National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Friendship Hill National Historic Site

Natural Resource Report NPS/FRHI/NRR—2019/1978

ON THE COVER
Photo of the Gallatin House, Friendship Hill National Historic Site.
Credit: NPS.

Natural Resource Condition Assessment

Friendship Hill National Historic Site

Natural Resource Report NPS/FRHI/NRR—2019/1978

Charles Andrew Cole[1], Abhinandan Bera[1], Sarah Rothman[2], C. Paola Ferreri[3]

[1] The Pennsylvania State University
Department of Landscape Architecture
329 Stuckeman Family Building
University Park, PA 16802

[2] The Pennsylvania State University
Intercollege Graduate Degree Program in Ecology
105 Stuckeman Family Building
University Park, PA 16802

[3] The Pennsylvania State University
Department of Ecosystem Science and Management
408 Forest Resources Building
University Park, PA 16802

August 2019

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

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

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review, which was provided by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. The level and extent of peer review was based on the importance of report content or its potentially controversial or precedent-setting nature.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the Natural Resource Condition Assessment Program website and the Natural Resource Publications Management website. If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Cole, C. A., A. Bera, S. Rothman, and C. P. Ferreri. 2019. Natural resource condition assessment: Friendship Hill National Historic Site. Natural Resource Report NPS/FRHI/NRR—2019/1978. National Park Service, Fort Collins, Colorado.

NPS 476/159884, August 2019

Contents

Contents (continued)

Contents (continued)

Contents (continued)

Contents (continued)

Figures

Page

Figures (continued)

Page

Figures (continued)

Page

Tables

Page

Tables (continued)

Page

Appendices

Page

Executive Summary

Background and Context

Friendship Hill National Historic Site (FRHI) was established in November 1978 to commemorate the life and many accomplishments of Albert Gallatin (1761-1849). In 1785, he purchased 370 acres (150 hectares) of land in southwest Pennsylvania and named it Friendship Hill. Despite Gallatin's love for this frontier estate, he frequently traveled for his political career, which began as early as 1788 with his contribution to the creation of the Bill of Rights and Pennsylvania's constitution. From 1790-1793, Gallatin represented Fayette County in the Pennsylvania State Legislature, where he worked toward a state-wide public education system and the abolition of slavery. He then moved to the U.S. House of Representatives, in which he founded the Ways and Means Committee. In 1801, newly-elected President Thomas Jefferson appointed Gallatin as Secretary of the Treasury, a position he held until 1814. During this tenure, the longest of any Secretary of the Treasury, Gallatin reduced the national debt, reformed the tax system, and negotiated terms for the end of the War of 1812. Though his duties kept him away from Friendship Hill, he continued to develop the western frontier by acquiring the Louisiana Purchase and supporting infrastructure such as the National Road. In addition to doubling the size of the country, these actions allowed previously landlocked settlers access to an ocean port (New Orleans) thus improving trade. Gallatin also commissioned the famed exploration of Lewis and Clark to map the new territory in the interest of scientific knowledge and potential economic opportunities for western landowners such as himself. In 1825, Gallatin left Friendship Hill to live in the East near his wife's family, eventually selling the home in 1832. Gallatin's former residence is now an Historic Site including 675 acres (273 hectares) of rolling hills overlooking the Monongahela River, and its unique mix of cultural and natural resources is preserved by the National Park Service.

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. 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 FRHI 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 FRHI in addition to those analyzed in this report.

Threats to FRHI

Friendship Hill National Historic Site is primarily a cultural park, but it includes a variety of natural resources. Regrettably, this area has been affected by mining, timbering, and the presence of a railroad, among other impacts. While impacts 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 FRHI in other, often more indirect, ways. The effects of mining for coal are still evident as acid mine drainage (AMD) still impacts Ice Pond Run. The forest understory is 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 FRHI 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 increase, although FRHI is somewhat shielded at the moment by its rural buffer.

Current Condition of Natural Resources in FRHI

Air Quality

Air quality can affect visitor and wildlife well-being, plant health, water quality, and the lightscape in FRHI. Parameters of interest for FRHI'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 FRHI's air quality for visibility and wet nitrogen and sulfur deposition as *resource warrants significant concern*. Visibility has not improved over time and we rate this as *resource warrants significant concern*.

Water Quality
Water quality is impaired within FHI as evidenced by the macroinvertebrate data and the presence of AMD in Ice Pond Run. As such, we rate this as *resource warrants significant concern*.

Wetlands
Wetlands in the park receive a rating of *resource warrants moderate concern*. Most are in good shape, but some are impacted by AMD associated with Ice Pond Run.

Aquatic Species
Macroinvertebrate data indicate conditions where streams and ponds are depauperate with respect to diversity and species indicative of high-quality waters. We rate this as *resource warrants significant concern*. Fish species data are lacking, though represent typical warm water streams when found. No fish data were collected from Ice Pond Run due to AMD issues. As such, we rate this as *resource warrants significant concern*.

Wildlife
Wildlife populations (mammals, birds, amphibians, and reptiles) all appear to be doing well. As such, we rate this as *resource is in good condition*.

Threatened and Endangered Species
Only one species within FRHI is listed as federally threatened (Northern long-eared myotis (*Myotis septentrionalis*)) and only one species is Pennsylvania endangered (Yellow-bellied flycatcher (*Empidonax flaviventris*)). We rate this as *resource is in good condition*.

Invasive Plants
Non-native and invasive vegetation and pests are established within FRHI as a result of past and present anthropogenic activities and environmental factors. We assigned this issue a status of *resource warrants significant concern* due to the potential for invasive plants to 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 stiltgrass (*Microstegium vimineum*), Morrow's honeysuckle (*Lonicera morrowi*), and multiflora rose (*Rosa multiflora*).

Forest Health
Much of the forested landscape in and around FRHI has been subject to multiple disturbances, including logging and mining. Regeneration of the forest has been slow and below replacement levels. As such, we rate this as *resource warrants significant concern*.

Landscape
FRHI 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 FRHI 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 FRHI (data are from models), 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

For a small cultural park, FRHI has 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. 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 Friendship Hill National Historic Site 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.

Chapter 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.

Chapter 2. Introduction and Resource Setting

2.1. Introduction

Friendship Hill National Historic Site (FRHI) was established in November 1978 to commemorate the life and many accomplishments of Albert Gallatin (1761-1849) (NPS 2013). In 1785, he purchased 370 acres (150 hectares) of land in southwest Pennsylvania and named it Friendship Hill; construction of his house, now restored and on display in the heart of the park, began in 1789. Despite Gallatin's love for this frontier estate, he frequently traveled for his political career, which began as early as 1788 with his contribution to the creation of the Bill of Rights and Pennsylvania's constitution. From 1790-1793, Gallatin represented Fayette County in the Pennsylvania State Legislature, where he worked toward a state-wide public education system and the abolition of slavery. He then moved to the U.S. House of Representatives, in which he founded the Ways and Means Committee. In 1801, newly-elected President Thomas Jefferson appointed Gallatin as Secretary of the Treasury, a position he held until 1814. During this tenure, the longest of any Secretary of the Treasury, Gallatin reduced the national debt, reformed the tax system, and negotiated terms for the end of the War of 1812. Though his duties kept him away from Friendship Hill, he continued to develop the western frontier by acquiring the Louisiana Purchase and supporting infrastructure such as the National Road. In addition to doubling the size of the country, these actions allowed previously landlocked settlers access to an ocean port (New Orleans) thus improving trade. Gallatin also commissioned the famed exploration of Lewis and Clark to map the new territory in the interest of scientific knowledge and potential economic opportunities for western landowners such as himself. In 1825, Gallatin left Friendship Hill to live in the East near his wife's family, eventually selling the home in 1832.

Gallatin's former residence is now an Historic Site including 675 acres (273 hectares) of rolling hills overlooking the Monongahela River, and its unique mix of cultural and natural resources is preserved by the National Park Service (NPS) (Thornberry-Ehrlich 2008, NPS 2013). This Natural Resource Condition Assessment (NRCA) aims to compile information from existing reports, documents, and maps to present a thorough synthesis of the state of natural resources associated with the park and identify areas that need attention.

2.1.1. Enabling Legislation

Friendship Hill National Historic Site was established in November 1978 to commemorate the life and accomplishments of Albert Gallatin (1761-1849), who is significant for the

> *...important role [he played] in the development of the early Republic. As a leader of the Jeffersonian Republicans, Gallatin held national office as a congressman, secretary of the treasury, and minister to France and England. He arranged financing for the Lewis & Clark Expedition, the National Road, and the Louisiana Purchase and helped negotiate the Treaty of Ghent, ending the War of 1812* (LRIP 2002).

As his primary home throughout his political career, Friendship Hill is thus historically significant as well; indeed, its location on the western boundary of the United States at the time may have influenced Gallatin's political decisions to expand and develop the frontier (NPS 2018).

Accordingly, the mission of FRHI personnel and partners is to

> *…engage people with the ideals, philosophy, and accomplishments of Albert Gallatin, and his contributions to the development of the United States through interpretation, preservation, protection, and enjoyment of the cultural, historical, and natural resources of Friendship Hill* (LRIP 2002).

To accomplish this mission, personnel and partners of FRHI strive to:

- *preserve and protect the cultural and natural resources associated with Albert Gallatin and Friendship Hill, which are located within the legislated boundary of the site;*
- *engage visitors and educate them about the life and times of Albert Gallatin and his vision for the nation by informing them of his influence on U.S. history; and*
- *enable comprehensive and meaningful learning through a recreational environment* (LRIP 2002).

2.1.2. Geographic Setting

The Friendship Hill National Historic Site is located 45 miles (72 km) south of Pittsburgh and 15 miles (23 km) southwest of Uniontown in Fayette County, Pennsylvania (Figure 2.1). A detailed map of the site and its resources is shown in Figure 2.2. There are some streams that originate inside the park boundaries, as well as a few wetlands, but the main water feature is the adjacent Monongahela River. Though aesthetically beautiful, FRHI's hydrology is compromised by water pollution due to acid mine drainage (AMD) (Sibrell and Watten 2003; Sibrell et al. 2003) (Figure 2.3). Nevertheless, the rolling hills support rich vegetation that provides for more than 200 species of mammals, amphibians, reptiles, and birds (irma.nps.gov/NPSpecies).

