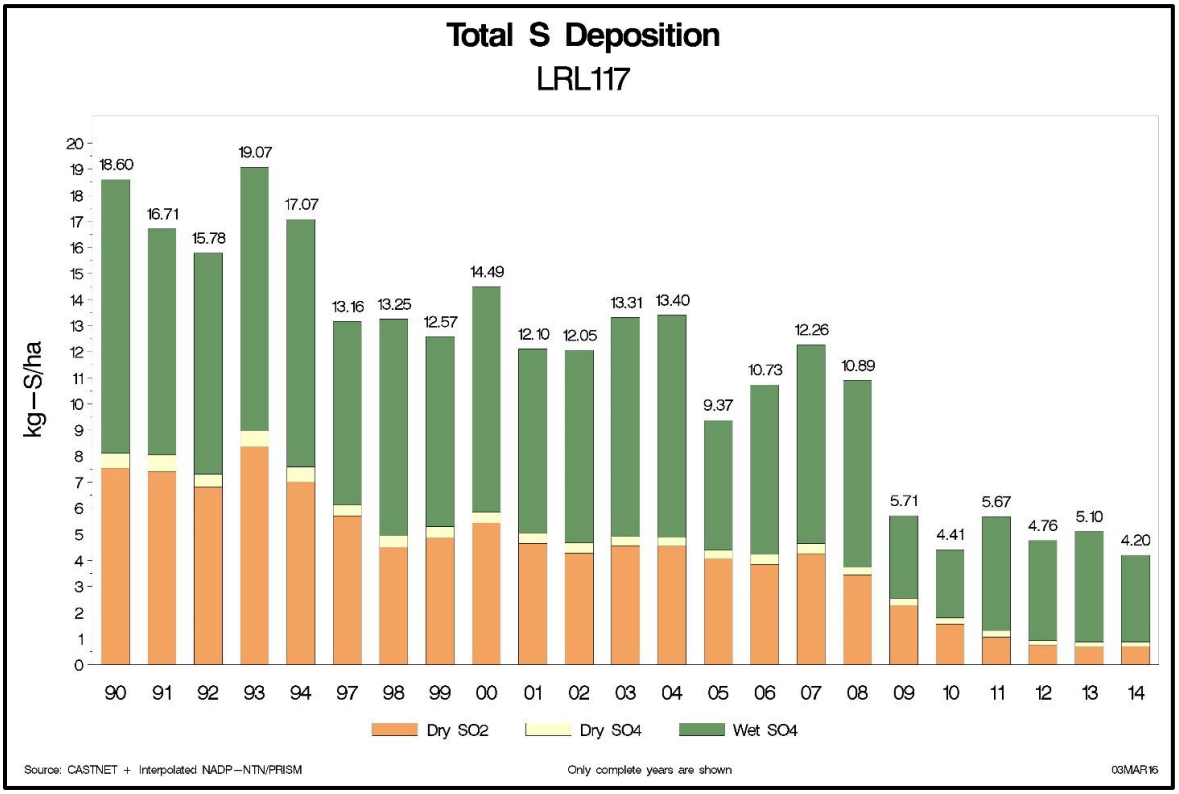


Figure 4.3. Total nitrogen deposition at Laurel Hill State Park, PA, the nearest NADP/NTN and CASTNET site to Fort Necessity National Battlefield (US EPA, 2017d).

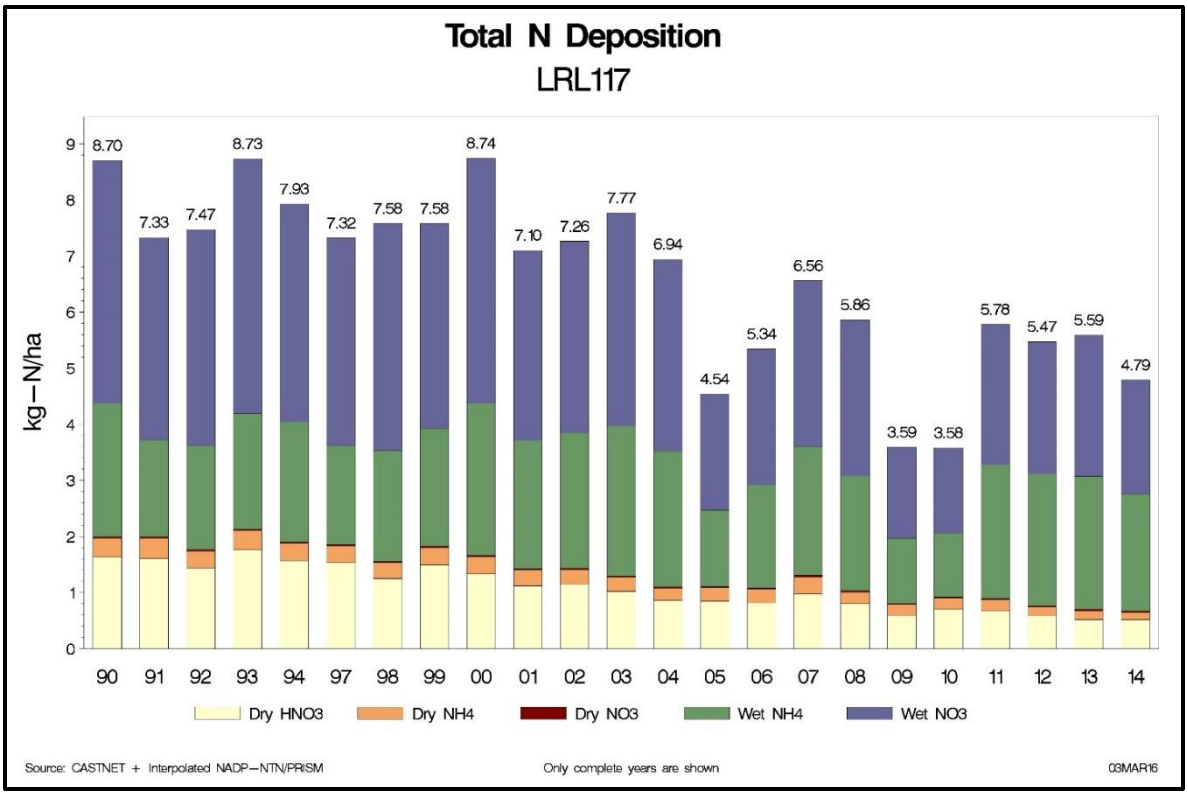


Figure 4.4. Total sulfur deposition at Laurel Hill State Park, PA, the nearest NADP/NTN and CASTNET site to Fort Necessity National Battlefield (US EPA, 2017d).

Confidence Assessment

Atmospheric deposition of nitrogen and sulfur would not be expected to vary much over the 48 km divide between the NADP/NTN and CASTNET stations and FONE; therefore, confidence in the assessment is *high* (Table 4.6).

4.2. Water Quality

Relevance

Streams at FONE are classified as High Quality – Cold Water Fishery (HQ-CFW), as defined by the Pennsylvania Code (2018). Maintaining high quality streams in the park is vital to provide satisfactory habitat for aquatic species such as fish and macroinvertebrates, as well as food and shelter for waterfowl, insects, and amphibians (US EPA, 2013). Additionally, healthy streams contribute to the recreational and cultural value of FONE. Streams with high water quality also influence the region surrounding the park by filtering pollutants that may enter and contributing to the health of water bodies downstream (US EPA, 2013).

Methods and Data

Water quality data are relatively scarce for FONE; we relied heavily on reports by Cravotta and Eggleston (2011), Tzilkowski et al. (2015), Tzilkowski and Sheeder (2006), and Webber (2012). Tzilkowski and Sheeder (2006) primarily looked at fish and macroinvertebrate communities at FONE but did measure some water quality parameters such as stream temperature, pH, dissolved

oxygen, and conductivity. Tzilkowski et al. (2015) provide a more recent report of these core water quality parameters from 2008-2013.

For a reference condition against which to assess FONE's water quality, we used the HQ-CWF designation and its associated criteria as provided by the Pennsylvania Code (2018b).

Condition Assessment

FONE includes nine streams and eight ponds within its boundaries. Tzilkowski et al. (2015) sampled sections of three of those streams and found that they all met the state HQ-CWF designation despite water temperatures exceeding the maximum threshold value; this is because there is no heated discharge into the streams, and discrete measurements do not constitute a violation of the HQ-CWF requirements (Figure 4.5). Though Tzilkowski et al. found no issues in 2010, the 2015 conclusion supports what Tzilkowski and Sheeder observed in 2006 when they sampled eight streams and five ponds in FONE: the temperatures of Great Meadow Run, Braddock's Run, and the headwaters of Dunbar Creek surpassed allowable levels (Figure 4.6). In no case could Tzilkowski and Sheeder (2006) identify a cause for the high temperatures due to a lack of data.

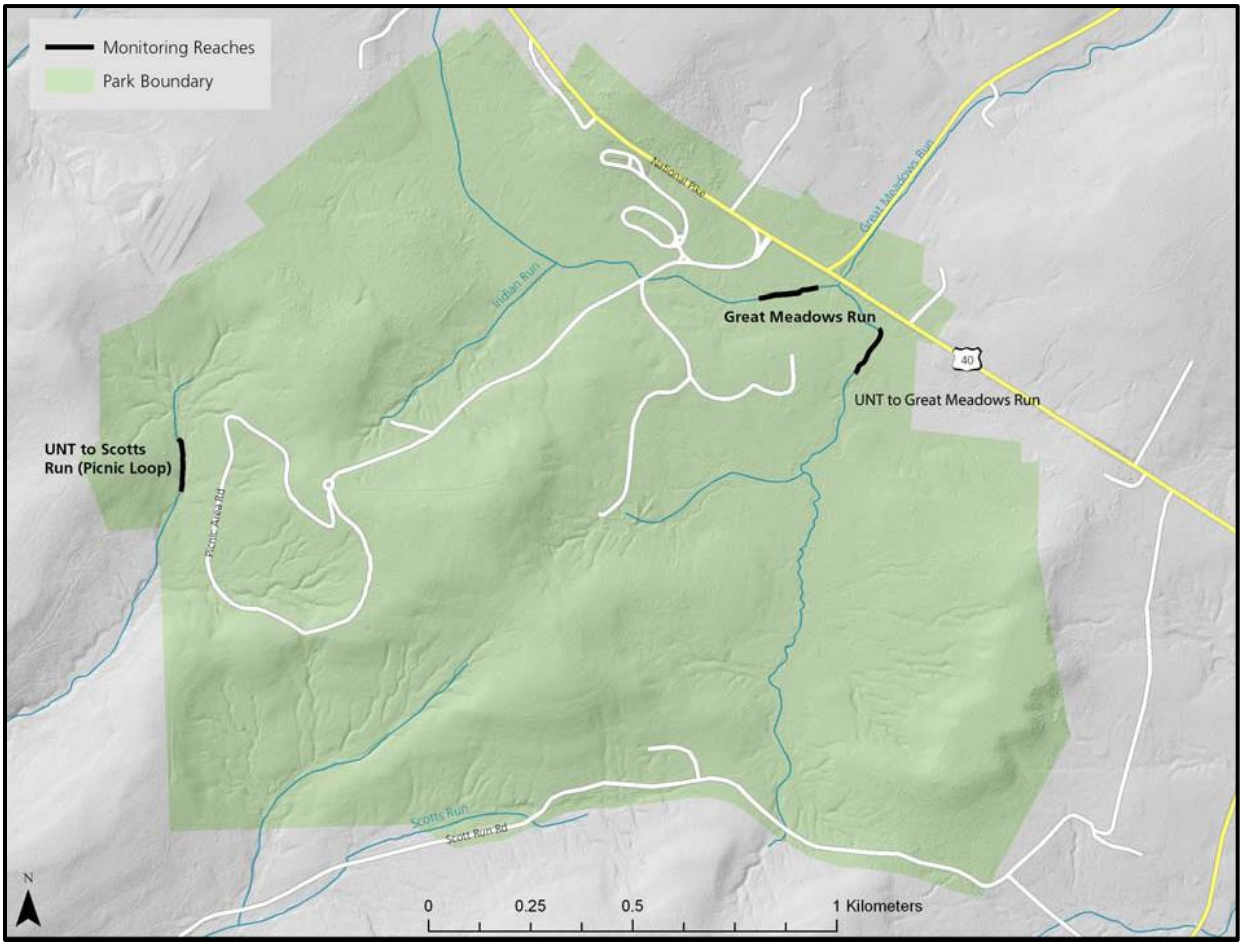


Figure 4.5. Core water quality parameter sampling sites, shown by black lines, located in the main unit of Fort Necessity National Battlefield (Tzilkowski et al., 2015).

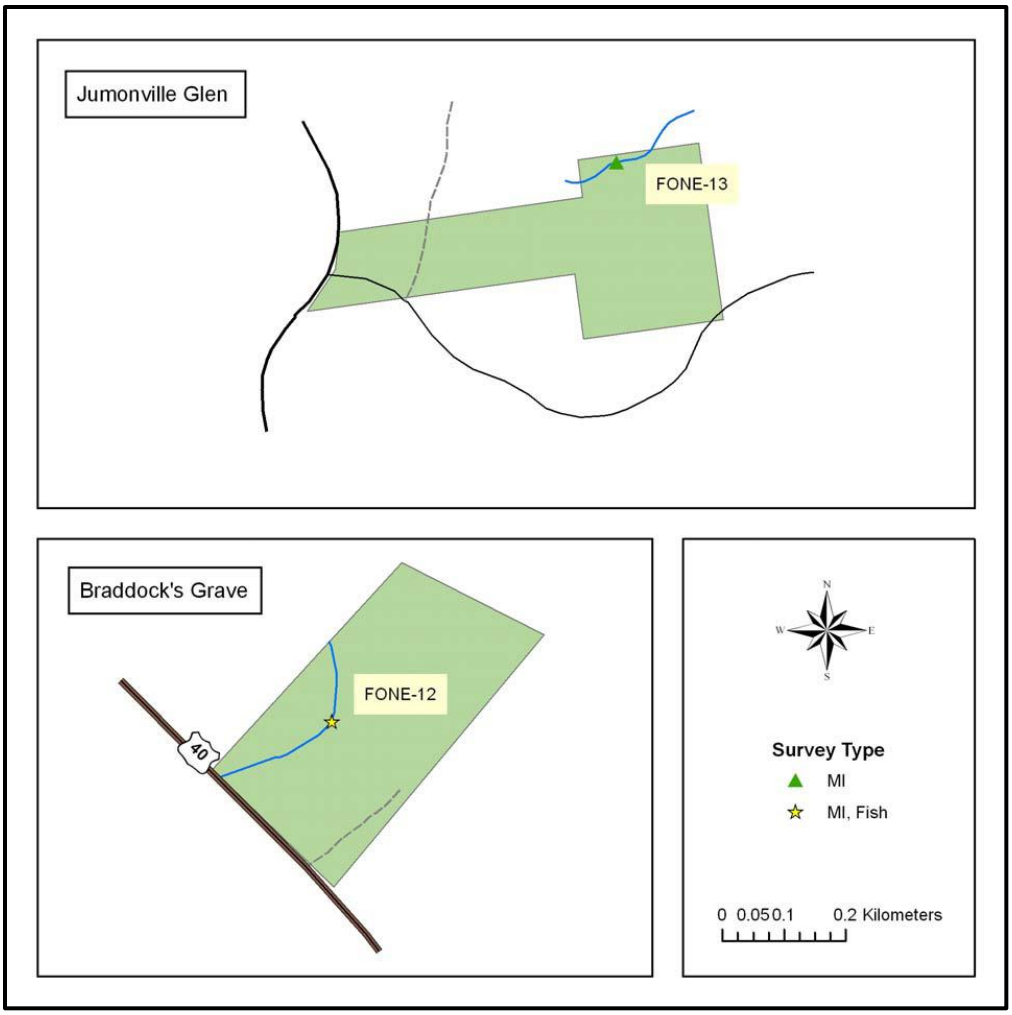


Figure 4.6. Fish and macroinvertebrate (MI) sampling sites at the Jumonville Glen and Braddock's Grave units at Fort Necessity National Battlefield (Tzilkowski and Sheeder, 2006).