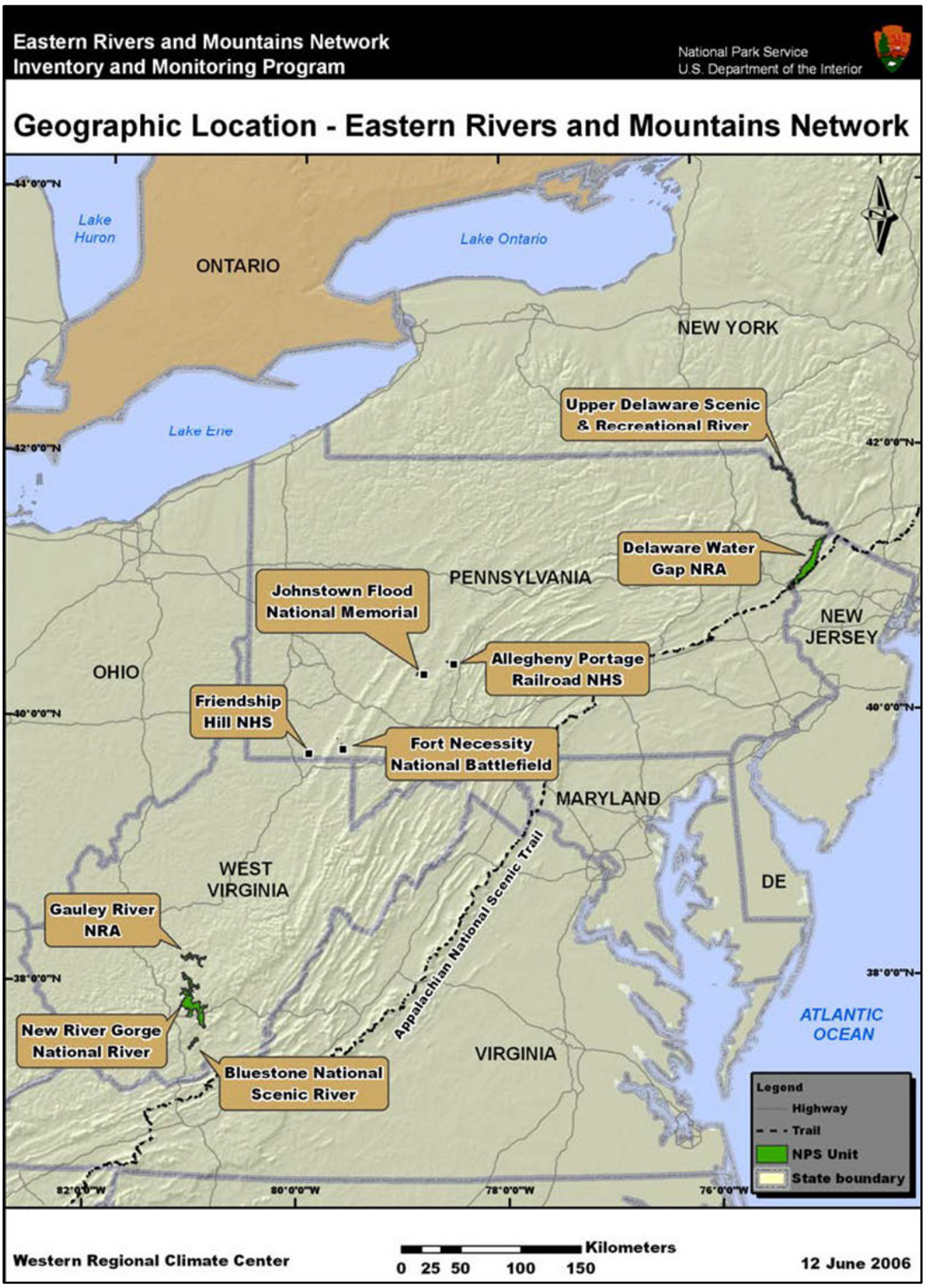


Figure 2.1. Friendship Hill National Historic Site amongst the other National Parks of the Eastern Rivers and Mountains Network (Davey et al. 2006).

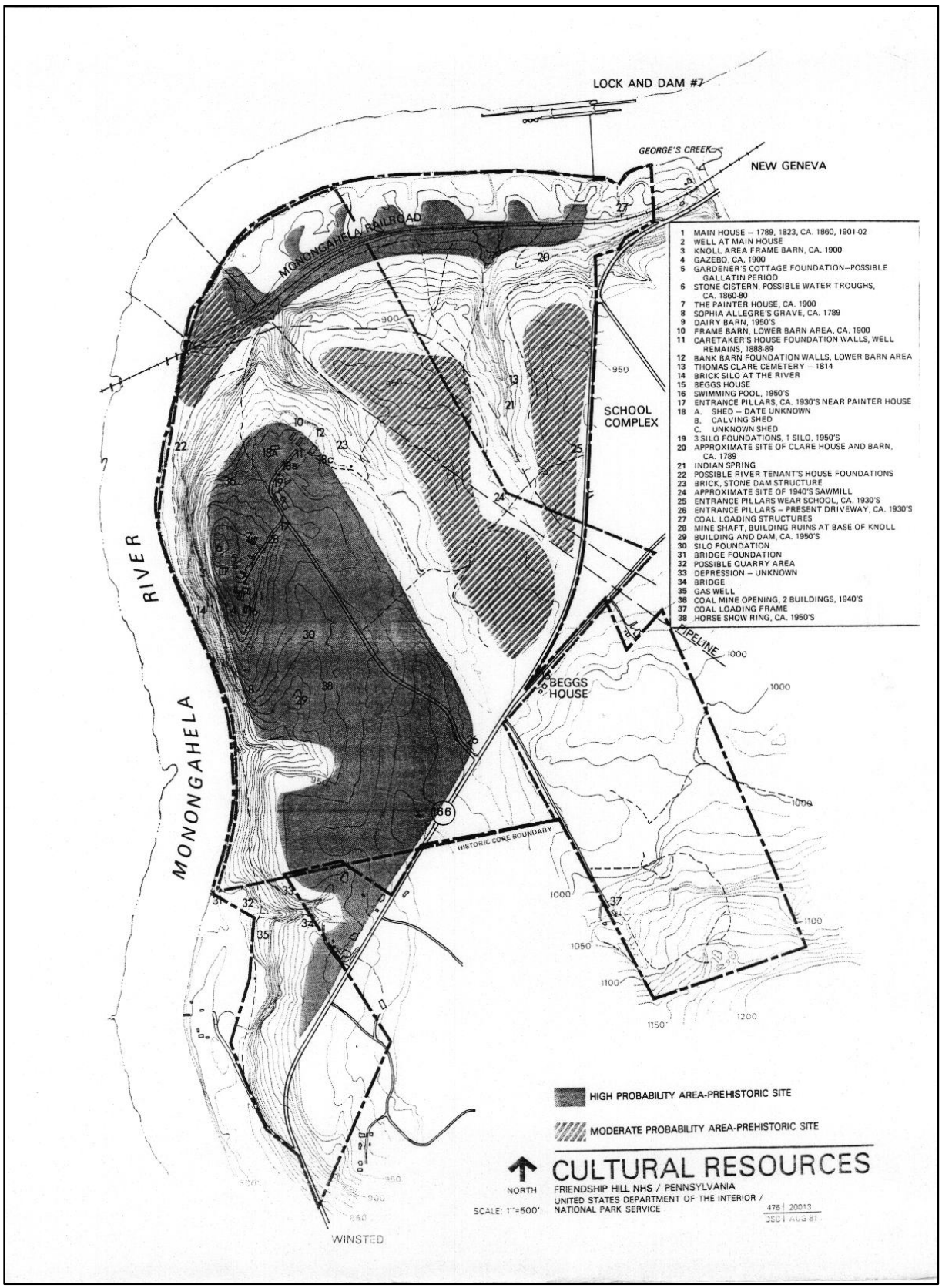


Figure 2.2. Map of Friendship Hill National Historic Site (Unrau 1981).

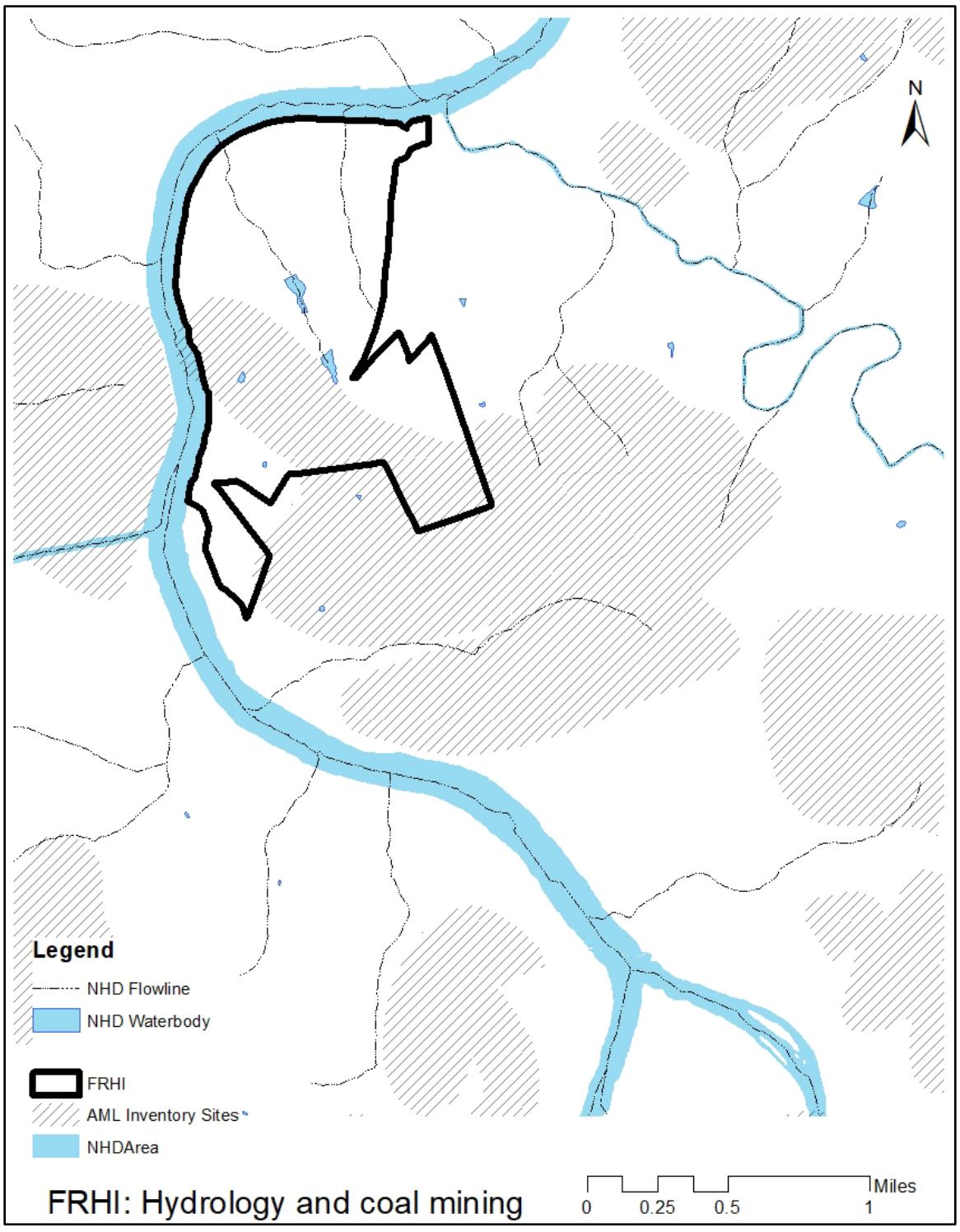


Figure 2.3. Surface water hydrology and abandoned coal mine lands in and around Friendship Hill National Historic Site (USGS 2004a, 2004b; PA DEP 2018).

2.1.3. Visitation Statistics

Visitors to FRHI enjoy a unique combination of cultural and natural resources along the banks of the Monongahela River. Monthly visitation statistics from 1983-2016 show peak visitation occurs in September, the month of FestiFall, with more than 6,500 people on average. FestiFall is a free, annual event that celebrates life on the frontier during Albert Gallatin's era with 18th century food, music, toys, and demonstrations (NPS 2018) (Table 2.1). Visitation is slowest in the winter from December-February, with fewer than 1,000 visitors each month on average. Mean annual visitation for the past 33 years is nearly 25,000 people per year, with increasing visitation over time. The Long Range Interpretive Plan's 2002 report included the improvement of visitor experience as a primary objective, and since then annual visitation has increased by 15% (LRIP 2002).

Table 2.1. Monthly and annual visitation to Friendship Hill National Historic Site from 1983-2016 (NPS Stats 2018).

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2016	945	1,313	1,348	1,879	3,247	2,502	2,591	2,575	16,262	2,904	1,568	713	37,847
2015	910	673	1,247	1,476	3,275	1,998	2,354	2,711	13,797	3,065	1,981	1,200	34,687
2014	438	672	1,165	2,450	3,164	2,359	2,907	2,695	13,580	2,770	1,316	801	34,317
2013	1,012	816	1,509	2,665	3,559	2,483	3,378	3,532	11,984	1,365	1,371	698	34,372
2012	686	978	1,050	2,539	2,684	2,461	2,221	2,657	13,854	2,990	1,168	1,001	34,289
2011	670	927	1,175	1,879	2,695	2,662	2,298	2,285	10,784	2,570	1,337	757	30,039
2010	713	304	1,827	2,888	4,080	2,561	3,432	3,212	8,127	3,472	1,529	417	32,562
2009	506	682	1,514	2,323	3,629	2,813	6,780	2,874	5,503	2,433	1,960	437	31,454
2008	541	480	966	1,687	4,634	1,950	2,615	3,201	9,125	3,538	1,203	683	30,623
2007	649	448	1,190	1,790	5,799	2,564	2,932	1,965	10,621	3,062	978	578	32,576
2006	794	570	1,254	2,169	3,180	1,702	1,713	1,823	7,513	2,505	1,265	1,148	25,636
2005	454	653	986	1,866	5,743	2,155	2,517	2,150	8,879	2,009	1,300	476	29,188
2004	581	1,431	1,474	1,839	3,784	2,063	2,406	2,007	9,984	2,742	1,194	513	30,018
2003	861	579	1,624	2,086	5,375	2,225	5,134	3,053	8,537	2,622	1,954	826	34,876
2002	1,241	1,323	1,473	2,818	5,627	2,596	2,884	2,523	7,285	2,563	1,620	901	32,854
2001	868	1,074	1,203	2,521	5,624	2,626	2,845	3,689	6,760	3,152	2,410	1,019	33,791
2000	463	839	1,562	1,986	5,114	1,760	2,523	2,690	7,038	3,263	1,926	749	29,913
1999	665	646	694	964	2,696	2,343	1,753	1,825	8,382	2,460	1,423	707	24,558
1998	606	742	1,008	1,373	3,624	1,517	2,701	2,647	7,266	3,794	1,571	862	27,711
1997	503	607	1,010	1,419	3,004	1,972	1,881	2,129	4,121	2,733	664	623	20,666
1996	227	559	1,062	1,583	2,957	1,781	2,271	1,933	3,100	2,091	933	731	19,228
1995	332	465	950	1,103	2,105	1,603	2,016	1,761	3,931	2,100	773	233	17,372
1994	122	552	512	1,365	1,901	1,704	1,721	1,256	2,927	1,688	575	358	14,681
1993	742	379	473	1,141	3,030	2,116	2,011	1,784	4,852	2,081	725	211	19,545
1992	280	353	614	1,092	2,367	1,329	1,905	1,977	3,943	3,664	2,672	452	20,648
1991	288	388	585	722	2,037	1,142	1,647	1,783	3,057	1,042	458	377	13,526

Table 2.1 (continued). Monthly and annual visitation to Friendship Hill National Historic Site from 1983-2016 (NPS Stats 2018).

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1990	481	392	866	1,249	2,108	1,914	1,844	2,142	1,751	2,936	1,054	575	17,312
1989	272	385	646	1,189	1,876	1,529	1,693	1,788	1,257	3,850	646	275	15,406
1988	604	538	680	1,010	1,537	1,040	1,155	1,202	817	2,930	392	97	12,002
1987	972	503	1,123	1,019	2,450	1,366	1,174	1,401	1,309	3,637	985	293	16,232
1986	278	304	932	1,043	1,707	1,633	1,347	1,841	1,847	2,376	476	344	14,128
1985	341	362	851	1,097	1,609	1,531	1,494	1,436	1,296	2,660	715	228	13,620
1984	277	418	422	792	1,892	949	1,110	1,464	1,113	1,928	476	494	11,335
1983	133	240	360	313	1,258	927	1,183	1,631	949	1,714	458	147	9,313
Avg.	572	635	1,040	1,628	3,217	1,938	2,366	2,225	6,516	2,668	1,208	586	24,598

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 (http://climate.psu.edu/; accessed February 2019).

Both global and regional trends in climate affect biotic and abiotic processes, such as nutrient cycling, subsurface hydrology, and plant-soil interactions (Davey et al. 2006). Thus, defining regions with similar climatic features can be helpful in understanding ecosystem patterns and trends. Pennsylvania is divided into ten climatic divisions; FRHI is situated in Pennsylvania Climate Division 9, also known as the Southwest Plateau (Knight et al. 2015).

The Southwest Plateau is typified by a humid, continental climate, although the region's rolling hills and elevated altitude somewhat temper the extreme of a hot summer (Knight et al. 2015). Thus, the average annual maximum temperature of 63.4° F (17.4° C) is slightly lower than the surrounding region; the mean annual temperature for the park is between 50.2-51.8˚F (10.1-11˚C) (Figure 2.4). FRHI receives a relatively even distribution of precipitation throughout the year, usually totaling 35-54 in (91-137 cm) annually. The amount of precipitation is often greatest in the spring and summer months and lowest in February (Knight et al. 2015).

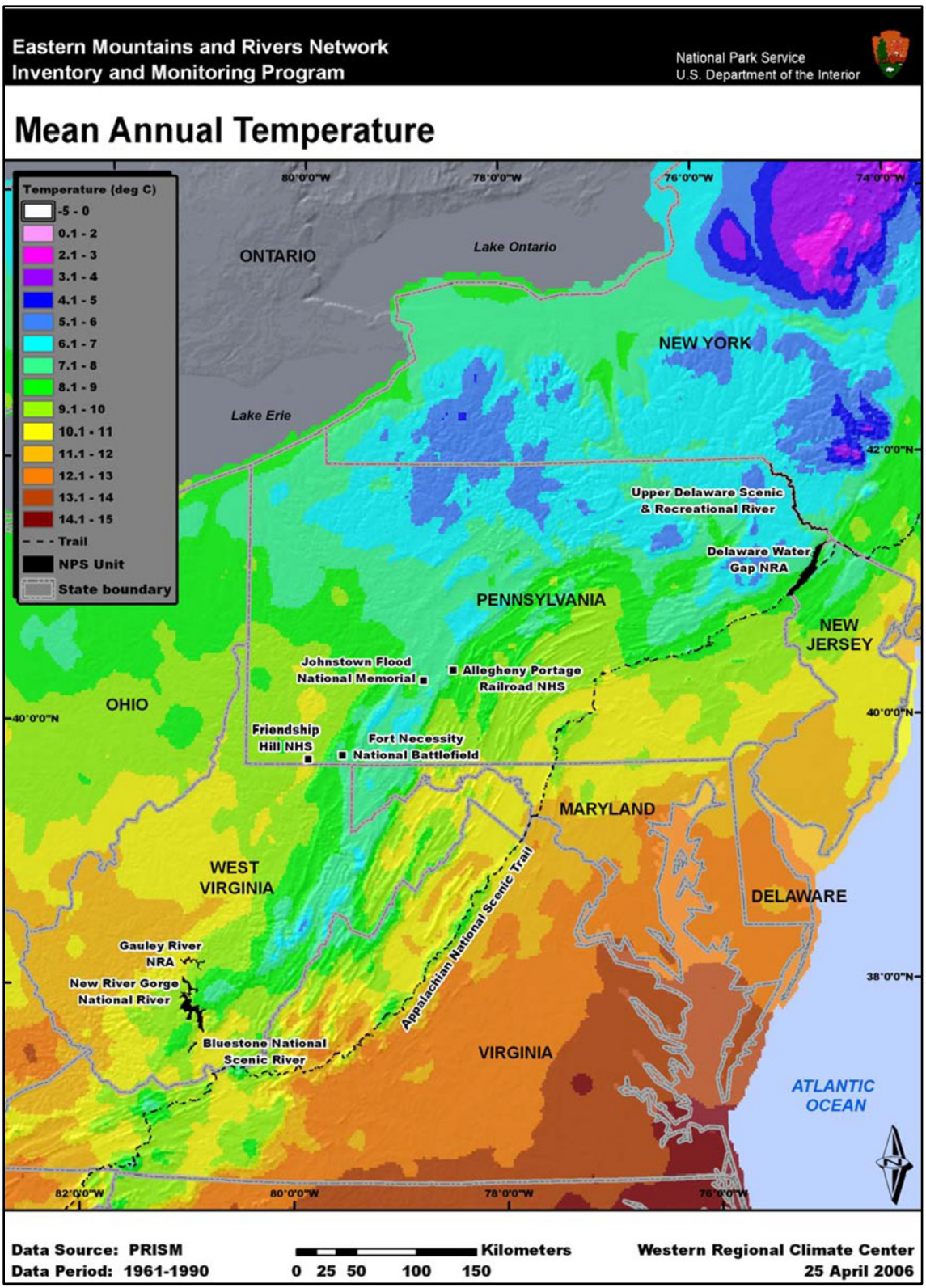


Figure 2.4. Mean annual temperature across the Eastern Rivers and Mountains Network; the area surrounding Friendship Hill National Historic Site had a mean annual temperature between 10.1-11˚C from 1961-1990 (Davey et al. 2006).