Dissolved oxygen levels were more than sufficient at all FONE sites in 2015 (Tzilkowski et al. 2015).

Eckhardt and Sloto (2012) measured baseline groundwater quality at all parks potentially impacted by the Marcellus Shale play; they recorded low specific conductance (105 µS/cm) and noted that FONE's water was "soft" with a very low concentration of dissolved solids (62 mg/L). More recently, specific conductance varied and was typical of a forest stream in some reaches and slightly elevated in others, suggesting some deterioration in condition since 2012 (Tzilkowski et al., 2015).

Tzilkowski et al. (2015) also used a multimetric index of biotic integrity (MIBI) to assess stream quality in FONE. Though the index was developed for streams of a different type than typical at FONE, it can still provide an estimate for FONE water quality. Scores based on the macroinvertebrate data indicated that an unnamed tributary to Dunbar Creek, in the Jumonville Glen Unit, was severely impaired (Tzilkowski and Sheeder 2006). While they attributed the impairment to

acid mine drainage, Kimmel and Clark (2000) credit it to precipitation, geology, and wildlife activity. Cravotta and Eggleston (2011) also found low pH (< 5) and ascribe it to acid precipitation.

Other studies failed to find any impairments. Webber (2012) looked at water quality for the entire ERMN region; he sampled two locations in FONE, Great Meadows Run and an unnamed tributary (UNT) to Great Meadows Run and found both samples to have high water quality (Figure 4.7). Webber (2012) used chemical parameters including pH, acid neutralizing capacity (ANC), sulfate, chloride, total nitrogen (TN) and total phosphorus (TP) to classify reference (R), fair (F), or impaired (I) stream conditions, and determined no stream to be below fair conditions (Table 4.7).

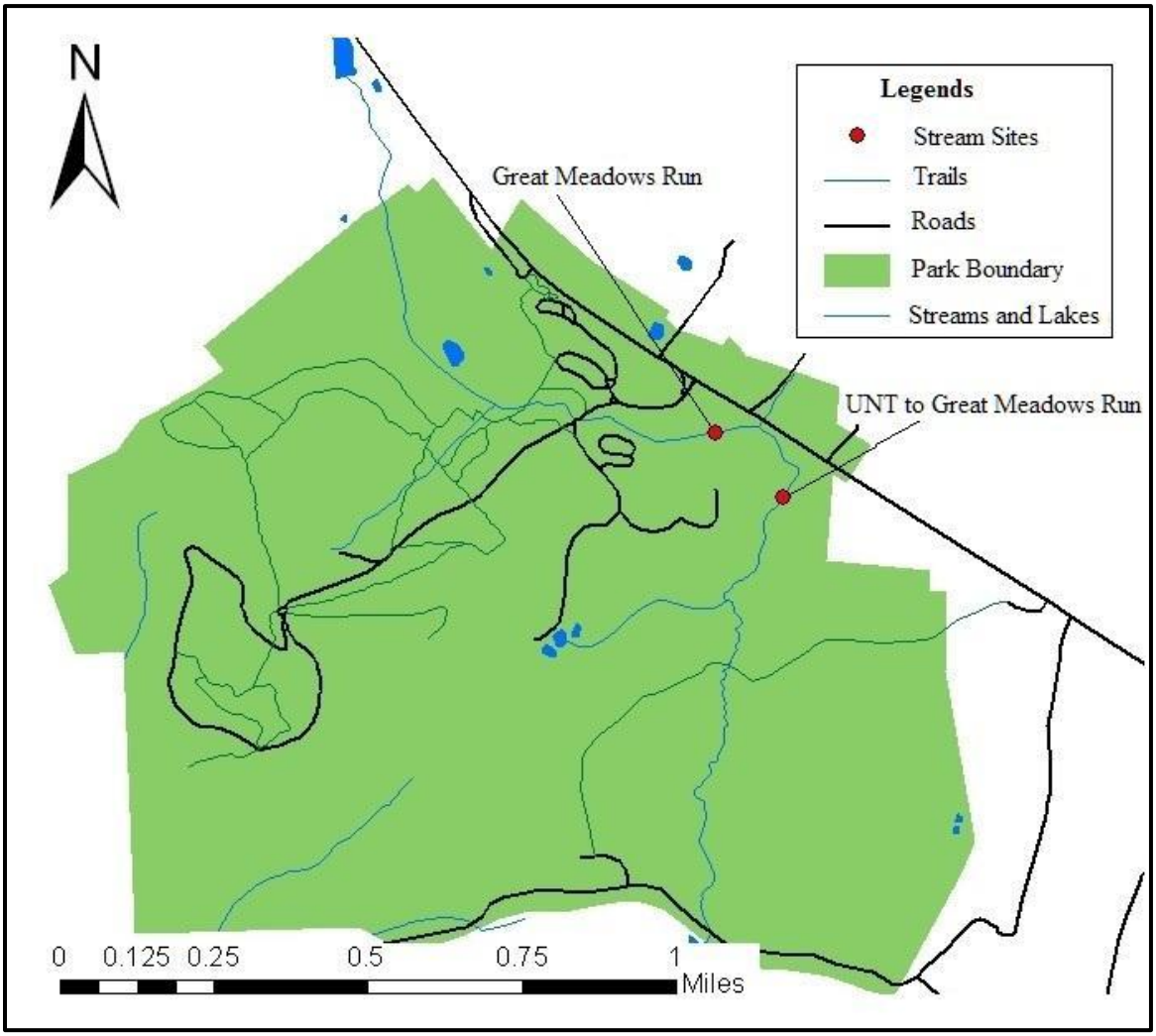


Figure 4.7. Water quality sampling locations at Fort Necessity National Battlefield (Webber 2012).

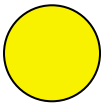
Table 4.7. Water quality in two streams of Fort Necessity National Battlefield (Webber 2012).

Stream Name (Park)	Chemical Parameters						Mean Qualitative Habitat Score	Overall Condition
	pH	ANC	Sulfate	Chloride	TN	TP		
Great Meadows Run (FONE)	—	R	R	F	R	R	F	F
UNT to Great Meadows Run (FONE)	—	R	R	F	R	R	R	F

R – reference conditions, F – fair

Given issues with temperature and habitat quality, and even though FONE's streams meet state HQ-CWF standards, we assign water quality a status of *resource warrants moderate concern* (Table 4.8).

Table 4.8. Water quality status at Fort Necessity National Battlefield; only temperature was considered as it was outside the bounds of recommended water quality standards.

Water Quality Indicator	Specific Measure	Condition Status/Trend	Rationale
Temperature, dissolved oxygen, specific conductance, dissolved solids, pH	^{o}C		**Condition:** Stream temperatures warrant moderate concern at FONE. This status is based on Pennsylvania stream classification standards for High Quality - Cold Water Fishery (maximum of 19 ^{o}C (66 ^{o}F) in August). Because few data are available, it seems prudent to advise caution on this measurement. **Trend:** Some trend information is available but there are not sufficient long-term monitoring data to justify a rating. **Confidence:** The degree of confidence at FONE is medium due to lack of data.

Trend Assessment

Sufficient long-term data are lacking to allow for a determination of the trend of water quality in FONE (Table 4.8).

Confidence Assessment

Long-term and repeatable data are scarce for FONE. This leaves us with *medium* confidence in any statement about the quality of water within FONE (Table 4.8). Furthermore, there are very few stream flow measurements, making any flow-related judgments questionable. Water quality is often tied to water quantity and the synchronization of monitoring quality and quantity variables would provide managers with an improved understanding of water quantity/quality relationships in FONE.

4.3. Wetlands

Relevance

Wetlands are areas that

> *"…are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas"* (e-CFR, 2018).

Pennsylvania follows the federal definitions for wetlands and thus the wetlands within the park are subject to federal and state jurisdiction. Furthermore, the NPS follows Director's Order #77-1 (NPS, 2016) which directs all activities regarding wetlands within a park and can be more stringent than either state or federal guidelines.

There are several wetland areas within the park, the largest of which is the Great Meadows. Sharpe and Dammeyer (2013) mapped the palustrine emergent (PEM) and riverine (Cowardin et al. 1979) wetlands of the Great Meadows as well as riverine wetlands along Indian Run; they also documented several ponds within FONE that are classified as palustrine unconsolidated bottom (PUB) (Figure 4.8) (Cowardin et al. 1979). Perles et al. (2006) mapped out the vegetation groups within FONE and found several areas of wet meadow (Figure 4.9).

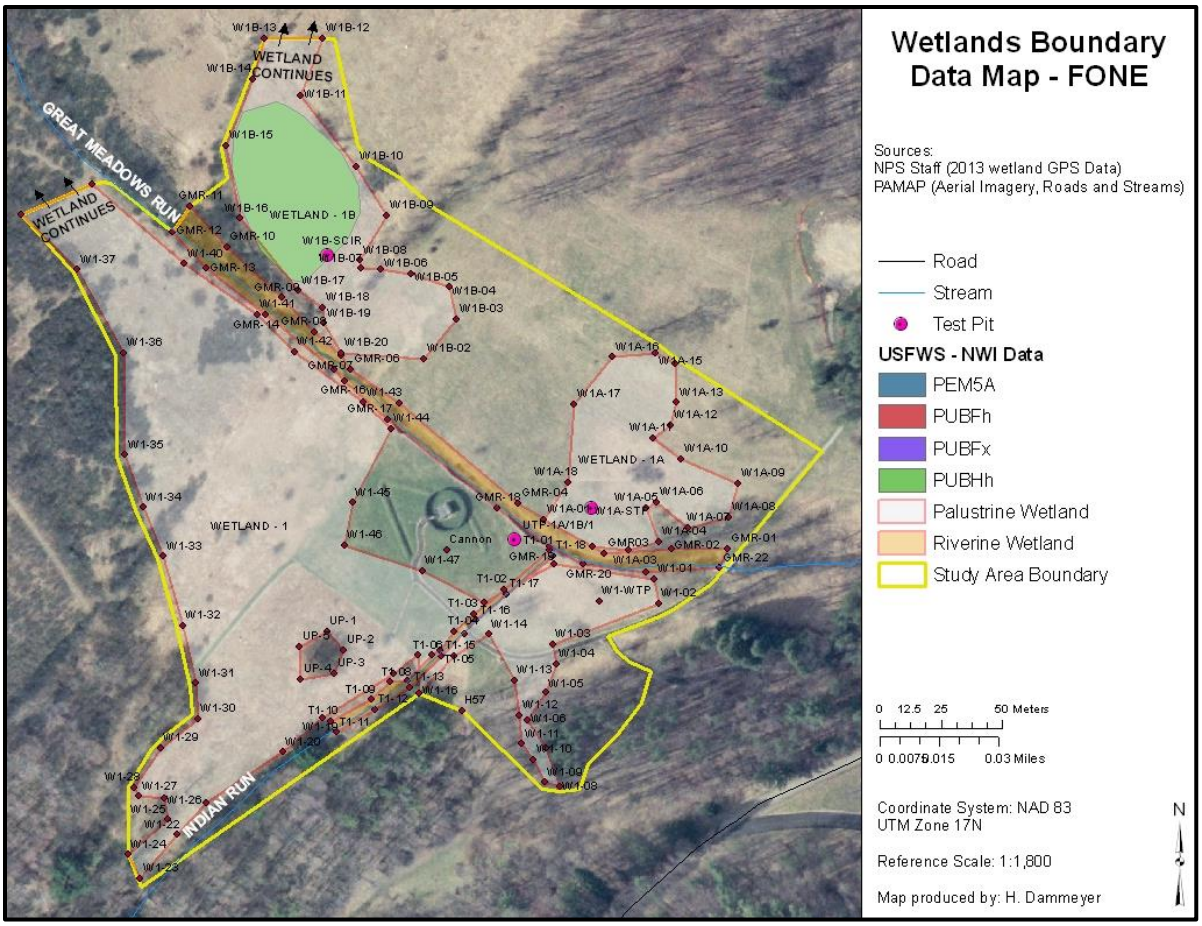


Figure 4.8. Delineated wetlands in the main unit of Fort Necessity National Battlefield (Sharpe and Dammeyer, 2013).