2.2.2. Ecoregions

Ecological regions, known as ecoregions, are areas that are relatively homogenous in terms of environmental characteristics and allied ecological processes. Ecoregions were designated by the U.S. EPA as a spatial framework to help with inventory, monitoring, and analysis of natural resources and to more easily set resource management goals concerning ecological features such as soil, vegetation, and geology (Woods et al. 1999).

FRHI is situated in the Monongahela Transition Zone – Level IV sub-Ecoregion within the wider Western Allegheny Plateau (Level III Ecoregion) (Woods et al. 1999) (Figure 2.5). Woods et al. (1999) have described this area as one with mixed land use and land cover including forests, urban-suburban-industrial activity, agricultural farms, dairy and livestock farms, pastures, coal mines, and oil-gas fields. Due to AMD, siltation, and industrial pollution, the region has shown signs of degraded water quality, which has affected fish and invertebrate populations (Cooper et al. 1985; Woods et al. 1999); however, recent efforts have led to improved stream quality in the Allegheny, Monongahela, Youghiogheny, and Ohio rivers. The Monongahela Transition Zone contains unglaciated terrain with underlying beds of limestone, shale, sandstone, and coal from the Monongahela group. Vegetation in this region mainly consists of Mixed Mesophytic Forest with some Appalachian Oak Forest in the surrounding regions (Woods et al. 1999).

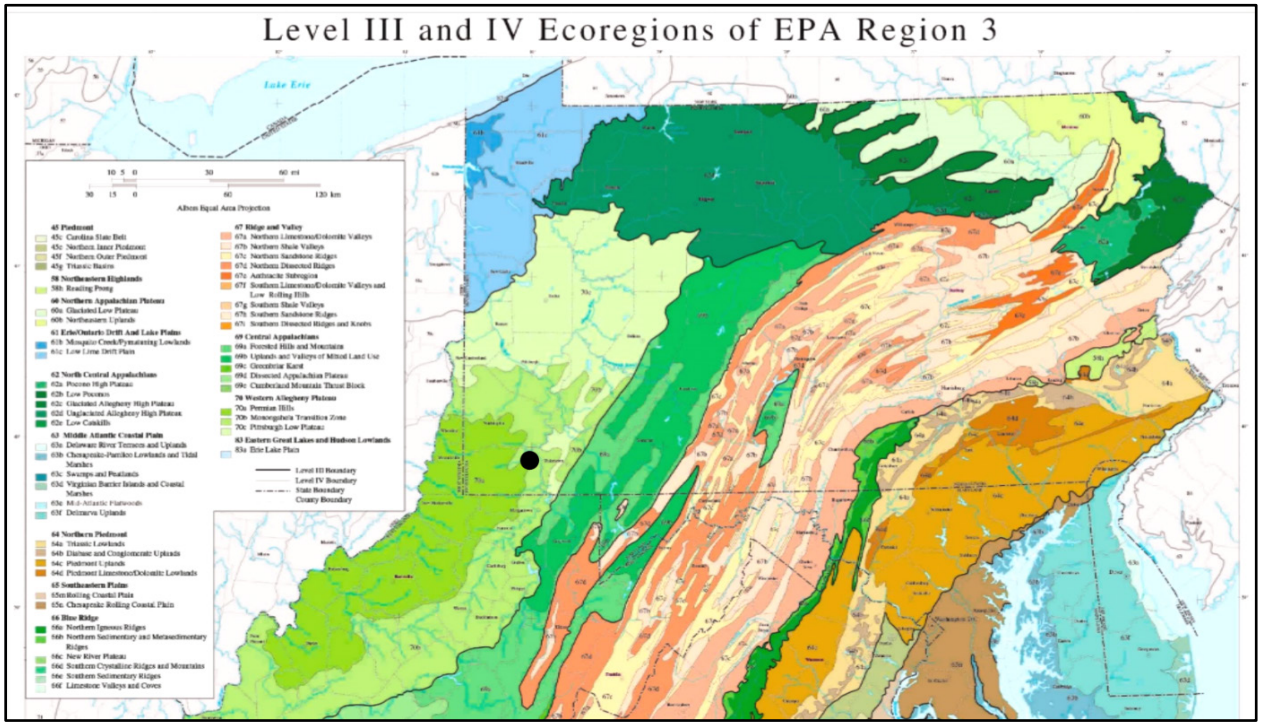


Figure 2.5. Ecoregions for the area surrounding Friendship Hill National Historic Site (FRHI). FRHI (shown by the black dot) is in the Monongahela Transition Zone within the Western Allegheny Plateau (US EPA 2017a).

2.2.3. Watersheds

FRHI is in the Monongahela River sub-basin, one of five sub-basins within the larger Ohio River basin (FCCD 2016). The Monongahela River sub-basin itself comprises six lesser hydrologic units, each bearing a unique hydrologic unit code (HUC) assigned by the United States Geological Survey (USGS) (Figure 2.6). FRHI is inside the Lower Monongahela hydrologic unit (USACE 2012). The Lower Monongahela is further divided into smaller watersheds, of which the park covers portions of three: the Monongahela River Watershed, the Rocky Hollow Watershed, and the Georges Creek Watershed (Figure 2.7). The Monongahela River sub-basin consists of mixed land use/land cover types, including urban, pastoral, and industrial. Bituminous coal mining and industrial pollution in the region has led to problems from AMD and surface subsidence, thereby degrading water quality in the Monongahela River (Thornberry-Ehrlich 2008).

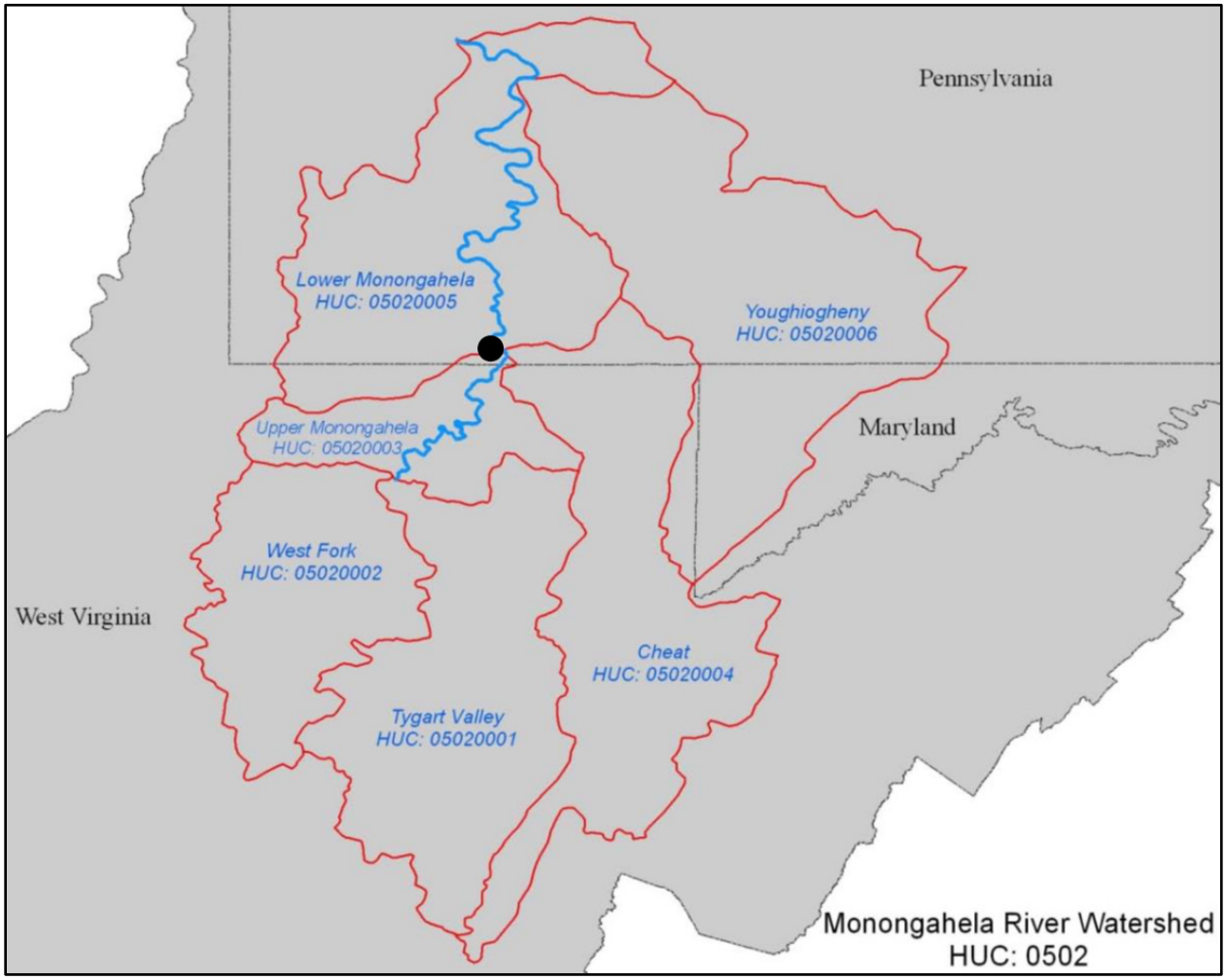


Figure 2.6. Smaller HUC 8 sub-basins in the Monongahela sub-basin; the black dot is the approximate location of Friendship Hill National Historic Site (USACE 2012).

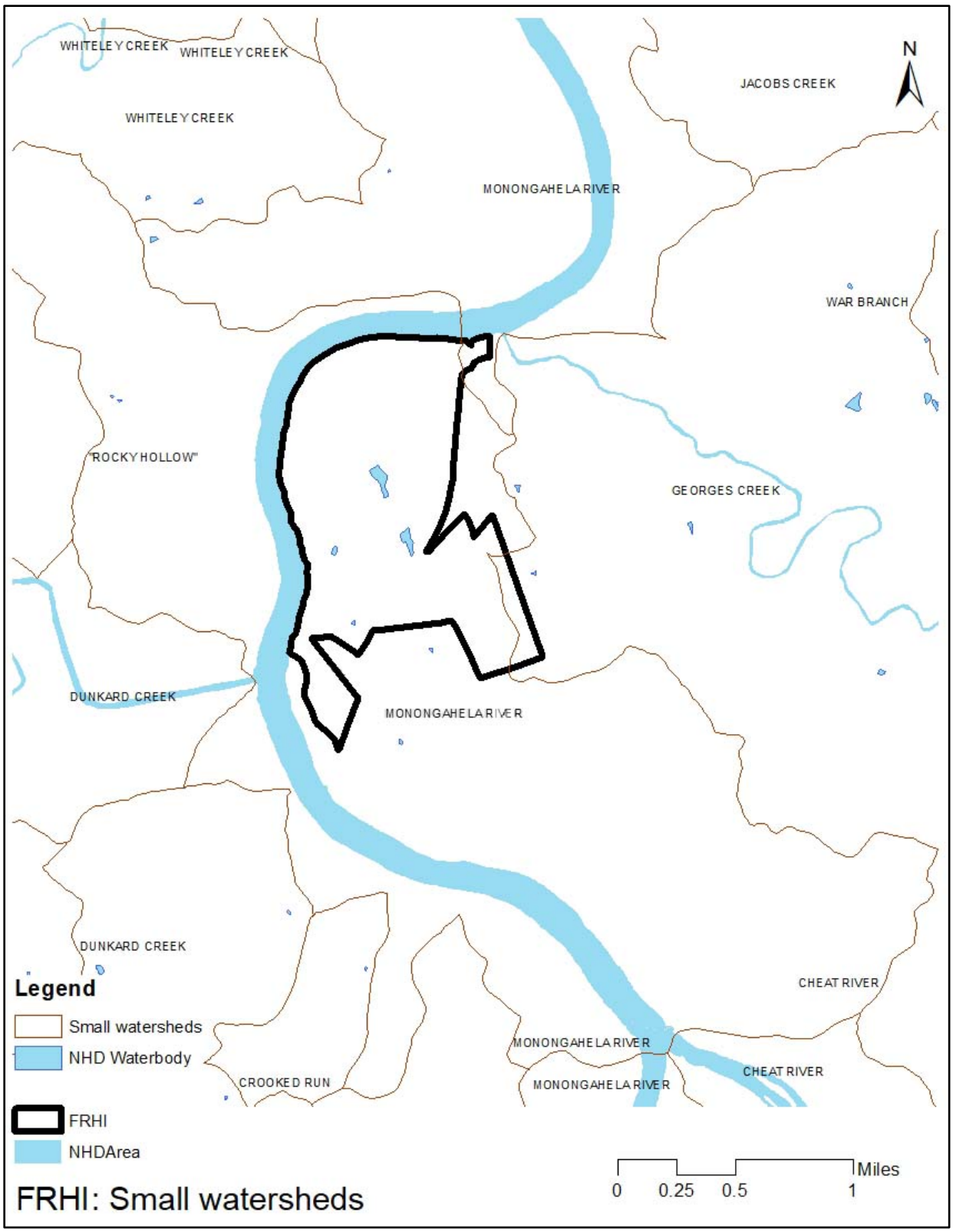


Figure 2.7. Small watersheds at Friendship Hill National Historic Site (Source: National Hydrologic Data Set).

2.2.4. Resource Descriptions

Geology and Topography

The underlying rock structure in the area around FRHI had been eroded by rivers over time to create undulations in the landscape. The park is located in the junction of two physiographic sub-provinces: Waynesburg Hills and Pittsburgh Low Plateau; consequently, part of FRHI has the rolling hills and valleys in the west, while the eastern half has a sharp inclination of terrain towards the Allegheny Mountain Section (Figure 2.8). The steep terrain may potentially lead to geologic hazards like landslides, slumps, and rockfalls. Additionally, the site shows clear signs of manmade disturbances from logging, farming, and coal-mining that led to hazards like land subsidence and AMD (Thornberry-Ehrlich 2008).

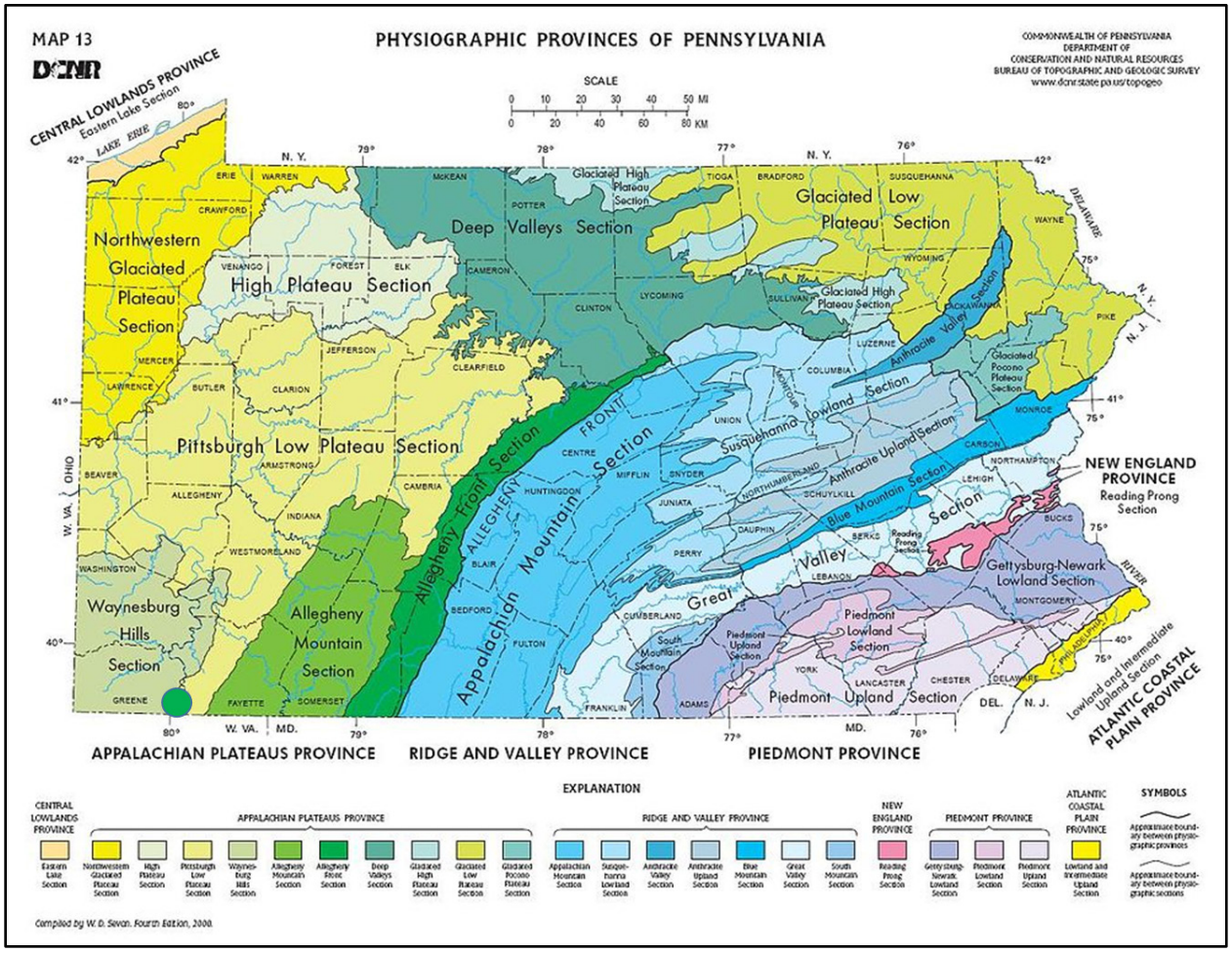


Figure 2.8. Physiographic provinces of Pennsylvania; Friendship Hill National Historic Site (green circle) (www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_016202.pdf).

The geology of FRHI is much flatter that the lands to the east which lie in the Valley and Ridge Province. The two regions are separated by the Allegheny Mountains. In FRHI, the geology is primarily sedimentary, consisting of sandstones, limestones, claystones, conglomerates, dolomites, and shales, and commercially viable coals (Figure 2.9) (Thornberry-Ehrlich 2008).