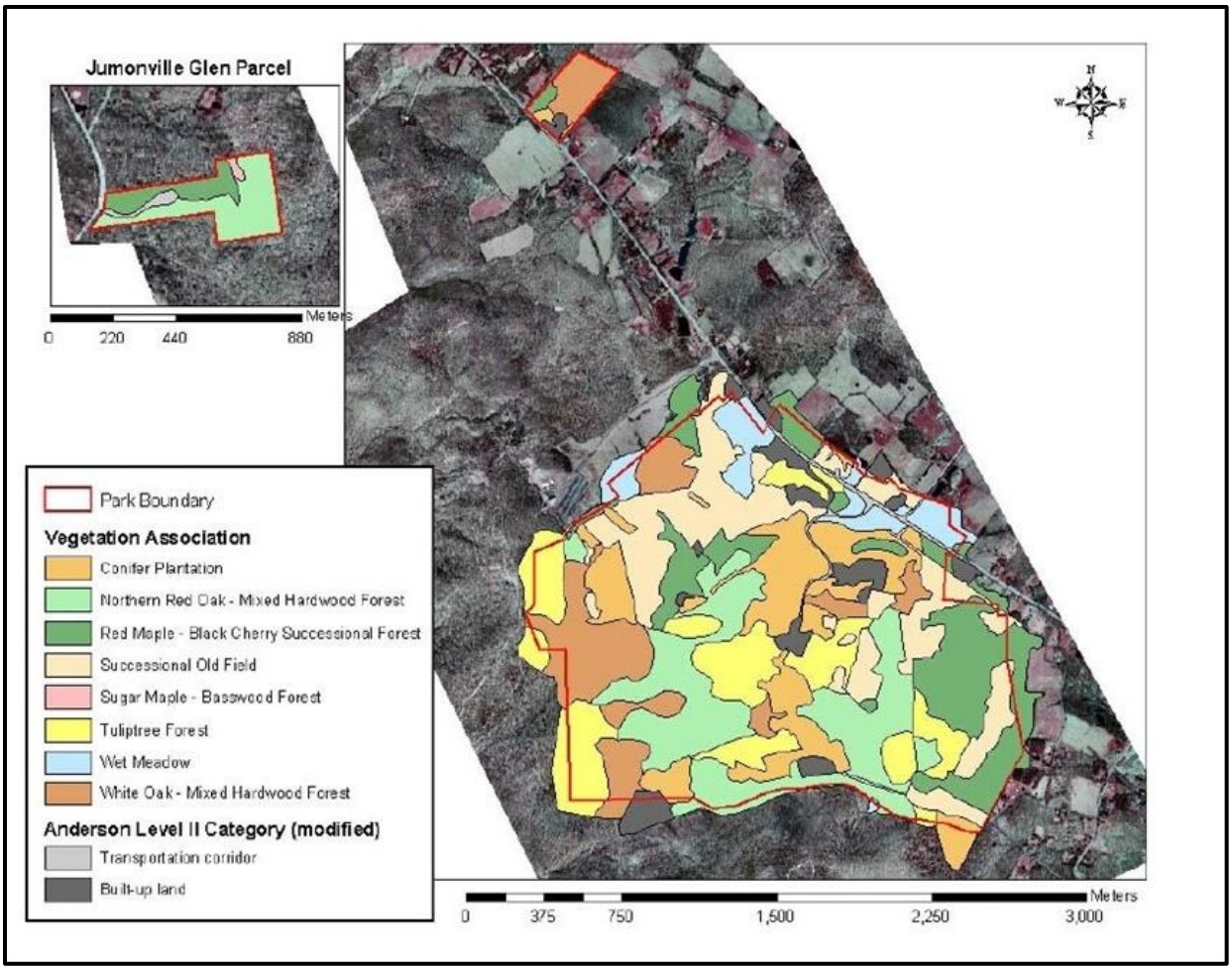


Figure 4.9. Vegetation associations at Fort Necessity National Battlefield with wet meadows shown in light blue (Perles et al., 2006).

The Great Meadows is a riparian wetland that was substantially altered prior to the implementation of federal and state regulations (Figure 4.10). Early records (*circa* 1750s) indicate that the Great Meadows extended about a mile long and perhaps 300 yards wide with alders and sedges dominating (NPS, 1998). Kelso (1994) found evidence of wetland species through pollen located near the fort, indicative of wet conditions around that same time. By the mid-1800's, it is likely that much of the Great Meadows had been cleared for agriculture and Indian Run had been straightened (NPS, 1998). Since, considerable development has disturbed the area. By 1998, the Great Meadows had become a 17 ha (42 ac) tract with alders (*Alnus* sp.), sedges (*Carex* spp.), rice cutgrass (*Leersia oryzoides*), and goldenrods (*Solidago* spp.).



Figure 4.10. Wetlands surrounding the reconstructed Fort Necessity (Credit: P. Sharpe).

In 2002, Johnson and Cherry studied stream characteristics of Great Meadow Run as a means of assessing restoration possibilities for the Great Meadows. Passive options, intended to encourage out-of-bank flooding, included engineered debris jams, placed boulders, and increasing stream roughness. More aggressive approaches included a full restoration of the 1754 wetlands, largely consisting of the removal of fill, cutting back the stream banks, and developing a two-stage channel. Their ultimate recommendation was to engineer debris jams.

Later, Sharpe and Dammeyer (2013) conducted a review of management activities, including those completed, underway, and planned for the future, in an effort to predict outcomes and potential side effects. After surveying, they described an abandoned pond and an artificial terrace that appear to sit atop historic wetlands; at some point, the pond had been breached and now drains into Great Meadows Run. To restore the area, they recommended reestablishing stream sinuosity of Great Meadows Run and reconstructing proper hydrology in the Great Meadows wetlands by extracting old fill materials, removing historic ditches, regrading the parking lot along the left bank, and breaching all ponds.

Methods and Data

The southern area of the Great Meadows floodplain below the footbridge at the replica fort was surveyed using the 1987 Army Corps protocol by Andrew Martin Associates, Inc. (1992). The sections of Great Meadow Run and Indian Run within the immediate vicinity of the replica fort were assessed by Sharpe and Dammeyer using the latest Army Corps regional supplement and 1987

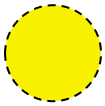
manual (2013). Outside of those regions, the park must rely on either USGS/NPS vegetation mapping or National Wetland Inventory spatial data.

There are no standard methods for determining the quality of wetlands as no federal nor state standards have been developed against which to judge a site. Instead of a written standard, a largely undisturbed wetland nearby may be designated as a reference wetland for the sake of comparison. There exists a large set of reference wetlands in Pennsylvania developed by Riparia at PSU (http://www.riparia.psu.edu), but none of these are located near FONE and are therefore not suitable for comparison. Without a reference wetland, we relied on best professional judgement.

Condition Assessment

Given the history of anthropogenic interference with the Great Meadows, including logging, drainage, pasturing, and the introduction of non-native plant species, it is our judgment that the condition of wetlands within FONE deserve a rating of resource warrants moderate concern (Table 4.9).

Table 4.9. Status of wetlands within the area outlined by Sharpe and Dammeyer (2013).

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological integrity	Hydrologic modification		**Condition:** Wetlands warrant moderate concern due to substantially impacted hydrology (ditches, drains). **Trend:** No trend information is available because there are not sufficient on-site data, though restoration efforts indicate a possible improving trend. **Confidence:** The degree of confidence at FONE is low due to a lack of long-term data.

Trend Assessment

Though recent efforts to restore the Great Meadows are indicative of possible improvements, there is not enough trend data to reliably assess change over time (Table 4.9).

Confidence Assessment

Confidence in this assessment is *low* as it lacks long term data and is based solely on best professional judgment (Table 4.9).

4.4. Aquatic Species

4.4.1. Macroinvertebrates

Relevance

Benthic macroinvertebrates are aquatic and semi-aquatic invertebrates larger than microscopic size that inhabit the lowest region of the stream (Tzilkowski et al., 2010). They are important components of stream food webs and are instrumental in nutrient and carbon dynamics (Webster, 1983). Aquatic macroinvertebrates are sensitive to a wide range of stream, riparian, and landscape features. Stream

channel characteristics, water quality, water quantity, aquatic vegetation communities, and landscape changes determine aquatic macroinvertebrate assemblage patterns.

Methods and Data

There have been several recently published studies of macroinvertebrates within FONE, and the ERMN has even more up-to-date, unpublished data. The most recent publication on macroinvertebrates summarized data from 2008-2013, though only from the main unit (Tzilkowski et al., 2015). Tzilkowski et al. (2010) also focused on the main unit while Tzilkowski and Sheeder (2006) covered all three park units.

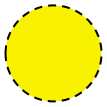
No reference conditions were calculable because the methods used in the park to assess macroinvertebrate health were developed for streams with characteristics that FONE streams do not share; therefore, judgement on condition of benthic macroinvertebrates in relation to water quality was based on best professional judgement.

Condition Assessment

MIBI scores from 2013 were relatively low for Great Meadows Run but showed an UNT to Scott's Run to be in good condition (Tzilkowski et al. 2015). These results are consistent with the MIBI scores from 2010 that also show the UNT to Scott's Run to be the only water body tested not in poor condition (Tzilkowski et al. 2010). However, it should be noted that procedure used was designed for streams that have riffle habitat with cobbled substrate, characteristics that Great Meadows Run lacks. For this reason, Tzilkowski et al. (2010) were not convinced that the stream is actually poor macroinvertebrate habitat. Tzilkowski and Sheeder (2006) do assert, however, that the macroinvertebrate community in an UNT to Dunbar Creek in the Jumonville Glen unit is severely impaired, likely due to chronic acidification.

Most of the streams at FONE are not currently heavily impacted by human activity, though they have been in the past and the legacy of past abuses remains evident. As described above, the Great Meadows area has been channelized, tiled, drained, and used as pasture—activities that degrade water quality, thus affecting macroinvertebrate communities (Johnson & Cherry, 2002). Based on the limited data available, our estimation is that the overall aquatic macroinvertebrate community merits a rating of *resource warrants moderate concern* and may become further depauperate in situations of low flow and low oxygen (Table 4.10).

Table 4.10. Status of aquatic macroinvertebrates at Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological integrity	Macroinvertebrate IBI		**Condition:** Macroinvertebrate data indicate that some of the streams and ponds are depauperate with respect to diversity and species indicative of high-quality streams. **Trend:** Information is moderately available but FONE lacks an extended time series of data. **Confidence:** The degree of confidence at FONE is low due to limited data.

Trend Assessment

Without a more extended series of data over time, we cannot make a judgement on the trend of macroinvertebrates in FONE (Table 4.10). The park will obtain more information on trends as additional data are collected through the Inventory and Monitoring Program.

Confidence Assessment

Due to limited data, our confidence in this assessment is *low* (Table 4.10).

4.4.2. Fish Species

Relevance

Fish are important components of most healthy streams, serving as both predators and prey in many aquatic and terrestrial food webs, and thus play a critical role in energy and nutrient cycling. Fish can additionally serve as a food source to humans, and their value in recreation makes the condition of this natural resource of particular interest to the public. Fish assemblages are influenced by a wide range of stream, riparian, and landscape features.

Methods and Data

All streams in FONE

> *"… currently have the protected use of High Quality Cold-Water Fishes (HQ-CWF) designated by the PADEP (1996), which means they must be suitable for the 'maintenance and/or propagation of fish species including the family Salmonidae and additional flora and fauna which are indigenous to cold water habitat' " (*Tzilkowski & Sheeder, 2006).

Some work has been done to document fish at Fort Necessity. The most recent was reported by Faulk and Weber (2017); we also relied on the report by Tzilkowski and Sheeder (2006) and the NPSpecies database (Table 4.11).

Table 4.11. Fish that have been identified at Fort Necessity National Battlefield (Faulk and Weber 2017; NPSpecies, n.d.; Tzilkowski and Sheeder, 2006). FW=Faulk and Weber, NPS=NPSpecies, TS=Tzilkowski and Sheeder.

Family	Scientific name	Common name	Source
Catostomidae	*Catostomus commersoni*	White Sucker	FW, NPS, TS
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	NPS
	Lepomis macrochirus	Bluegill	TS
	Micropterus salmoides	Largemouth bass	FW
Cottidae	*Cottus bairdi*	Mottled Sculpin	FW, TS
Cyprinidae	*Rhinichthys atratulus*	Blacknose Dace	FW, NPS, TS
	Semotilus atromaculatus	Creek Chub	FW, NPS, TS
Percidae	*Etheostoma nigrum*	Johnny Darter	FW, TS

Condition Assessment

Given that all FONE streams are designated as HQ-CWF, it is striking that no trout were caught by Tzilkowski and Sheeder (2006), though another cold-water fish (mottled sculpin) was present. All species found were native and this leads us to rate the fish communities in FONE as *resource is in good condition* (Table 4.12).

Table 4.12. Status of fish populations at Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological integrity	Fish diversity		**Condition:** Data indicate that fish communities are generally in good condition. **Trend:** No trend information is available because there are not sufficient data. **Confidence:** The degree of confidence at FONE is medium.

Trend Assessment

We cannot identify trends due to a lack of long-term data (Table 4.12).

Confidence Assessment

Confidence in the assessment is *medium* as the data are infrequent but recent (Table 4.12).

4.5. Wildlife

Relevance

Wildlife assessments usually target small mammals (e.g. raccoons, mice, shrews) and volant animals (e.g. bats, songbirds, raptors); amphibians and reptiles may not be included because they are often elusive and thus difficult to evaluate. Fortunately, because large carnivores generally require extensive habitat ranges, large mammal conservation serves as umbrella protection for many other species. Large mammal conservation is also important because the greater an animal's range, generally the more susceptible they are to habitat fragmentation within and surrounding the park (Turner, 1996; van Manen et al., 2001). In addition to fragmenting, habitat structure can be altered by the encroachment of invasive species, changing food web dynamics, and pests and pathogens, all of which are issues occurring in or near FONE (Mahan and Yahner, 1999; Muzika et al., 2004; Rooney et al., 2004).

Methods and Data

Data collated from public reports (mostly ranging from 1973-2010) are available on the NPSpecies website and used here to provide an overview of the wildlife in FONE.

Condition Assessment

According to NPSpecies, there are 32 mammalian species in the park, the most abundant of which are the white-tailed deer (*Odocoileus virginianus*), meadow vole (*Microtus pennsylvanicus*), white-footed mouse (*Peromyscus leucopus*), and eastern chipmunk (*Tamias striatus*) (Appendix A). Other common species include the Virginia opossum (*Didelphis virginiana*), big brown bat (*Eptesicus*

fuscus), little brown myotis (*Myotis lucifugus*), common racoon (*Procyon lotor*), eastern cottontail (*Sylvilagus floridanus*), and meadow jumping mouse (*Zapus hudsonius*).

Despite the challenges of surveying amphibians and reptiles, there are 36 such species present, or probably present, in FONE (Appendices B and C). Amphibians were detected more frequently than reptiles, with the mountain dusky salamander (*Desmognathus ochrophaeus*), red-spotted newt (*Notophthalmus viridescens*), and northern spring peeper (*Pseudacris crucifer*) found in the greatest abundance. Other common amphibians include the northern dusky salamander (*Desmognathus fuscus*), redback salamander (*Plethodon cinereus*), slimy salamander (*Plethodon glutinosus*), and green frog (*Lithobates clamitans melanota*). Though only seen occasionally, reptile species such as the common snapping turtle (*Chelydra serpentina*), northern ringneck snake (*Diadophis punctatus edwardsii*), and rat snake (*Pantherophis alleghaniensis*) have been recorded in the park.

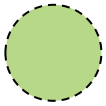
There are 145 species of birds present, or probably present, in FONE (Appendix D). According to Yahner et al. (2004), one of the contributing studies to NPSpecies, the most common species observed during spring migrations were the American crow (*Corvus brachyrhynchos*), black-throated green warbler (*Dendroica virens*), eastern towhee (*Pipilo erythrophthalmus*), black-capped chickadee (*Poecile atricapilla*), American goldfinch (*Spinus tristis*), field sparrow (*Spizella pusilla*), and red-eyed vireo (*Vireo olivaceus*). Other abundant birds include the cedar waxwing (*Bombycilla cedrorum*), wild turkey (*Meleagris gallopavo*), and indigo bunting (*Passerina cyanea*).

Bird communities are often used as indicators of ecological health. One way to summarize the condition of bird communities and report changes is through the Bird Community Index (BCI). The BCI is a measure of biotic integrity based on the breeding bird communities of the central Appalachians (O'Connell et al., 1998a, 1998b, 2000). It includes 16 response guilds, each of which is broadly classified as "specialist" or "generalist" depending on that guild's relationship to certain elements of biotic integrity. Every bird species is assigned to a response guild, and the BCI ranks the overall bird community detected at a site according to the proportional representation of the species in the response guilds. Higher BCI scores describe a community in which specialists are well-represented relative to generalists; this indicates high biotic integrity.

Marshall et al. (2013) calculated the BCI for FONE and determined that the ecological condition of the bird community ranged from "medium" integrity to "highest" integrity; no sites showed "low" integrity. Thus, the bird community in FONE comprises more species in specialist guilds than generalist guilds, reflecting a relatively intact, extensive, and mature forest structure. Marshall et al. (2013) also showed that the average condition within the park from 2008-2012 was generally better than the average condition throughout the Mid-Atlantic region, according to O'Connell et al. (2000), and similar to the other parks within the ERMN.

Overall, based on data collected on mammals, amphibians, reptiles, and birds, we rate wildlife in FONE as *resource is in good condition* (Table 4.13).

Table 4.13. Status of wildlife in Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological Integrity	Mammals, amphibians, reptiles, and birds		**Condition:** Data indicate that species are generally in good condition. **Trend:** No trend information is available because there are not sufficient on-site monitoring data. **Confidence:** The degree of confidence at FONE is low due to lack of data.

Trend Assessment

In 2011, Marshall et al. (2016) set sampling locations and methods for evaluating the BCI of streamside birds in FONE; they repeated the practice roughly biennially to gauge the trend over time. Based on a simple linear regression of the BCI scores over time, including unpublished 2017 data, it appears that the ecological condition of the streamside bird community and the associated forest habitat at these sites has not changed significantly since 2011 (Figure 4.11). However, similar trend data, even over a brief time period such as this, do not exist for mammals, amphibians, or reptiles in the park, and therefore we cannot assign a trend rating for wildlife (Table 4.13).

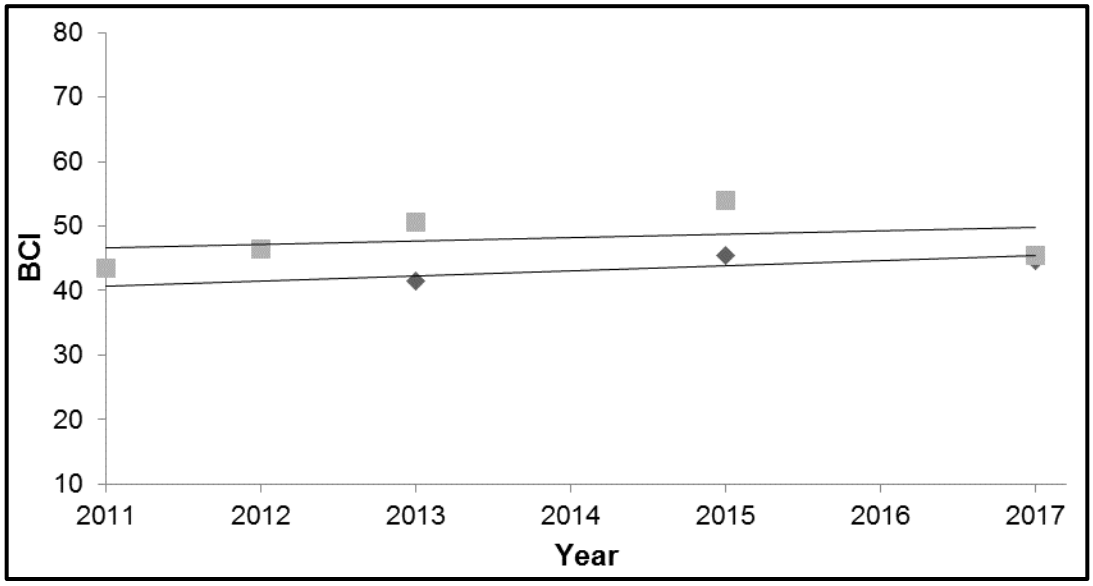


Figure 4.11. Simple linear regression of Bird Community Index (BCI) scores from 2011-2017 at two Fort Necessity National Battlefield sites (diamonds = Great Meadows Run; squares = unnamed tributary to Great Meadows Run). (Marshall et al., 2013; Marshall, unpublished data).

Confidence Assessment

Without more long-term data, our degree of confidence in this assessment is *low* (Table 4.13).

4.6. Threatened and Endangered Species

Relevance

An endangered species is one that is in danger of going extinct throughout all or a significant part of its range, a threatened species is one that may soon become endangered, and a species of concern is one that may soon be threatened. The NPS mission to preserve habitat undisturbed by humans is vitally important to protecting vulnerable species.

> *"In recent years, it has become apparent that human activities are causing the loss of biological diversity at an increasing rate: the current rate of extinctions appears to be among the highest in the fossil record. Although non-human organisms can cause extinctions of other species to a small degree, no other organisms produce such large effects over such wide areas as humans do…Habitat alteration and degradation are probably the most severe effects humans have on other species today"* (NRC, 1995).

For this reason, National Parks often serve as a haven for vulnerable species; more than half of all units harbor at least one endangered species (NPS, 2017b).

Methods and Data

As with the wildlife assessment, data presented here on the status of vulnerable species in the park were taken from the NPSpecies website. Information from personal communications with FONE personnel is also described.

Condition Assessment

There are currently no federally threatened or endangered organisms in FONE, though several species of plants, mammals, and birds are considered to be species of concern. One bird, the yellow-bellied flycatcher (*Empidonax flaviventris*), is listed as endangered by the Commonwealth of Pennsylvania, and one plant, bushy St. John's wort (*Hypericum densiflorum*), is threatened at the state level. Another plant, southern adder's-tongue (*Ophioglossum vulgatum*) may be extirpated in Pennsylvania. A full list of vulnerable organisms present, or probably present, in FONE is presented in Table 4.14.

Table 4.14. Vulnerable species present, or probably present, in Fort Necessity National Battlefield (NPSpecies, n.d.).

Category	Scientific Name	Common Name	Classification**
Plant	*Dichanthelium acuminatum**	Panic grass	SC
	Hypericum densiflorum	Bushy St. John's wort	PT
	Monotropa uniflora	Indian-pipe	SC
	Ophioglossum vulgatum	Southern adder's-tongue	PX
Mammal	*Eptesicus fuscus*	Big brown bat	SC
	Myotis lucifugus	Little brown myotis	SC
Bird	*Accipiter cooperii**	Cooper's hawk	SC
	Accipiter striatus	Sharp-shinned hawk	SC

Table 4.14 (continued). Vulnerable species present, or probably present, in Fort Necessity National Battlefield (NPSpecies, n.d.).

Category	Scientific Name	Common Name	Classification**
Birds (continued)	*Ammodramus savannarum*	Grasshopper sparrow	SC
	Ardea Herodias	Great blue heron	SC
	Buteo lineatus	Red-shouldered hawk	SC
	Cathartes aura	Turkey vulture	SC
	Certhia americana	Brown creeper	SC
	Coccyzus erythropthalmus	Black-billed cuckoo	SC
	*Contopus cooperi**	Olive-sided flycatcher	SC
	Dryocopus pileatus	Pileated woodpecker	SC
	Empidonax flaviventris	Yellow-bellied flycatcher	PE
	Empidonax traillii	Willow flycatcher	SC
	Icteria virens	Yellow-breasted chat	SC
	Melospiza lincolnii	Lincoln's sparrow	SC
	Picoides pubescens	Downy woodpecker	SC
	*Progne subis**	Purple martin	SC
	Sphyrapicus varius	Yellow-bellied sapsucker	SC
	Tachycineta bicolor	Tree swallow	SC
	Vermivora ruficapilla	Nashville warbler	SC
	Wilsonia pusilla	Wilson's warbler	SC

* Probably present

** PE – PA Endangered, PT – PA Threatened, PX – PA Extirpated, SC – Federal Species of Concern

Additionally, the American Woodcock (*Scolopax minor*), though not officially listed by either the federal or state governments, is considered by FONE personnel to be a species of concern in the park; they report that sightings have become more uncommon due to habitat loss. The woodcock favors wet, shrubby areas and maters from early March to mid-May. Restoration of the historic forest and meadow landscapes in FONE is critical to the successful recovery of this bird. To that end, 10 ha (25 ac) of habitat will be restored in FONE by the American Woodcock Habitat Restoration Project in a partnership with West Virginia University and the Great Lakes/Northern Forest Cooperative Ecosystem Studies Unit.

Since none of the species in the park are federally listed as threatened or endangered, we assign vulnerable species in FONE a rating of *resource is in good condition* (Table 4.15).

Table 4.15. Status of threatened and endangered species in Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological Integrity	Vulnerable Species Listed by the Government		**Condition:** No species are federally threatened or endangered. **Trend:** Unknown **Confidence:** The degree of confidence at FONE is medium due to lack of data.

Trend Assessment

There is not enough long-term data on the conservation status of organisms in the park to be able to assign a trend rating (Table 4.15)

Confidence Assessment

Confidence in this assessment is *medium* (Table 4.15).

4.7. Invasive Plant Species

Relevance

Invasive species are species outside of their native range that harm the environment, economy, or human health; they pose a threat to national parks by interfering with ecological processes, jeopardizing ecosystem integrity, and damaging cultural resources, potentially hampering visitor experience (NPS, n.d.).

Methods and Data

For this metric, we relied primarily on vegetation assessments by Zimmerman and Yoder (2006), Perles et al. (2010), Perles et a. (2014), Manning (2016), and ERMN Forest Health Monitoring data (unpublished) as they are the most recent and comprehensive vegetation data sets for the park. We also used Love and Anderson's (2009) assessment to develop our evaluation of the impact of invasive plants on FONE.

The reference condition for the eastern deciduous forest is an absence of non-native and invasive plants, though, given a long human history in the region, it is an unrealistic expectation. A recent review of forests in two nearby state parks, Ohiopyle and Laurel Hill, indicated that approximately 15% of plants present were non-native; according to expert opinion, this percentage is low given the history of anthropogenic disturbance in the area (Cole, 2017).

Comparison between FONE and the other ERMN parks can provide a frame of reference for conditions within FONE. Compared with other ERMN parks, FONE ranks third highest in invasive plant species metrics (Figure 4.12), containing more invasive plant species per plot and higher cover of invasive species than all but two ERMN parks.

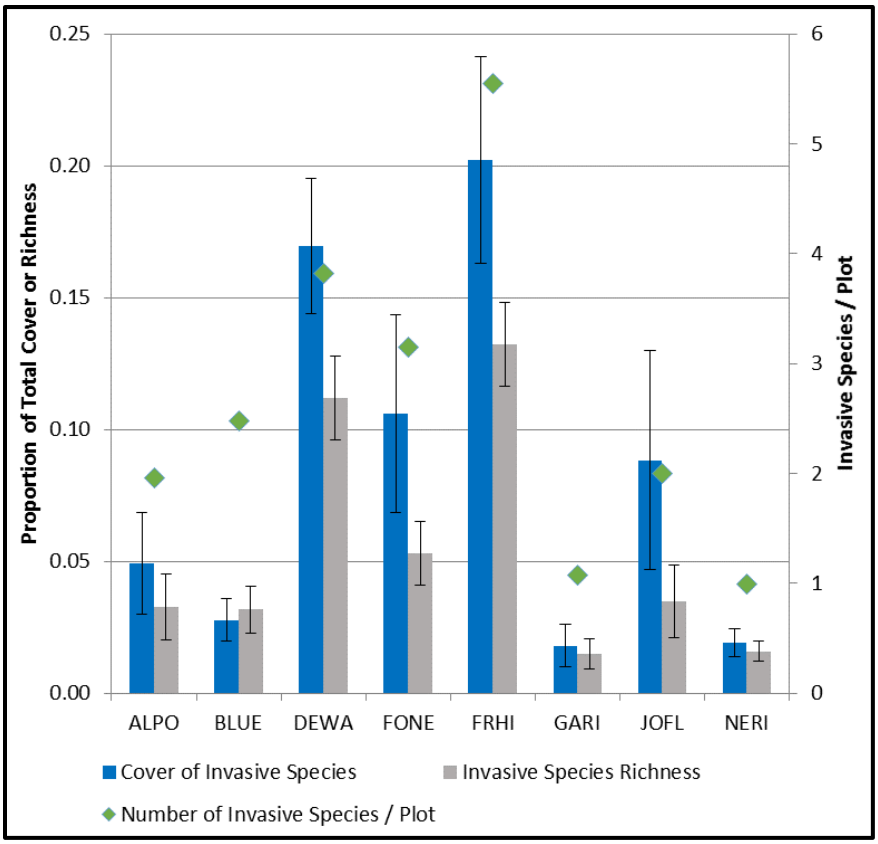


Figure 4.12. Average (± standard error) proportion of the total cover (blue bars) and species richness (brown bars) held by invasive exotic plant species as measured in monitoring quadrats in ERMN parks. The orange diamonds show the average number of invasive species/plot for each park, using all species data collected on each plot (Perles et al. 2014).