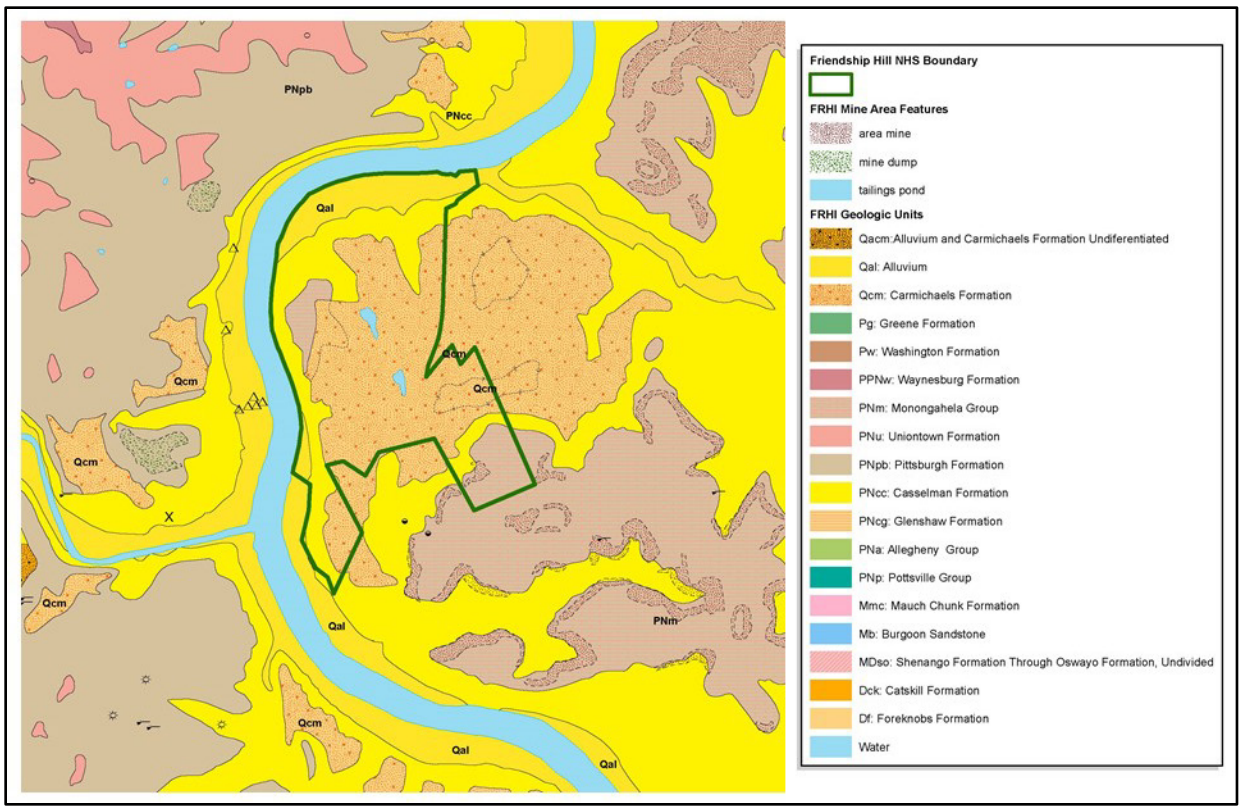


Figure 2.9. Geology of FRHI (NPS https://irma.nps.gov/DataStore/Reference/Profile/2251665).

Soils

The soil types found in FRHI are greatly influenced by the rolling terrain. Areas of steep slopes have soils that are shallow, weakly developed, and poorly drained with a high likelihood of erosion. The relatively flatter regions tend to have soils that are deep and fertile, ranging from weakly to extensively developed. Most of FRHI soils along the river and higher elevations contain alluvial deposits (Thornberry-Ehrlich 2008). Monongahela silt loams (MoA, MoB, MoC) are common away from the river's edge while Gilpert-Weikert silt loam (GwF) and Gilpert channery silt loam (GcD) are more common nearer the river. Along the banks of the Monongahela we find Gilpin-Rock outcrops (GoF), with very steep slopes (Figure 2.10). Having supported agricultural practices for many years, the land around FRHI has been recognized by the Pennsylvania State Conservationist as prime farmland (Kopas 1991, NPS 2005).

Figure 2.10. Soils of the Friendship Hills National Historic Site (https://websoilsurvey.sc.egov.usda.gov).

Vegetation

In Fayette County, the region supports 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 FRHI are invasive plants and both native and introduced forest pests and pathogens such as 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 of FRHI consists of typical oak forests, mixed mesophytic hardwoods, pine and spruce forests, and old-growth white oak (Thornberry-Ehrlich 2008) (Figure 2.11). According to NPSpecies (n.d.), there are 445 species of plants present, or probably present, in the park, including 61 tree species and 311 species of herbs and shrubs (NPS 2005). Perles et al. (2006) identified seven vegetation associations in this historic site: Early Successional Hardwood Forest, Conifer Plantation, Mixed Forb Marsh, Northern Red Oak-Mixed Hardwood Forest, Successional Old Field, Sycamore Floodplain Forest, and Tuliptree-Beech-Maple Forest. Tuliptree-Beech-Maple Forest is the most commonly found vegetation type in the park and Northern Red Oak-Mixed Hardwood Forest is the least common, typically only found on steep slopes. Sycamore Floodplain Forest dominates the floodplain region near the Monongahela River. The defining qualities of these vegetation associations, as described by Perles et al. (2006) are summarized below.

Early Successional Hardwood Forest

When open fields are abandoned, and natural succession allowed to occur, the grass- and forb-dominated area will be gradually taken over by woody plants, eventually developing into mature forest. In the long interim before a mature forest exists, the changing habitat can first be described as Successional Old Field, characterized below, and then Early Successional Hardwood Forest, as trees begin to flourish. Thus, Early Successional Hardwood Forests are establishing themselves in FRHI in decades-old agricultural areas, located on level or slightly sloping uplands where farming use to occur. These young hardwood stands are generally no more than 50 ft (15 m) tall. The composition of such stands is largely location-dependent. In FRHI, the canopy and subcanopy are dominated by boxelder (*Acer negundo*), red maple (*Acer rubrum*), tuliptree (*Liriodendron tulipifera*), and black cherry (*Prunus serotina*). The shrub layer mostly contains flowering dogwood (*Cornus florida*), northern spicebush (*Lindera benzoin*), multiflora rose (*Rosa multiflora*), Allegheny blackberry (*Rubus allegheniensis*), and black raspberry (*Rubus occidentalis*). The herbaceous layer is largely composed of white snakeroot (*Ageratina altissima* var. *altissima*), small-spike false nettle (*Boehmeria cylindrica*), poverty rush (*Juncus tenuis*), and Canadian clearweed (*Pilea pumila*). Virginia creeper (*Parthenocissus quinquefolia*) and eastern poison ivy (*Toxicodendron radicans*) are common vines in these stands. Multiple invasive species are also present, such as tree-of-heaven (*Ailanthus altissima*), Japanese barberry (*Berberis thunbergii*), Japanese honeysuckle (*Lonicera japonica*), Japanese stiltgrass (*Microstegium vimineum*), and oriental lady's-thumb (*Polygonum caespitosum*).

Conifer Plantation

Only a few patches of conifers remain as most have been harvested. As with Early Successional Hardwood Forests, these stands are found on level or slightly sloping uplands of the park where agricultural activities once occurred. The canopy of these remnants, reaching 65-80 ft (20-25 m) in height, is made up of Norway spruce (*Picea abies*), eastern white pine (*Pinus strobus*), and Scotch pine (*Pinus sylvestris*). The subcanopy, usually 50-65 ft (15-20 m) high, is populated by sugar maple (*Acer saccharum*), sweet birch (*Betula lenta*), and black cherry. Northern spicebush is the most abundant species found in the shrub layer. The herbaceous layer mostly comprises ribbed sedge (*Carex virescens*), Canada mayflower (*Maianthemum canadense*), and New York fern (*Thelypteris*

noveboracensis). These conifer patches are typically invaded by garlic mustard (*Alliaria petiolata*), Japanese barberry, Morrow's honeysuckle (*Lonicera morrowii*), and multiflora rose.

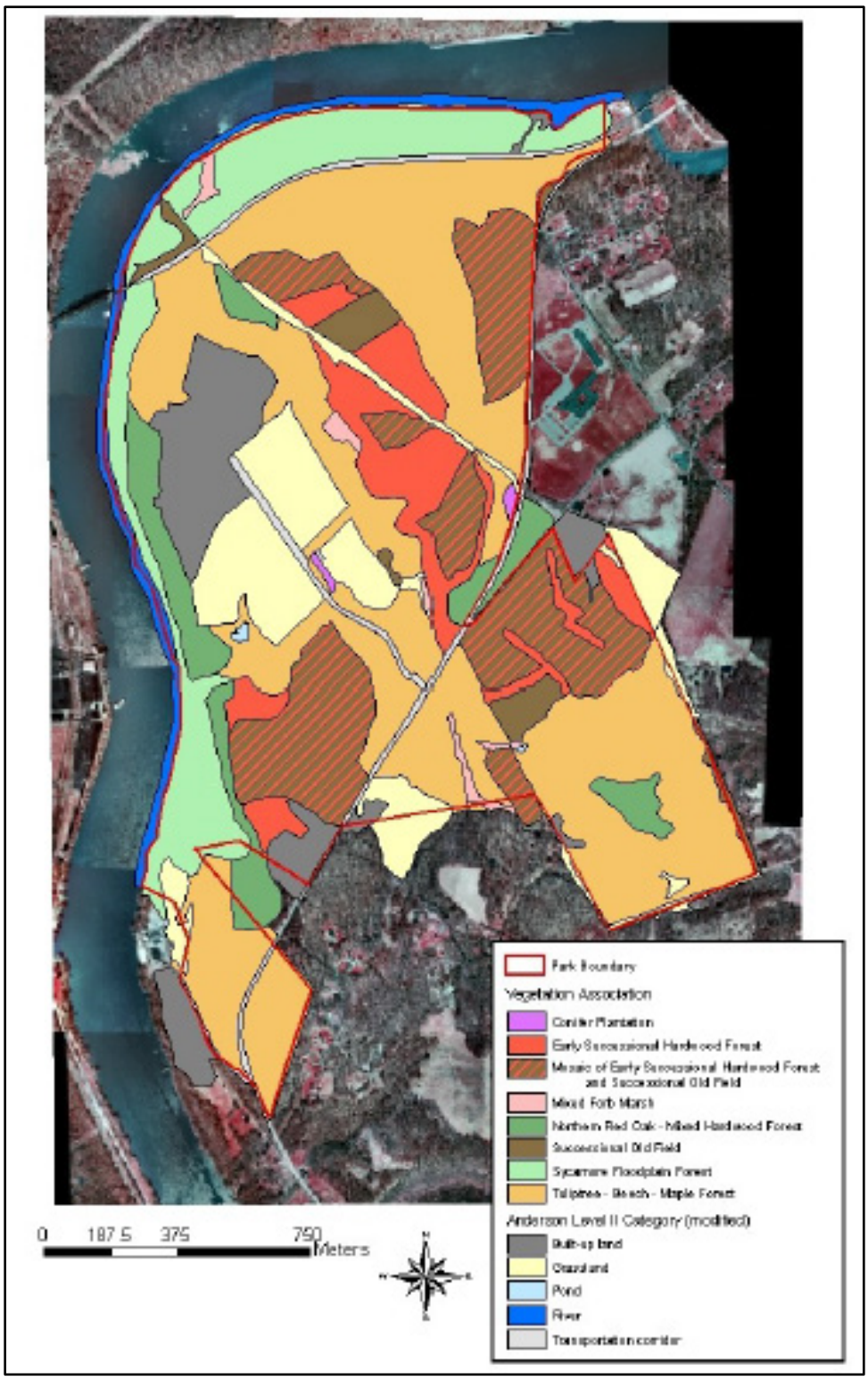


Figure 2.11. Vegetation communities at Friendship Hills National Historic Site (Perles et al. 2006).