Condition Assessment

The Invasive Species Early Detection (ISED) Program of the ERMN surveys for incipient populations of invasive species in ERMN parks. Using this program, Manning (2016) searched for, and found no nascent issues with, notorious species such as narrowleaf bittercress (*Cardamine impatiens*), burning bush (*Euonymus alatus*), giant hogweed (*Heracleum mantegazzium*), Japanese hop (*Humulus japonicus*), privet (*Ligustrum* spp.), Chinese silver grass (*Miscanthus sinensis*), wavyleaf basketgrass (*Oplismenu hirtellus* ssp. *undulatifolius*), common reed (*Phragmites australis*), Asiatic tearthumb (*Polygonum perfoliatum*), kudzu (*Pueraria montana* var. *lobate*), pilewort (*Ranunculus ficaria*), buckthorn (*Rhamnus cathartica*), jetbead (*Rhodotypos scandens*), or linden viburnum (*Viburnum dilatatum*), although recent communication with FONE personnel suggests that burning bush has become a more serious concern in one section of the park. Many other invasive plant species are established in FONE. Perles et al. (2010) found that 60% of observed forest plots at FONE contained two or more non-native plant species; only about 25% of all plots were free from non-native plants. Japanese stiltgrass (*Microstegium vimineum*) is one of the most prolific invasive species in the forests of FONE (Perles et al., 2010). Successional habitats were even more likely than oak forest types to have high numbers of non-native plants (Zimmerman and Yoder, 2006). Zimmerman and Yoder (2006) documented 64 non-native species within the park and found that a

quarter of them were abundant or common (found in >10% of surveyed plots); the rest were uncommon or rare (found in <10% of surveyed plots) (Table 4.16). The three most abundant and widespread non-native species were Japanese barberry (*Berberis thunbergii*), Morrow's honeysuckle (*Lonicera morrowii*), and multiflora rose (*Rosa multiflora*). Morrow's honeysuckle is especially a concern as it is a prolific seed producer whose fruit is widely eaten and dispersed by wildlife (Perles et al., 2006). As a result, this shrub grows densely at 176,000 stems/ha and generally outcompetes native plants and trees in the region (Love and Anderson, 2009). In FONE, Morrow's honeysuckle primarily grows in the Great Meadows, thereby threatening a major cultural resource within the park. Other problematic species in that area include Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), teasel (*Dipsacus fullonum*), multiflora rose, and crown vetch (*Securigera varia*) (Perles et al., 2006).

Table 4.16. Abundant and common non-native species documented by Zimmerman and Yoder (2006) in Fort Necessity National Battlefield.

Scientific name	Common name	Abundance*
Agrostis stolonifera	Creeping bentgrass	C
Anthoxanthum odoratum	Sweet vernalgrass	A
Berberis thunbergii	Japanese barberry	A
Bromus inermis	Smooth brome	C
Cirsium vulgare	Bull thistle	C
Dactylus glomerata	Orchardgrass	A
Festuca elatior	Tall fescue	C
Holcus lanatus	Common velvetgrass	A
Leucanthemum vulgare	Oxeye daisy	A
Lonicera morrowii	Morrow's honeysuckle	A
Persicaria maculosa	Spotted ladysthumb	A
Picea abies	Norway spruce	C
Poa pratensis	Kentucky bluegrass	A
Prunella vulgaris	Common selfheal	C
Rosa multiflora	Multiflora rose	A
Securigera varia	Crown vetch	C

* A – Abundant, C – Common

The ERMN Forest Health Monitoring Program tracks 30 invasive plant species known to occur in FONE. However, the number of invasive plant species that occur in the park appears to be stable. The number of invasive plant species observed in ERMN Forest Health monitoring plots show no consistent trend (Figure 4.13), and no new invasive plant species have been identified in the park through the ERMN Invasive Species Early Detection Program since 2008 (Keefer et al. 2014).

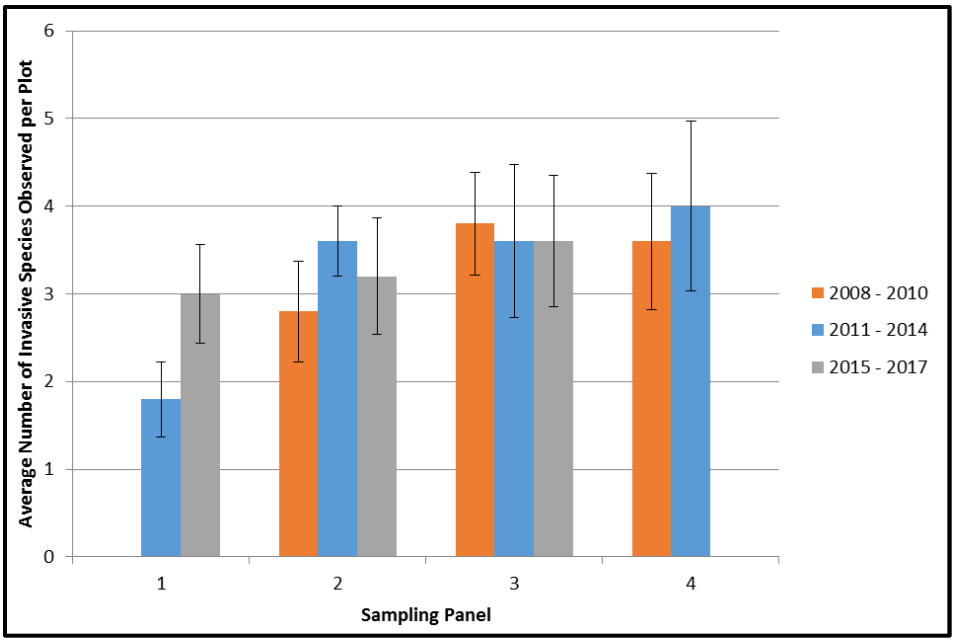


Figure 4.13. Average (± standard error) number of invasive plant species observed per plot in ERMN Forest Health monitoring plots (2008 – 2017).

Not surprisingly, the abundance of invasive plant species appears to be slowly increasing in FONE. Forest Health Monitoring data from ERMN show slight increases in the proportion of total groundstory cover (Figure 4.14) and the proportion of groundstory species richness (Figure 4.15) held by invasive plant species. However, these trends may not be statistically significant until more data are collected.

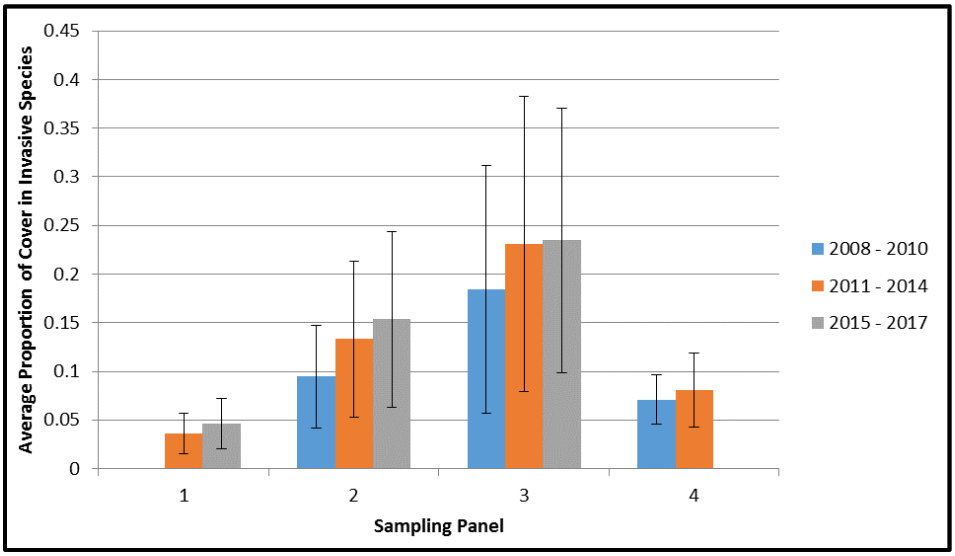


Figure 4.14. Average (± standard error) proportion of groundstory cover in invasive plant species (2008 – 2017), from ERMN Forest Health Monitoring Data.

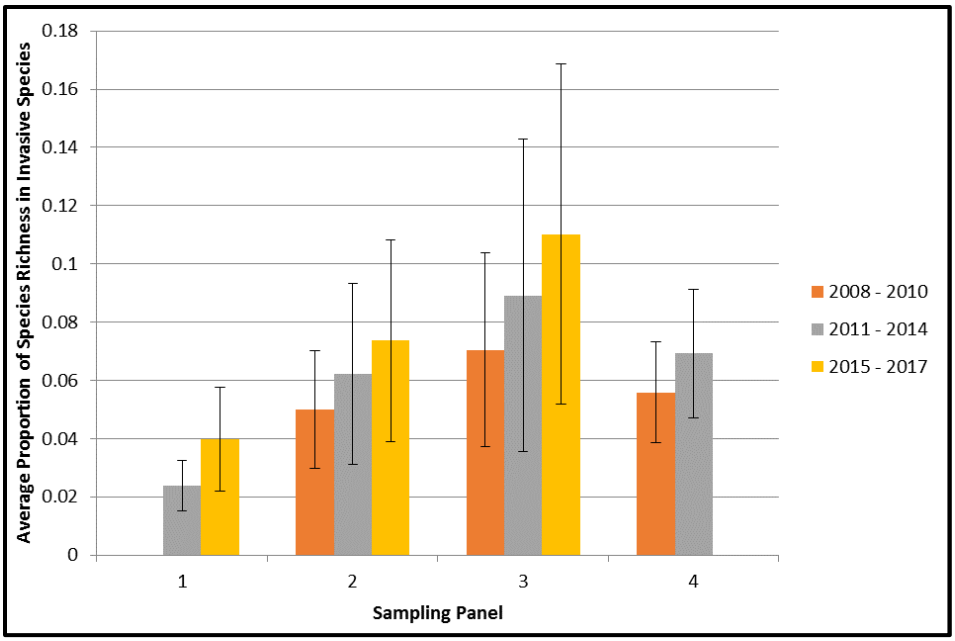
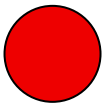


Figure 4.15. Average (± standard error) proportion of groundstory species richness in invasive plant species (2008-2017), from ERMN Forest Health Monitoring Data.

In addition to invasive plant species, invasive insects are a serious threat to forest resources in FONE. A recent Forest Health Assessment conducted by the US Forest Service (Sykes and Hill 2017) identified gypsy moth, emerald ash borer, hemlock wooly adelgid, Asian long-horned beetle, and Viburnum leaf beetle as invasive insects that could significantly alter the forests in FONE. The ERMN Invasive Species Early Detection Program (Keefer et al. 2014) also targets those invasive insects in FONE.

Based on the prevalence of non-native species within the park, we rate the condition as *resource warrants significant concern* (Table 4.17).

Table 4.17. Status of invasive plant species in Fort Necessity National Battlefield.

Biological Integrity Indicator	Measure	Condition Status/Trend	Rationale
Invasive plants	Invasive plants		**Condition:** Invasive plants are prevalent within the park and warrant significant concern for management of the forests and the Great Meadows. **Trend:** Further examination is required to understand the trends of invasive plants in the landscape and detect statistically significant trends. **Confidence:** The degree of confidence at FONE is medium due to a lack of repeated data.

Trend Assessment
More research is necessary to understand the trend of invasive plant species in FONE (Table 4.17).

Confidence Assessment
Given the large data set, confidence is *medium* (Table 4.17)

4.8. Landscape

Relevance
Transformations in the landscape due to natural and anthropogenic changes within and surrounding FONE is a fundamental component in evaluating the park's overall natural resource condition. The conversion of natural landscapes to agricultural and urban landscapes is usually permanent, and the replacement of natural habitat with development has been documented as the primary cause of biodiversity declines (Heinz Center, 2008; Luck, 2007; Wilcove et al., 1998).

Roads are particularly impactful on both biotic and abiotic variables in landscapes. The creation and use of roads fragments habitats, aids exotic plant dispersion, increases erosion, and adds to chemical pollution; roads also escalate animal mortality and create noise, lighting, and vibrations that interfere with wildlife (Forman et al., 2003).

Methods and Data
Feasibility studies and park reports were used in conjunction with NPScape data to provide a comprehensive evaluation of FONE's landscape; land cover change data was used in the assessment of landscape dynamics for FONE.

Condition categories are not established for land cover change. However, it is recognized that this factor is a stressor on natural resources. Data obtained from NPScape offer a representation of regional-scale changes for areas within and surrounding FONE. Land cover/use for FONE was assessed by using data that explained the type of land cover and land use conversion occurring around FONE in Fayette County. We deliberated if trends in these measures were increasing, decreasing, or remaining stable based on mapped projections provided by the NPScape program.

Condition Assessment
Based on 2010 land cover remote sensing data, FONE is mostly surrounded by forest and agriculture (Figure 4.16). Most of the forest is intact and viewed as core forest (Figure 4.17). The growth rate of Fayette County has been stable or in decline recently, and since development of these forests is not immediately threatened, we rate the landscape as *resource is in good condition* (Table 4.18).

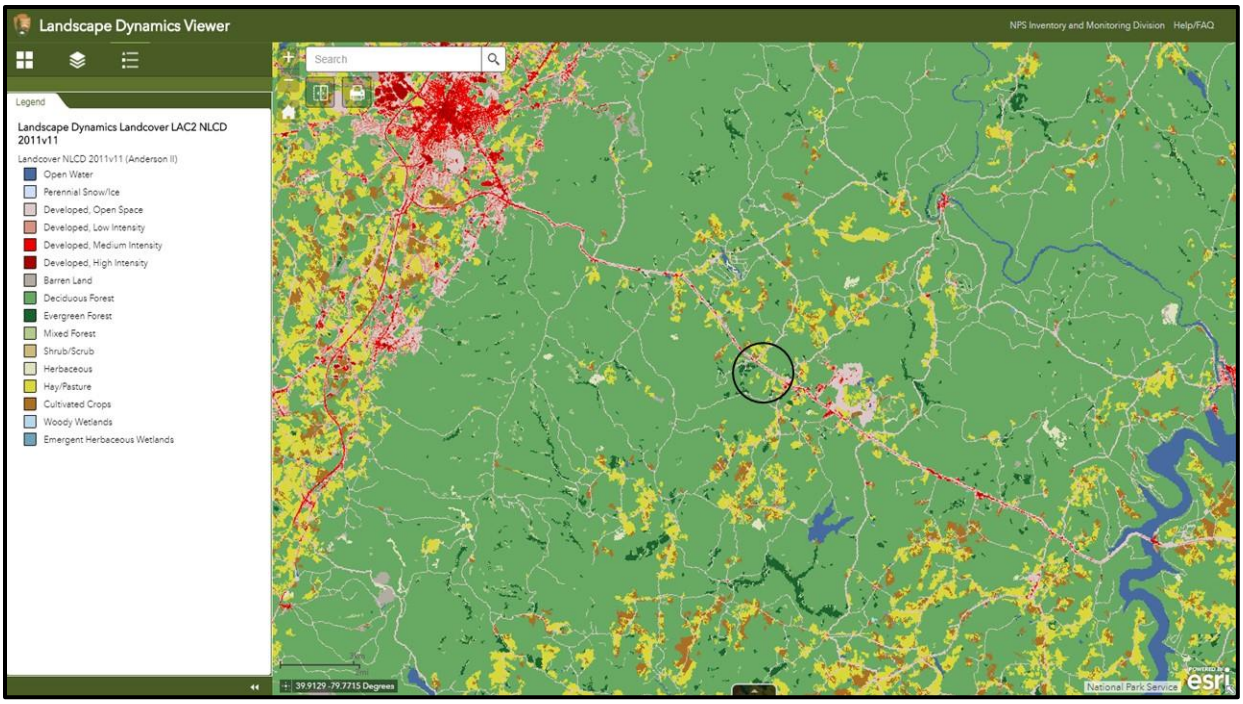


Figure 4.16. Land use surrounding Fort Necessity National Battlefield (black circle) in 2011, with green representing deciduous forest and yellow representing hay pasture; Uniontown, PA is the urban area to the west, in red. (NPScape, 2016).



Figure 4.17. The forested landscape surrounding Fort Necessity National Battlefield (black circle), showing intact core forest in green (NPScape, 2016).

Table 4.18. Status of landscape surrounding Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Land use	Forest Cover and Land Use		**Condition:** The area surrounding FONE has changed little in forest cover and land use over the past decade, remaining mostly forest or pasture. **Trend:** Stable. **Confidence:** The degree of confidence in forest cover and land use at FONE is high.

Trend Assessment

There has been little change in land use surrounding FONE since 2001, and thus we assign the landscape trend a status of *condition is unchanging* (Table 4.18).

Confidence Assessment

Confidence in the assessment was *high* (Table 4.18).

4.9. Soundscape

Relevance

Sound plays a critical role in intra- and interspecies communication, enabling crucial processes such as courtship, mating, predation, and predator avoidance. For this reason, studies have shown that wildlife can be adversely affected by sounds that intrude on their habitats. Documented responses of wildlife to noise include increased heart rate, startle responses, flight, disruption of behavior, and separation of mothers and young (Anderssen et al., 1993; Clough, 1982; Hartmann et al., 1992; Selye, 1956).

In addition to being vitally important to ecosystem health, an unimpaired acoustical environment is an essential part of visitor experience. Visitors often indicate that a significant reason for their visit is to enjoy the relative quiet and natural sounds that parks can offer (Haas and Wakefield, 1998; McDonald et al., 1995). Despite this desire for quiet environments, anthropogenic noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al., 2011). In fact, natural sounds have been referred to as an endangered resource because the ability to experience them is becoming progressively rarer (Jensen and Thompson, 2004).

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. Thus, NPS Management Policies require the NPS to preserve the park's natural soundscape and restore the degraded soundscape to the natural condition wherever possible (source? § 4.9). Although management policies currently refer to the term soundscape as the aggregate of all the natural sounds that occur in a park, there is a technical difference between 'acoustical environment' and 'soundscape.' The acoustical environment includes physical sound resources at a particular location (i.e., wildlife, waterfalls, wind, rain, and cultural or historical sounds), regardless of their audibility, whereas soundscape is the human perception of the

acoustical environment. There is also a concept of a cultural soundscape, established by NPS in section 5.3.1.7 of their Management Policies, which comprises cultural and historic sounds such as battle reenactments and tribal ceremonies (NPS, 2006a). Clarifying the distinction between 'acoustical environment' and 'soundscape' will allow managers to better create objectives for safeguarding both physical sound resources and the visitor experience.

Soundscape management is becoming more complex and challenging as threats to acoustic resources, both internal and external to park boundaries, increase. Noises that spoil the soundscape in FONE can originate from a number of sources, including various motorized equipment used in general park operations (e.g. mowing), increased visitation, aircrafts overhead, and nearby traffic on US 40. Understanding the condition and trend of FONE's soundscape will help determine the need, if any, for management and restoration efforts.

Methods and Data

The intensity, duration, and distribution of sound sources can be assessed by collecting sound pressure level (SPL) measurements, digital audio recordings, and meteorological data. Indicators typically summarized in resource assessments include natural and existing ambient sound levels and types of sound sources. Natural ambient sound levels are the acoustical conditions that exist in the absence of human-caused noise; it is to this level that the NPS compares the existing sound level as a measure of impact to the acoustical environment. Existing ambient sound level refers to the current sound intensity of an area, including both natural and anthropogenic sounds. The influence of anthropogenic noise on the acoustical environment is generally reported in terms of SPL across the full range of human hearing (12.5-20,000 Hz), but it is also useful to report results in a much narrower band (20-1250 Hz) since most human-caused sound is confined to these lower frequencies.

If we are to develop a complete understanding of a park's acoustical environment, we must consider a variety of sound metrics. This can make selecting one reference condition difficult. Ideally, reference conditions would be based on measurements collected in the park, but in cases where on-site measurements have not been gathered, one can reference meta-analyses of national park monitoring efforts such as those detailed in Lynch et al. (2011) and Mennitt et al. (2013).

As the National Park System comprises a wide variety of parks, one of two categories—urban or non-urban—is designated for each unit based on proximity to metropolitan areas (US Census, 2010). Park units that have at least 90% of their property within a metropolitan area are categorized as urban, while units that have at least 90% of the park property outside a metropolitan area, such as FONE, are categorized as non-urban. Parks that are distant from metropolitan areas possess lower sound levels, and they exhibit less divergence between existing sound levels and estimated natural sound levels (Schomer et al., 2011; U.S. EPA, 1971). Therefore, these quiet areas are more susceptible to subtle noise intrusions than urban areas, and both visitors and wildlife have a greater expectation for noise-free environments. Accordingly, the thresholds for caution and concern condition ratings are lower for non-urban parks than for units in urban areas.

Baseline acoustical monitoring has not been conducted in FONE, and therefore the condition and trend of the acoustic environment are unknown. In cases where the ability to collect acoustical data

on a site is limited, an alternative method is to use a geospatial sound model to predict natural and existing sound levels. The model developed by the NPS Natural Sounds and Night Skies Division (NSNSD) uses acoustic data collected at 244 sites in combination with 109 spatial explanatory layers, including land cover, hydrology, wind speed, and proximity to noise sources such as roads, railroads, and airports, to achieve a 270 m resolution (Mennitt et al. 2013) (Figure 4.18).

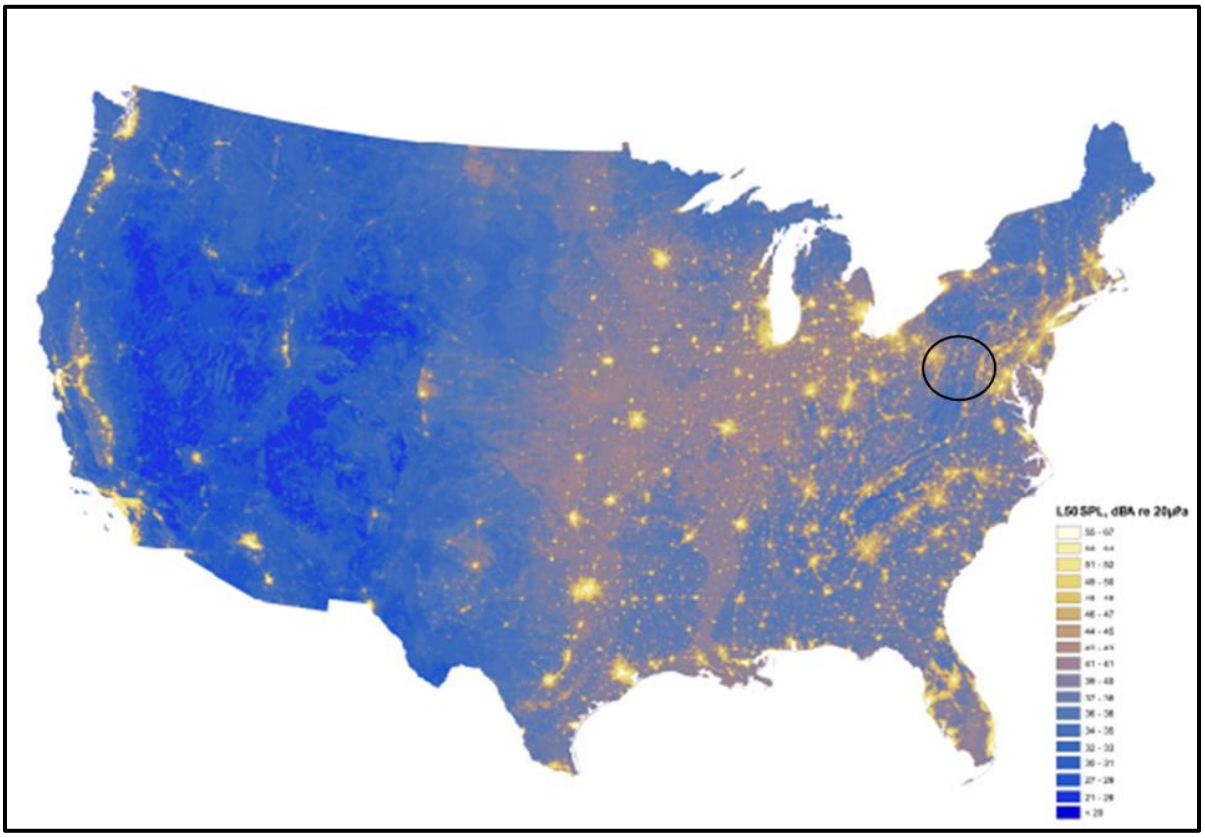


Figure 4.18. Ambient sound conditions for the United States; Fort Necessity National Battlefield is located within the black circle (NPS, 2017c).

Condition Assessment

Based upon the NPS NSNSD sound map above, we assign FONE's soundscape a rating of *resource is in good condition* (Table 4.19).

Table 4.19. Status of soundscape in Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Sound	Decibels		**Condition:** Based on the sound map, FONE appears to reside in a region of low noise. **Trend:** Unknown. **Confidence:** The degree of confidence is low because results come from a model.

Trend Assessment

No trend data are available since direct measurements have not been taken at FONE, meaning that we cannot assign trend rating (Table 4.19). However, given that little development has occurred outside of the park, it seems reasonable to presume that there has not been a substantial increase in noise.

Confidence Assessment

Confidence in the assessment for FONE's soundscape was *low* due to a lack of reference data specific to the park (Table 4.19). Baseline ambient data collection should be conducted, as it will clarify existing conditions and provide greater confidence in resource condition trends; in addition to providing site-specific information, such data could also strengthen the national noise model.

4.10. Lightscape

Relevance

The NPS uses the term 'natural lightscape' to describe the environment that exists in the absence of anthropogenic light at night (NPS, 2006b). The introduction of artificial light into the natural lightscape, either directly or indirectly, is called light pollution. Light pollution exists in two forms: sky glow, the brightening of the night sky from human-caused light scattered in the atmosphere, and glare, the direct shining of light. An examination of North American light emissions uncovers an approximately 6% annual increase from 1947 to 2000 (Cinzano and Elvidge, 2003). This rate of increased light emission exceeds the population growth rate, indicating that the intensification of light pollution is primarily due to more light emitted per capita and a greater percentage of uplight from fixtures. Light pollution tends to be most severe in urban environments and has pronounced ecological effects.

Natural lightscapes are critical for maintaining nocturnal habitat for wildlife. Research on the ecological consequences of artificial night lighting reveals numerous connections between light pollution and disruption of biological processes and rhythms, including foraging, communication, reproduction, and migration (Black, 2005; Boldogh et al., 2007; Buglife, 2011; Lorne and Salmon, 2007; Miller, 2006; Rich and Longcore, 2006; Santos et al., 2010; Stone et al., 2009; Svensson and Rydell, 1998).

Lightscapes are also culturally important and affect visitor enjoyment of nighttime scenery, such as starry skies; in the same manner that noise can disrupt a contemplative or peaceful scene, so too can anthropogenic light. Beyond aesthetics, a naturally dark surrounding may be integral to the historical content of a park. Just as the NPS strives to keep historic structures intact and the surrounding landscape representative of a significant time period, the lightscape of that historic time should also be conserved.

Methods and Data

The NPS has measured light intensity at more than 100 park sites across the U.S., but FONE is not one of them; in fact, only one site is in Pennsylvania (NPS NSNSD, 2016). As a result, we lack quantitative data and must rely on the overall night sky imagery developed by the NPS NSNSD

(Figure 4.19). The assessment was based on a visual comparison of the darkest parts of Pennsylvania to the areas around FONE.

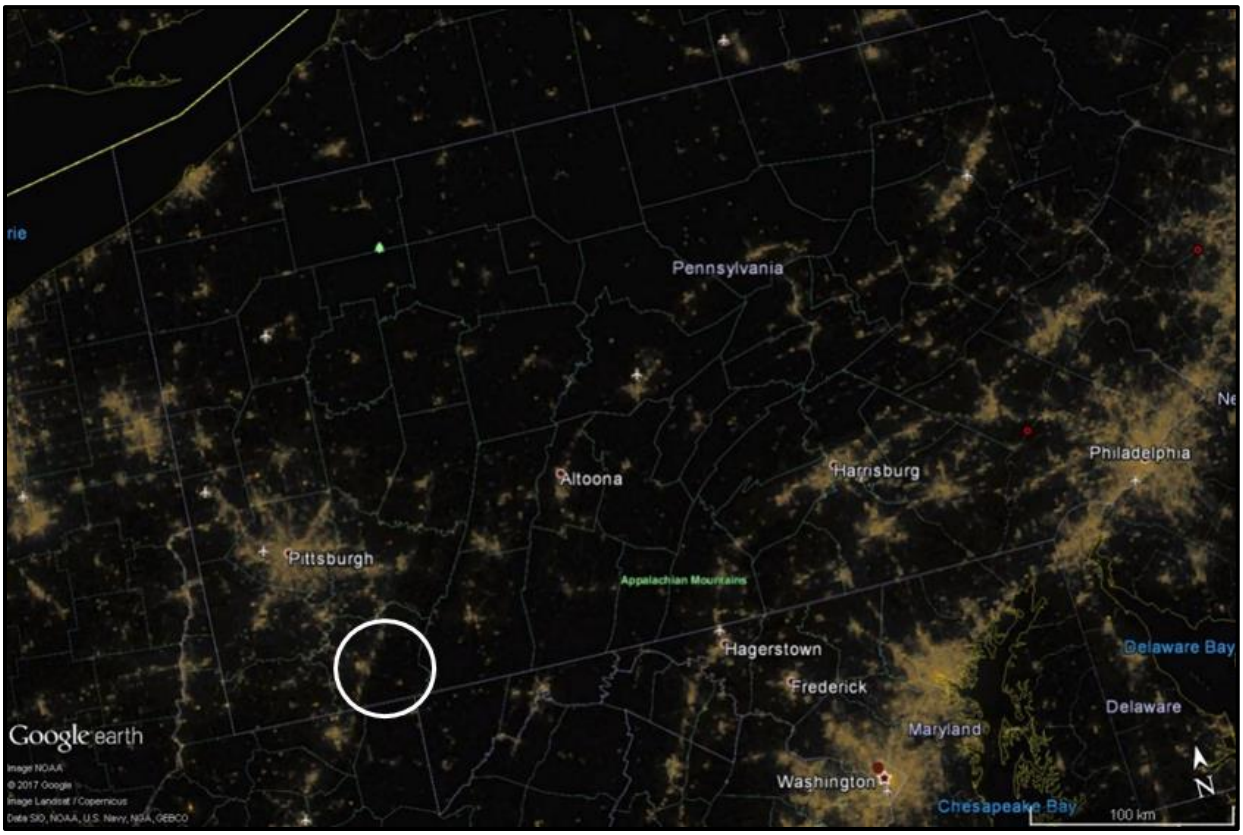


Figure 4.19. Nighttime light conditions for Fort Necessity National Battlefield (white circle) (NPS NSNSD, 2016).