Mixed Forb Marsh

The Mixed Forb Marsh occurs intermittently in poorly drained depressions along the banks of a stream that runs through the center of FRHI. These habitats have been significantly altered during AMD remediation activities, and as a result are highly variable in species composition and susceptible to invasion by nonnative plants. While herbs dominate, there can be as much as 60% coverage by woody species, though they rarely exceed more than 30 ft (10 m) in height; typical woody species include boxelder, red maple, sweet birch, tuliptree, pin oak (*Quercus palustris*), and black willow (*Salix nigra*). The most abundant herbaceous plants include rice cutgrass (*Leersia oryzoides*), reed canarygrass (*Phalaris arundinacea*), arrowleaf tearthumb (*Polygonum sagittatum*), woolgrass (*Scirpus cyperinus*), and broadleaf cattail (*Typha latifolia*), though there are numerous other species present. The most common invasives are Japanese stiltgrass and oriental lady's-thumb.

Northern Red Oak-Mixed Hardwood Forest

The Northern Red Oak-Mixed Hardwood Forest type is limited in FRHI to higher elevations and mid to upper slopes, where the soil is well-drained, and the severity of the topography made harvesting trees difficult. The canopy of such stands is extensive, usually covering more than 80% of the area at a height of 65-100 ft (20-30 m), and primarily contains white oak (*Quercus alba*), northern red oak (*Quercus rubra*), and black oak (*Quercus velutina*) with co-dominants such as red maple. The subcanopy generally covers 20-40% of the area at a height of 30-50 ft (10-15 m), and mostly includes red and sugar maples. The shrub layer is robust, including many saplings of the aforementioned species in addition to hophornbeam (*Ostrya virginiana*) and northern arrow-wood (*Viburnum recognitum*), covering 30-40% of the area at heights up to 15 ft (5 m). There are also shorter shrubs (below 7 ft (2 m), in height) that cover 15-40% of the area, such as Blue Ridge blueberry (*Vaccinium pallidum*) and deerberry (*Vaccinium stamineum*). With so much shade, the herbaceous layer is sparse, but it includes forbs such as flattened oatgrass (*Danthonia compressa*), white wood aster (*Eurybia divaricata*), mayapple (*Podophyllum peltatum*), and Carolina horsenettle (*Solanum carolinense*) as well as vines such as Virginia creeper and greenbriar (*Smilax glauca, S. rotundifolia*). Japanese honeysuckle and Japanese stiltgrass are common invaders.

Successional Old Field

The Successional Old Field habitat exists as one of the first steps in natural succession as woody plants begin to grow along the edges of abandoned open areas and slowly spread inward. This phase is difficult to define in detail, as the changes that occur in succession are gradual, variable, and site-specific. In FRHI, Successional Old Fields are found on level or slightly sloping uplands, where agricultural activities once occurred. The hardwoods that grow along the edges and in small, open patches throughout cover 25-60% of the field and are not more than 50 ft (16 m) high. Common species include boxelder, white ash (*Fraxinus americana*), tuliptree, and black cherry, among others. Tall shrubs, such as pawpaw (*Asimina triloba*) and autumn olive, (*Elaeagnus umbellata*) and short shrubs, such as multiflora rose and Allegheny blackberry, grow in dense thickets, covering 25-80% of the field. The most abundant herbaceous species are harvest-lice (*Agrimonia parviflora*), orchard grass (*Dactylis glomerata*), common velvet grass (*Holcus lanatus*), and wrinkleleaf goldenrod (*Solidago rugosa*). Vines, including Virginia creeper, eastern poison ivy, and grape (*Vitis aestivalis, V. riparia*) cover 15-50% of the area. As an open area experiencing significant change, Successional

Old Fields are susceptible to invasion by nonnative species; in addition to those already mentioned, invasive species include Japanese honeysuckle, Japanese stiltgrass, and oriental lady's-thumb.

Sycamore Floodplain Forest

Sycamore Floodplain Forests occur in moderately well-drained soils along low terraces that experience periodic or seasonal flooding during high water events. In FRHI, this habitat is along the floodplains of the Monongahela River, located on the northern and western boundaries of the park. Historically, this area was cleared to serve as a boat landing, since the river was the main method of transportation to reach Friendship Hill; in the years since, it had been used to grow crops, raise pigs, and act as a pasture. As a result, the Sycamore Floodplain Forests have only been allowed to grow naturally for the past 40 years. The impacts of old disturbances are visible in the plant community, which includes many weeds and invasive species. The canopy is open, covering only 40-60% of the area at a height of 40-100 ft (12-30 m). In addition to sycamore (*Platanus occidentalis*), boxelder and black cherry dominate. The subcanopy also covers up to 60% of the area and has a similar species composition as the canopy. Tall shrubs can cover 25-80% of the area at heights between 7-15 ft (2-5 m) and common species include boxelder, pawpaw, and northern spicebush. Shorter shrubs, typically the same species as are found in the tall shrub layer, cover 10-40% of the area and are less than 7 ft (2 m). With such an open canopy, the herbaceous layer in Sycamore Floodplain Forests is dense, and often covered in Japanese stiltgrass as well as abundant native species, including small-spike false nettle, riverbank wild rye (*Elymus riparius*), rice cutgrass, white cutgrass (*Leersia virginica*), Canadian clearweed, marsh-pepper knotweed (*Polygonum hydropiper*), and wingstem (*Verbesina alternifolia*). There are occasional vines such as Virginia creeper and grape. Other invasive species present include Japanese barberry, Japanese honeysuckle, Morrow's honeysuckle, oriental lady's-thumb, and multiflora rose.

Tuliptree-Beech-Maple Forest

This forest type is found on a variety of slopes and well-drained soils throughout FRHI, often growing in areas previously characterized by other vegetation associations, such as former pine plantations that had been harvested. Due to the successive nature of their development, these stands typically have a weedy appearance and are susceptible to invasion by nonnative plants. The canopy is dense, usually covering more than 80% of the area, and comprises mostly red maple, sugar maple, American beech (*Fagus grandifolia*), and tuliptree at heights of 80-115 ft (25-35 m). The subcanopy, of a similar species composition, covers 20-60% of the area at heights of 30-65 ft (10-20 m). Northern spicebush dominates both the tall and short shrub layers, though other species are present. The herbaceous layer is a mix of native plants, the most abundant of which are hay-scented fern (*Dennstaedtia punctilobula*), jumpseed (*Polygonum virginianum*), and New York fern, vines, such as Virginia creeper and greenbrier, and invasive species, including Japanese barberry, Japanese honeysuckle, and multiflora rose.

Hydrology

FRHI is situated beside the Monongahela River, which flows for 116 miles (187 km) from the merging point of the West Fork and Tygert rivers near Fairmont, WV to the merging point where it joins the Allegheny River in Pittsburgh (Thornberry-Ehrlich, 2008). A tributary of the Ohio River,

the Monongahela River drains an area of 7,340 sq. miles (19,010 sq. km) (Stewart and Mathes 1995) and holds special significance for the history of FRHI.

During Albert Gallatin's time, the Monongahela River supported the earliest boat-building industries in the area—a trade vital to the transport of logged timber, farm goods, and other materials produced by the frontier. In 1837, the Monongahela Navigation Company began constructing docks and dams to improve industrial shipping practices; nine of these docks are still present and active today, facilitating the shipment of coal to power steel and power plants (USACE 2012).

As a result of the boom in industrial activity, the Monongahela River and several streams that flow through FRHI are impaired by water pollution, especially from AMD; detrimental effects have been observed on fish and macroinvertebrate populations (Tzilkowski and Sheeder 2006). Within the park, South Run, Rhododendron Run, Dublin Run, and Ice Pond Run have shown water quality deterioration. Among these, Ice Pond Run, the longest stream running through FRHI, is the most impaired (Boone and Lisk 2002, Tzilkowski and Sheeder 2006, Thornberry-Ehrlich 2008).

In addition to the Monongahela River and numerous streams, FRHI contains nearly 5 acres (2 ha) of wetlands, the majority of which are located along the northeastern boundary of the park and around the merging point where Ice Pond Run and Dublin Run join the Monongahela River (NPS 2005).

2.2.5. 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 (and including) FRHI has a long history of mining coal (Thornberry-Ehrlich 2008). In fact, Bogovich and Member (1992) found that more than 15% of all abandoned coal mines in the state at the time were in southwestern Pennsylvania. Acid mine drainage (AMD) affects some of the streams flowing through FRHI (Tzilkowski and Sheeder 2006).

Numerous other anthropogenic activities have impacted natural resources inside FRHI's borders. Humans have logged forests, tilled fields and introduced grazing livestock, built roads and parking lots, and placed a railroad through the northern portion.

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

- Air Quality – FRHI 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, the northeastern US 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 FRHI. Acid mine drainage already affects streams within the park as well as Ice Pond.
- Biological integrity – Invasive plant species are prevalent throughout the park, posing a threat to ecosystem function.
- 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.

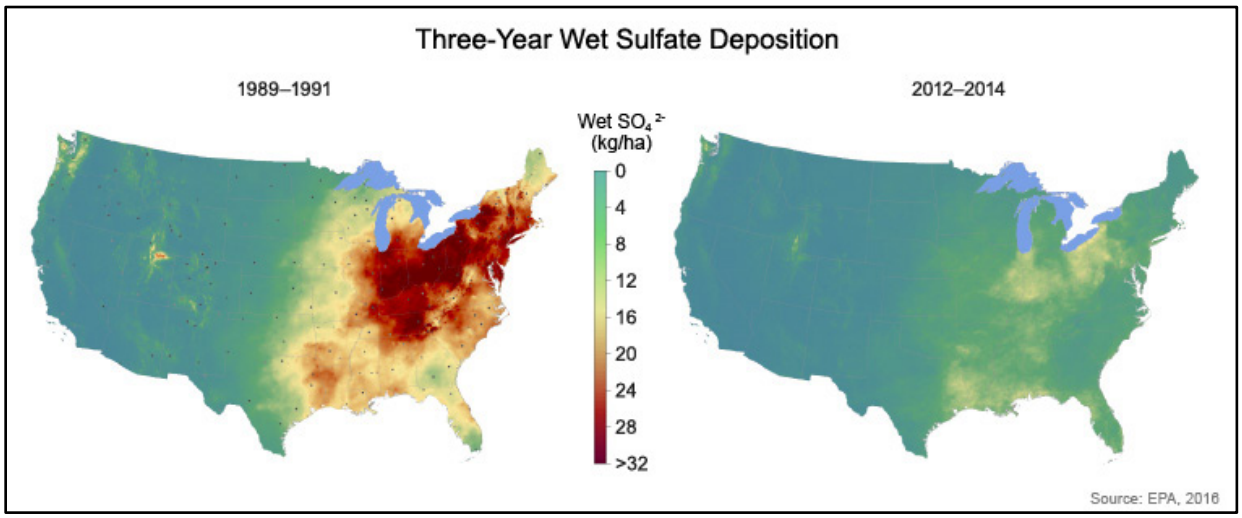


Figure 2.12. Historic and recent acid precipitation patterns in the US as reflected by sulfate deposition (US EPA 2017b).