Condition Assessment

Based on the NPS NSNSD map above, it seems that FONE is not heavily impacted by artificial light, despite Uniontown and Pittsburgh, to the northwest, exhibiting substantial light pollution. Though some glow may be evident from Uniontown, we still rate FONE's lightscape as *resource is in good condition* (Table 4.20).

Table 4.20. Status of lightscape in Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Light	Light at night		**Condition:** Based on the sound map, FONE appears to reside in a region of low anthropogenic light. **Trend:** Unknown. **Confidence:** The degree of confidence is low as results come from interpolation of a model.

Trend Assessment

With little development occurring around FONE, it seems unlikely that light pollution would be increasing; however, without quantitative light data from the region, we cannot assign a trend rating (Table 4.20).

Confidence Assessment

Confidence in the assessment was *low* due to the lack of light measurements in or around FONE (Table 4.20). Park management actions for lightscape conditions, if warranted, would require additional information, such as maximum vertical illuminance, horizontal illuminance, current impact to wildlife, and presence of sensitive species.

4.11. Visitor Usage

Relevance

From 1935-2016, FONE has received 12,390,571 recreational visitors (NPS Stats, 2017). Hosting such a large number of people has consequences for FONE's natural resources. To accommodate visitors and facilitate their enjoyment of the park, roads, parking lots, a visitor's center, a picnic area, lodging, and other infrastructure has been built. Once there, humans and their vehicles can contribute to noise and air pollution, trample vegetation, introduce foreign species, and remove resources for souvenirs, among other deleterious effects.

Methods and Data

NPS Stats (2017) collects visitation data for each NPS park, and these data were used to assess visitor activity. Visitation counts were analyzed from 1935-2016 and traffic counts were examined from 1993-2011. Trails and roads used by visitors were mapped in order to assess their possible impact to sensitive habitats within FONE.

Quantitative data regarding visitor impacts on natural resources, such as area of soil eroded, or percent of vegetation trampled, were absent for FONE; therefore, best professional judgment was used to assess the effects of visitor use on FONE's natural resources and discuss potential scenarios of visitor use conflicts in the park.

Condition Assessment

Fort Necessity has seen an increase in visitation over the past decade, more than doubling the number of visits that were typical during the 1990's and roughly equaling rates seen during the 1960's (Figure 4.20). The majority of visits occurs between April and October with peak visitation during July. In 2016, FONE ranked third in visits to battlefield parks with 290,021 visitors, behind only Antietam and Stone River National Battlefields. With many trails accessible to visitors year-round in FONE, people may be altering the environment by inducing soil erosion, creating side trails, and increasing trail width. We were unable to quantitatively determine the intensity of impact on soils, vegetation, and wildlife along trails in FONE from public use, but recommend the creation and continuation of proactive recreation rules to preserve the integrity of natural resources in FONE (NPS, 2006b).

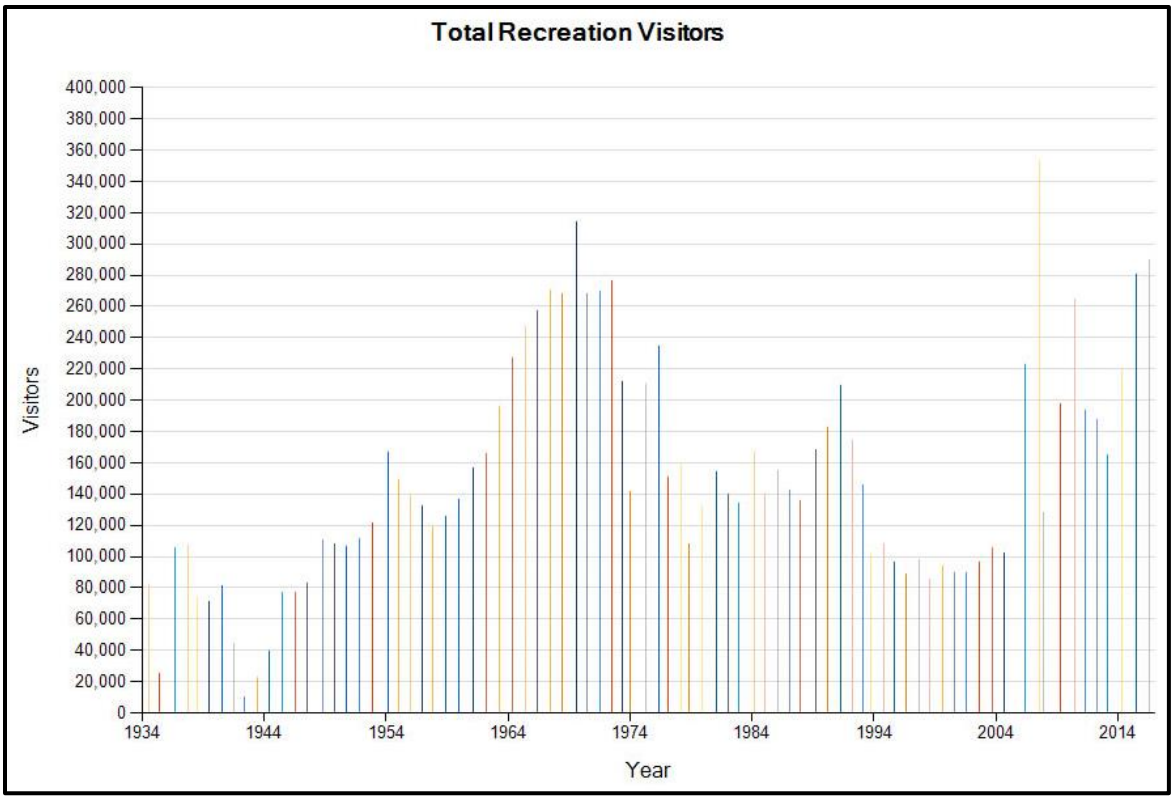
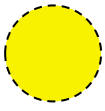


Figure 4.20. Annual visitation to Fort Necessity National Battlefield from 1935-2016 (NPS Stats, 2017).

Traffic counts were measured on the picnic loop road and at the visitor's center in the main unit, as well as at Braddock's Grave and in Jumonville Glen. Traffic was generally higher at the visitor's center and lowest at the picnic loop road.

Based on these patterns, we assign visitor usage and impact to FONE's natural resources a condition rating of *resource warrants moderate concern* (Table 4.21). While we don't currently see major impacts from visitation to FONE, such a rapid increase in visitation in a small park could lead to excessive pressure on natural resources and should, therefore, be treated with some concern.

Table 4.21. Status of visitor usage at Fort Necessity National Battlefield.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Visitation	Visitor counts		**Condition:** Visitation is increasing but no specific measures of impacts are known. Given the surge in visits to the park, moderate concern is warranted. **Trend:** Visitation trends are strong but data on visitor impacts are lacking. **Confidence:** The degree of confidence in the effects of visitation at FONE is low due to lack of data.

Trend Assessment

While visitation rate has increased since the 1930's, there is not enough data available on the impact of visitation on natural resources to determine if the condition is improving, deteriorating, or unchanging. Therefore, we cannot assign a trend rating (Table 4.21).

Confidence Assessment

Little quantitative data are available regarding impacts in FONE due to visitor usage; assessing visitor impacts on trails and natural resources should therefore be of moderate priority for FONE. Accordingly, our confidence in this assessment is *low* (Table 4.21).

5. Discussion

Table 5.1 shows a compilation of the natural resource condition assessments for FONE. A recurring obstacle in designating condition, trend, and confidence statuses was a lack of spatial and temporal data. Ideally, to address this issue, the park would begin to collect site-specific data, both to confirm resource conditions and to serve as a baseline for future trend analyses, and regularly manage and interpret said data. However, due to modest physical size and limited financial resources, FONE does not have the ability to collect detailed knowledge on each metric, nor is there a designated natural resource specialist on staff to maintain and decipher the desired information. This situation is not uncommon for small parks with a cultural focus, even though natural resources play a prominent role in presenting the circumstances of historic events. This is partly why the NPS established the Inventory and Monitoring Program so that a core suite of natural resources can be monitoring over the long-term to define and track changes in resource condition. FONE is part of the Eastern Rivers and Mountains Network (https://www.nps.gov/im/ermn/) which monitors forest health including invasive plants, stream condition using benthic macroinvertebrates as indicators, and the bird community as several locations within FONE. Similarly, the NPS Air Resource Division provides air quality condition and trends data for all NPS units. That said, there are numerous important natural resources in FONE for which the ERMN (or other divisions within NPS) does not collect status and trends information. The recommendations that follow for each natural resource acknowledge these constraints and include alternative methods for making data-driven management decisions at FONE.

Table 5.1. Summary of natural resource status and trends at Fort Necessity National Battlefield.

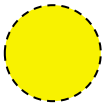
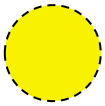
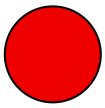
Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status	Rationale and Data Sources for Resource Condition	Reference Condition
Air Quality	Ozone	Human Health		NPS ARD 2011-2015 ozone level of 68.4 ppb	Exceeds NPS ARD *good* rating of ≤60 ppb
Air Quality	Ozone	Vegetation Health		NPS ARD 2011-2015 W126 metric of 8.7 ppm-hr	Exceeds NPS ARD *good* rating of <7 ppm-hrs
Air Quality	Visibility	Haze Index		NPS ARD 2011-2015 visibility of 8.5 dv above natural conditions	Exceeds NPS ARD *good* rating of <2 dv
Air Quality	Nitrogen	Wet Deposition		NPS ARD 2011-2015 deposition of 4.8 kg/ha/yr	Exceeds NPS ARD *good* rating of <1 kg/ha/yr
Air Quality	Sulfur	Wet Depostion		NPS ARD 2011-2015 deposition of 3.9 kg/ha/yr	Exceeds NPS ARD *good* rating of <1 kg/ha/yr

Table 5.1 (continued). Summary of natural resource status and trends at Fort Necessity National Battlefield.

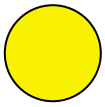
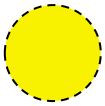
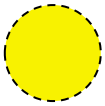
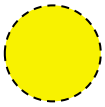
Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status	Rationale and Data Sources for Resource Condition	Reference Condition
Water Quality	Temperature, dissolved oxygen, specific conductance, dissolved solids, pH	˚C		Temperature exceeded standards for HQ-CWF streams	PA HQ-CWF streams not to exceed 19˚C in August
Wetlands	Biological Integrity	Hydrologic Modification		History of disturbance such as draining and ditching	Best professional judgment
Aquatic Species	Biological integrity	Macro-invertebrate IBI		MIBI score indicated some impairment	Lack of site-specific baseline data to serve as reference condition
Aquatic Species	Biological integrity	Fish Diversity		Fish community mostly typical of HQ-CWF streams	Lack of site-specific baseline data to serve as reference condition
Wildlife	Biological integrity	Mammals, Amphibians, Reptiles, and Birds		Abundant mammals and amphibians, high BCI score	Lack of site-specific baseline data to serve as reference condition
Threatened and Endangered Species	Biological Integrity	Vulnerable Species Listed by the Government		No species are federally threatened or endangered	Lack of site-specific baseline data to serve as reference condition
Invasive Plant Species	Invasive Plants	Invasive Plants		Non-native and invasive plants are prevalent	Best professional judgment
Landscape	Land Use	Forest Cover and Land Use		Surrounding land core forest and agricultural fields with little change in past decade	Best professional judgment
Soundscape	Sound	Decibels		NPS NSNSD map shows region has low noise levels	Best professional judgment
Lightscape	Light	Light at Night		NPS NSNSD map shows region has low light levels	Best professional judgment

Table 5.1 (continued). Summary of natural resource status and trends at Fort Necessity National Battlefield.

Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status	Rationale and Data Sources for Resource Condition	Reference Condition
Visitor Usage	Visitation	Visitor Counts		Visitation is increasing, but impacts are unknown	Best professional judgment

Air quality monitoring is a prime example of the aforementioned limitations; equipment is expensive, and the cost of measuring wet deposition is prohibitive for an area as small as FONE. Therefore, in addition to continuing to use regional data from the nearest CASTNET station, we encourage FONE to work with the NPS Air Resources Division as well as further cooperative efforts with local NGOs and educational institutions to measure site-specific air quality parameters when collaborative opportunities arise. The park should also discuss air quality with visitors, as their external actions may influence internal air quality.

Basic water quality instrumentation is more financially reasonable for the park to obtain, and we therefore advise regular monitoring of dissolved oxygen content, temperature, and pH; these three traits are easily measured and relevant indicators of stream health. We recommend at least monthly readings, which should be sufficient to track long-term trends. While this rate does not capture pulse changes, generating higher frequency data would require sophisticated, and expensive, instrumentation. So, too, would gathering water quantity data; the costs of installing and maintaining a gauging station are likely more than the park can afford. Additionally, placement of a gauge would be problematic, as it would be most effective within or near the Great Meadows, where it would interfere with the cultural landscape. Nonetheless, evaluation of water quality data is more complete when combined with water quantity data, and we suggest that FONE engage with as many outside research endeavors as possible to build a more complete data set.

We support ongoing efforts to rehabilitate FONE's central wetlands in the Great Meadows section adjacent to the reconstructed fort and urge all artificial ponds to be breached to allow for the return of upland and wetland habitats. Though the process of removing invasive plants, man-made ditches, and extraneous fill materials may make the area appear unsightly for a period of time, wetland vegetation regenerates quickly, and the overall result will be an improvement in site quality, both functionally and visually. We also suggest that the park produce a new spatial wetland layer that incorporates Perles et al.'s (2006) and Sharpe's (2013) and wetland layers with a digitized wetland map; this can be easily done by a skilled GIS technician and would provide the park with a useful, updated, and comprehensive wetland map from planning purposes.

Keeping abreast of water quality in the park in crucial to ensure that FONE's HQ-CWF streams continue to provide excellent habitat and do not fall out of compliance. Aquatic macroinvertebrates are now being sampled at least bi-annually in the park by the NPS Eastern Rivers and Mountains Network (Tzilkowski et al. 2016), which helps to generate a comprehensive, time series data set for

future trend analyses. Fish have also been sampled recently, and we recommend repeating that exercise every 2-3 years.

Amphibian and terrestrial wildlife in FONE should also be regularly monitored to better assess condition and trend. Small mammals can be surveyed with the help of traps and large mammals can be studied with trail cameras. The creation of a digital record collection for FONE bird sightings on the Cornell Lab of Ornithology's eBird site (https://ebird.org/hotspot/L1185879), with entries from 2003 and ongoing, should help with long-term data compilation for birds; we also recommend that the park join in Audubon's Christmas bird count (CBC), as there currently is no CBC site in the region that covers FONE. The NPS Eastern Rivers and Mountains Network monitors birds at several locations within FONE on a bi-annual basis (Marshall et al. 2016).

To prevent and monitor the spread of invasive plants, FONE should utilize input from the NPS Eastern Rivers and Mountains Network vegetation and soils monitoring program (Perles et al. 2014) and the NPS Eastern Rivers and Mountains Invasive Species Early Detection Program (e.g., Manning 2016) and help from local non-profits and universities. Regrettably, there is a substantial amount of non-native and invasive plant species already established in the park, in which cases NPS personnel should focus on removal strategies. Instead of employing a blanket technique for all non-native species, FONE should attempt a mix of physical and chemical approaches in targeted actions as necessary. For example, while a combination of mechanical control and selective herbicide application can be effective for honeysuckle, manual removal is the best way to control unrestricted growth of Japanese barberry (Perles et al., 2006; TNC CT and CT DEP, 1996).

Land use changes are perhaps the least of the park's concerns since the surrounding region is not experiencing rapid anthropogenic development—a problem affecting other small, cultural parks such as Morristown NHP (Wagner et al., 2014). The surrounding forest cover keeps noise and light levels low, so FONE should maintain positive relationships with neighboring land owners. For future condition and trend analyses, it would be useful to have noise and light measurements taken within the park as a baseline; our conclusions were drawn from large-scale maps and more precise data would be helpful.

It would also be beneficial to develop baseline data on visitor impacts to natural resources, as we could not find existing information on the subject. Such data is especially important as human traffic in the park increases; the surge in visitation over the past decade is good for the park's message but necessitates some caution with respect to natural resources.

In summary, the natural resources within Fort Necessity National Battlefield are moderately impacted. Most of the serious concerns reflect regional air quality issues over which the park has little control; the most important action the park can take in response to this assessment is to continue to collect site-specific baseline data on its natural resources.

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Appendix A. Mammals present, or probably present (*), in Fort Necessity National Battlefield (NPSpecies, n.d.).

Scientific Name	Common Name
Blarina brevicauda	Short-tailed shrew
Clethrionomys gapperi	Southern red-backed vole
Condylura cristata	Star-nosed mole
Didelphis virginiana	Virginia opossum
Eptesicus fuscus	Big brown bat
Erethizon dorsatum	Porcupine
Felis catus	Feral cat
Glaucomys volans	Southern flying squirrel
Lasiurus borealis	Red bat
Marmota monax	Groundhog, woodchuck
Martes pennanti	Fisher
Mephitis mephitis	Striped skunk
Microtus pennsylvanicus	Meadow vole
Mustela frenata	Long-tailed weasel
Myotis lucifugus	Little brown myotis
Napaeozapus insignis	Woodland jumping mouse
Odocoileus virginianus	White-tailed deer
Parascalops breweri	Hairy-tailed mole
Peromyscus leucopus	White-footed mouse
Peromyscus maniculatus	Deer mouse
Procyon lotor	Common raccoon
Sciurus carolinensis	Gray squirrel
Sciurus niger	Fox squirrel
Sorex cinereus	Masked shrew
Sorex fumeus	Smokey shrew
Sylvilagus floridanus	Eastern cottontail
Synaptomys cooperi	Southern bog lemming
Tamias striatus	Eastern chipmunk
Tamiasciurus hudsonicus	Red squirrel
Urocyon cinereoargenteus	Gray fox
Ursus americanus	Black bear
Zapus hudsonius	Meadow jumping mouse

Appendix B. Amphibians present, or probably present (*), in Fort Necessity National Battlefield (NPSpecies, n.d.).

Scientific Name	Common Name
*Ambystoma maculatum**	Spotted salamander
Anaxyrus americanus americanus	Eastern American toad
Anaxyrus fowleri	Fowler's toad
Desmognathus fuscus fuscus	Northern dusky salamander
Desmognathus monticola	Seal salamander
Desmognathus ochrophaeus	Mountain dusky salamander
Eurycea bislineata	Northern two-lined salamander
Eurycea longicauda longicauda	Long-tailed salamander
Gyrinophilus porphyriticus	Northern spring salamander
Hemidactylium scutatum	Four-toed salamander
Hyla chrysoscelis	Cope’s gray treefrog
Hyla versicolor	Gray tree frog
Notopthalamus viridescens	Red-spotted newt
Plethodon cinereus	Redback salamander
Plethodon glutinosus	Slimy salamander
Pseudacris crucifer crucifer	Northern spring peeper
Pseudotriton ruber ruber	Northern red salamander
Lithobates catesbeiana	Bullfrog
Lithobates clamitans melanota	Green frog
Lithobates palustris	Pickerel frog
Lithobates pipiens	Northern leopard frog
Lithobates sylvatica	Wood frog

Appendix C. Reptiles present, or probably present (*), in Fort Necessity National Battlefield (NPSpecies, n.d.).

Scientific Name	Common Name
*Agkistrodon contortrix mokasen**	Northern copperhead
Chelydra serpentina	Common snapping turtle
Chrysemys picta	Painted turtle
Coluber constrictor constrictor	Northern black racer
Diadophis punctatus edwardsii	Northern ringneck snake
Pantherophis alleghaniensis obsolete	Rat snake
*Glyptemys insculpta**	Wood turtle
Lampropeltis triangulum triangulum	Eastern milk snake
Nerodia sipedon sipedon	Northern watersnake
Opheodrys vernalis	Smooth green snake
*Storeria occipitomaculata**	Northern redbelly snake
Terrepene carolina carolina	Eastern box turtle
Thamnophis sirtalis sirtalis	Eastern garter snake
Virginia valeriae pulchra	Mountain earth snake

Appendix D. Birds present, or probably present (*), in Fort Necessity National Battlefield (eBird, 2018; NPSpecies, n.d.).

Scientific Name	Common Name
*Accipiter cooperii**	Cooper's hawk
Accipiter gentilis	Northern goshawk
Accipiter striatus	Sharp-shinned hawk
Aegolius acadicus	Northern saw-whet owl
Agelaius phoeniceus	Red-winged blackbird
Aix sponsa	Wood duck
Ammodramus savannarum	Grasshopper sparrow
Anas platyrhynchos	Mallard
*Anthus rubescens**	American pipit
Archilochus colubris	Ruby-throated hummingbird
Ardea herodias	Great blue heron
Baeolophus bicolor	Tufted titmouse
Bombycilla cedrorum	Cedar waxwing
Bonasa umbellus	Ruffed grouse
Branta canadensis	Canada goose
Bubo virginianus	Great horned owl
Buteo jamaicensis	Red-tailed hawk
Buteo lineatus	Red-shouldered hawk
Buteo platypterus	Broad-winged hawk
Butorides virescens	Green heron
Calidris minutilla	Least sandpiper
*Caprimulgus vociferous**	Whip-poor-will
Cardinalis cardinalis	Northern cardinal
Carduelis flammea	Common redpoll
*Carduelis pinus**	Pine siskin
Carpodacus mexicanus	House finch
Carpodacus purpureus	Purple finch
Cathartes aura	Turkey vulture
*Catharus fuscescens**	Veery
Catharus guttatus	Hermit thrush
*Catharus minimus**	Gray-cheeked thrush
Catharus ustulatus	Swainson's thrush
Certhia americana	Brown creeper
Chaetura pelagica	Chimney swift
Charadrius vociferus	Killdeer
Coccothraustes vespertinus	Evening grosbeak

Scientific Name	Common Name
Coccyzus americanus	Yellow-billed cuckoo
Coccyzus erythropthalmus	Black-billed cuckoo
Colaptes auratus	Northern flicker
*Columba livia**	Rock dove
*Contopus cooperi**	Olive-sided flycatcher
Contopus virens	Eastern wood-pewee
Coragyps atratus	Black vulture
Corvus brachyrhynchos	American crow
Corvus corax	Common raven
Cyanocitta cristata	Blue jay
Dendroica caerulescens	Black-throated blue warbler
Dendroica castanea	Bay-breasted warbler
Dendroica cerulean	Cerulean warbler
Dendroica coronata	Yellow-rumped warbler
Dendroica discolor	Prairie warbler
Dendroica dominica	Yellow-throated warbler
Dendroica fusca	Blackburnian warbler
Dendroica magnolia	Magnolia warbler
Dendroica palmarum	Palm warbler
Dendroica pensylvanica	Chestnut-sided warbler
Dendroica petechia	Yellow warbler
Dendroica pinus	Pine warbler
Dendroica striata	Blackpoll warbler
Dendroica tigrina	Cape May warbler
Dendroica virens	Black-throated green warbler
Dryocopus pileatus	Pileated woodpecker
Dumetella carolinensis	Gray catbird
Empidonax alnorum	Alder flycatcher
Empidonax flaviventris	Yellow-bellied flycatcher
Empidonax minimus	Least flycatcher
Empidonax traillii	Willow flycatcher
Empidonax virescens	Acadian flycatcher
*Eremophila alpestris**	Horned lark
*Euphagus carolinus**	Rusty blackbird
Falco sparverius	American kestrel
Geothlypis trichas	Common yellowthroat
Helmitheros vermivorus	Worm-eating warbler
Hirundo rustica	Barn swallow
Hylocichla mustelina	Wood thrush

Scientific Name	Common Name
Icteria virens	Yellow-breasted chat
Icterus galbula	Baltimore oriole, northern oriole
*Icterus spurius**	Orchard oriole
Junco hyemalis	Dark-eyed junco
Larus delawarensis	Ring-billed gull
Megaceryle alcyon	Belted kingfisher
Melanerpes carolinus	Red-bellied woodpecker
Melanerpes erythrocephalus	Red-headed woodpecker
Meleagris gallopavo	Wild turkey
Melospiza georgiana	Swamp sparrow
Melospiza lincolnii	Lincoln's sparrow
Melospiza melodia	Song sparrow
Mimus polyglottos	Northern mockingbird
Mniotilta varia	Black and white warbler
Molothrus ater	Brown-headed cowbird
Myiarchus crinitus	Great crested flycatcher
*Oporornis agilis**	Connecticut warbler
Oporornis formosus	Kentucky warbler
*Oporornis philadelphia**	Mourning warbler
Otus asio	Eastern screech-owl
Parkesia motacilla	Louisiana waterthrush
Parula americana	Northern parula
Passer domesticus	House sparrow
Passerculus sandwichensis	Savannah sparrow
Passerella iliaca	Fox sparrow
Passerina cyanea	Indigo bunting
Pheucticus ludovicianus	Rose-breasted grosbeak
Picoides pubescens	Downy woodpecker
Picoides villosus	Hairy woodpecker
Pipilo erythrophthalmus	Eastern towhee, rufous-sided towhee
Piranga olivacea	Scarlet tanager
Poecile atricapillus	Black-capped chickadee
Poecile carolinensis	Carolina chickadee
Polioptila caerulea	Blue-gray gnatcatcher
Pooecetes gramineus	Vesper sparrow
*Progne subis**	Purple martin
Quiscalus quiscula	Common grackle
Regulus calendula	Ruby-crowned kinglet
Regulus satrapa	Golden-crowned kinglet

Scientific Name	Common Name
Sayornis phoebe	Eastern phoebe
Scolopax minor	American woodcock
Seiurus aurocapilla	Ovenbird
*Seiurus noveboracensis**	Northern waterthrush
Setophaga ruticilla	American redstart
Sialia sialis	Eastern bluebird
Sitta canadensis	Red-breasted nuthatch
Sitta carolinensis	White-breasted nuthatch
Sphyrapicus varius	Yellow-bellied sapsucker
Spinus tristis	American goldfinch
Spizella arborea	American tree sparrow
Spizella passerina	Chipping sparrow
Spizella pusilla	Field sparrow
Strix varia	Barred owl
Sturnella magna	Eastern meadowlark
Sturnus vulgaris	European starling
Tachycineta bicolor	Tree swallow
Thryothorus ludovicianus	Carolina wren
Toxostoma rufum	Brown thrasher
Troglodytes aedon	House wren
Turdus migratorius	American robin
*Tyrannus tyrannus**	Eastern kingbird
*Vermivora celata**	Orange-crowned warbler
Vermivora chrysoptera	Golden-winged warbler
Vermivora peregrina	Tennessee warbler
Vermivora pinus	Blue-winged warbler
Vermivora ruficapilla	Nashville warbler
Vireo flavifrons	Yellow-throated vireo
Vireo gilvus	Warbling vireo
Vireo griseus	White-eyed vireo
Vireo olivaceus	Red-eyed vireo
*Vireo philadelphicus**	Philadelphia vireo
Vireo solitarius	Solitary vireo, blue-headed vireo
Wilsonia canadensis	Canada warbler
Wilsonia citrina	Hooded warbler
Wilsonia pusilla	Wilson's warbler
Zenaida macroura	Mourning dove
Zonotrichia albicollis	White-throated sparrow
Zonotrichia leucophrys	White-crowned sparrow

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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