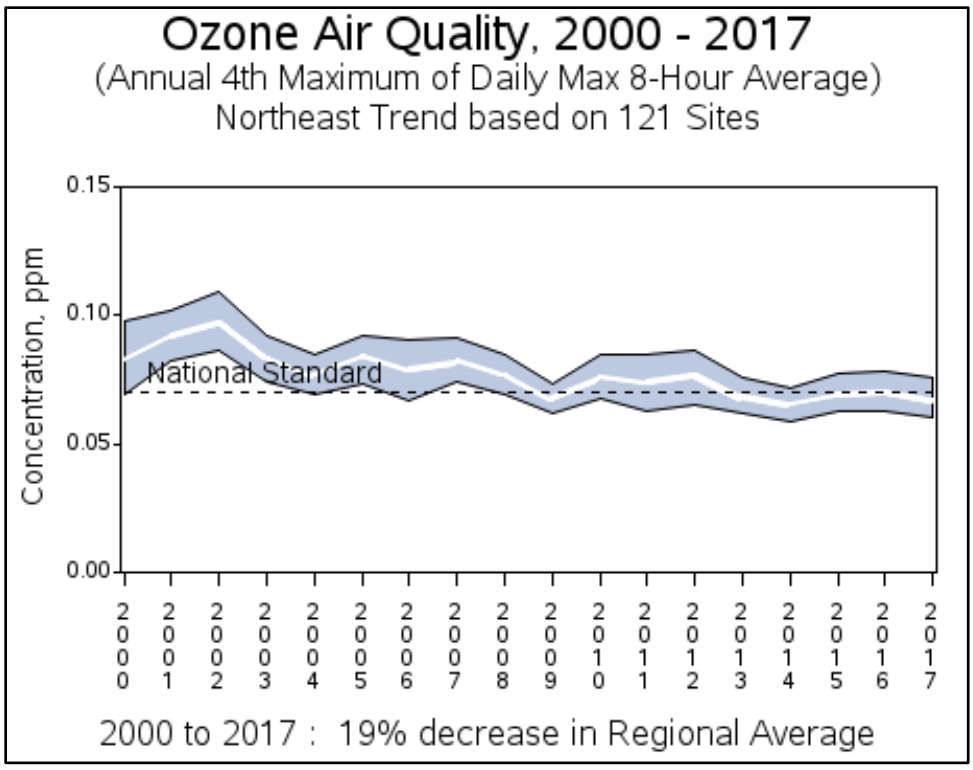


Figure 2.13. Ozone levels across the northeastern U.S. (https://www.epa.gov/air-trends/ozone-trends; accessed 2/11/2019).

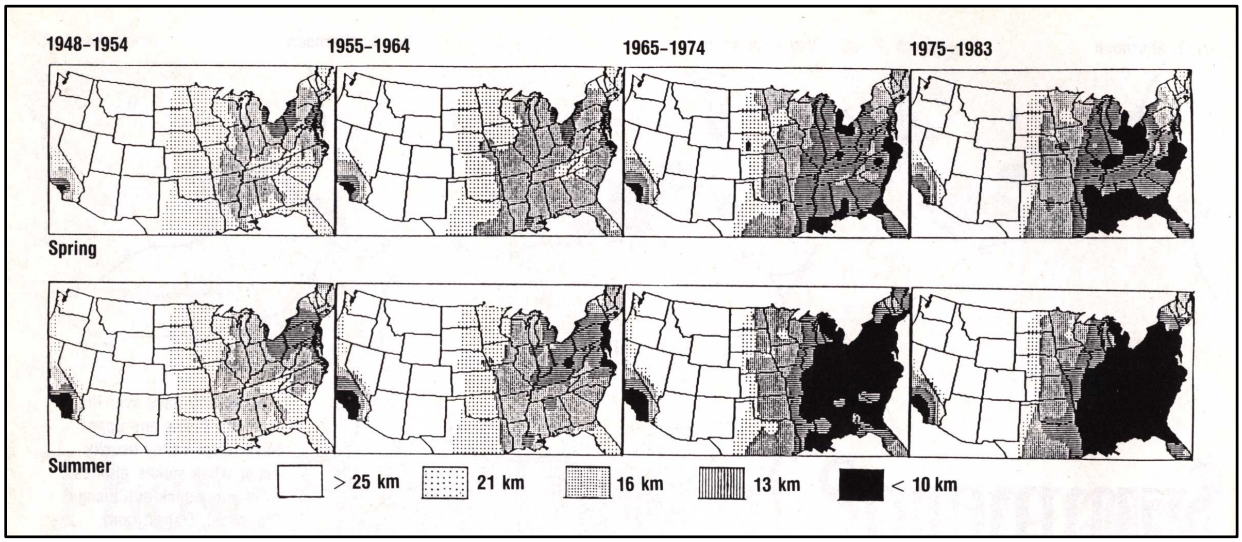


Figure 2.14. Average visibility due to haze across the U.S. from 1948-1983 (Corfidi 2013).

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

Friendship Hill National Historic Site is primarily a cultural resources park within which important natural resources exist. 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 FRHI'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. However, the FD only indirectly refers to natural resources as it focuses primarily on the issues surrounding the park's cultural resources.

2.3.2. Status of the Supporting Science

To complete this Natural Resource Condition Assessment, we utilized indicators developed by the Eastern Rivers and Mountains Network (ERMN) under the Inventory and Monitoring Vital Signs program. The Vital Signs program facilitates long-term monitoring in 270 national parks by creating protocols for tracking and evaluating the status of important natural resources. The vital signs used are information-rich indicators of a park ecosystem's overall health. The ERMN, which covers nine national parks including FRHI, has identified approximately a dozen of these vital signs as being a high priority for the region (Table 2.2).

Table 2.2. Eastern Rivers and Mountains Network high priority vital signs (Marshall and Piekielek 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

Chapter 3. Study Scoping and Design

3.1. Preliminary Scoping

Preliminary scoping efforts for the NRCA began in 2014 but 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 FRHI 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 FRHI 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 FRHI, 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

FRHI 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 FRHI'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 FRHI'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 FRHI 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 Friendship Hill National Historic Site 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	2007-2015	ERMN reports
	Air Quality	Ozone	Ozone	–	NPS Air Resources Division
	Air Quality	Wet & Dry Deposition	Atmospheric Deposition & Stress	–	NPS Air Resources Division; NADP database; Sullivan et al. (2001a,b)

Table 3.1 (continued). List of the indicators selected for Friendship Hill National Historic Site 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 (continued)	Air Quality	Wet & Dry Deposition	Contaminants	–	MDN database
	Air Quality	Wet & Dry Deposition	Visibility	–	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 reports, Cravotta & Eggleston 2011, Webber 2012
	Water Chemistry	Water Chemistry	AMD in Ice Pond	–	Klusman et al. 1993
	Wetlands	Wetlands	Rare riparian/riverine plant community and cliffs (Monongahela River)	–	NPS 2005, Perles et al. 2006, Thornberry-Ehrlich 2008
Biological Integrity	Community integrity	Invasive / Exotic Plants	Invasive/Exotic Plants-Status and Trends & Early detection	2008-2015	Perles et al. 2006; ERMN Reports; Zimmerman and Yoder 2006
	Community integrity	Forest health	Dynamics	2007-2012	Perles et al. 2016
	Community integrity	Fishes	Fishes	–	Tzilkowski & Sheeder 2006, Faulk and Weber 2017
	Community integrity	Birds	Birds and Streamside Birds	2007-2012	Yahner et al. 2004, ERMN Reports; Marshall et al. 2016 Appendix D
	Community integrity	Other wildlife	Mammals, reptiles, amphibians	–	Yahner et al. 2004; Kowalski et al. 2005,
	Community integrity	Stream benthic macro-invertebrates	Stream benthic macroinvertebrates	2009-2013	ERMN reports

Table 3.1 (continued). List of the indicators selected for Friendship Hill National Historic Site 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
Human Use	Visitor & Recreational Use	Visitor Usage	Visitor Usage	1935-2015 (visitation); 1992-2016 (traffic counts)	NPS STATS
	Visitor & Recreational Use	Landscape Dynamics	Landscapes	Historical data collection and projected models for landscape variables from 1950-2030.	NPScape historical and projected data;
Landscapes	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

Friendship Hill National Historic Site is a small park of about 675 acres (273 ha). Limited data availability made specific assessments difficult, and therefore results will be presented as a broad evaluation of the park as well as in a regional context.

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 FRHI 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 indicate 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; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	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.

Chapter 4. Natural Resource Conditions

4.1. Air Quality

Though national parks do not generate significant air pollution, air quality within a park's boundaries may still be a concern due to external sources nearby. The most likely source of air pollution entering FRHI is Pittsburgh, 45 miles (72 km) to the north. Although the city's air quality has improved drastically throughout the past few decades, it remains the largest urban center in the area, and therefore the most likely threat to good air quality in FRHI.

Since FRHI does not have air quality monitoring equipment on site, we therefore follow NPS Air Resources Division (ARD) protocols. The NPS ARD averages data collected by national, state, and local monitoring stations over a five-year period to generate interpolations from which estimates of air quality parameters can be derived for park units. Each air quality parameter is then assigned an interpolation condition category based on regulatory standards and peer-reviewed literature that examined the effects of air quality parameters on ecosystems. It should be noted that temporal delays of the impact of air pollution on the environment may lead to underestimating the effects pollutants may have on ecosystems.

In this report, 2011-2015 interpolated data were assessed following the guidelines distributed by the NPS ARD for three air quality categories: ozone, visibility, and atmospheric deposition. The effects of ozone were considered for both human and vegetative health, and atmospheric deposition of both nitrogen (N) and sulfur (S) were evaluated. Individual judgements of these categories follow. The overall air quality rating for the park, however, is *resource warrants significant concern*, regardless of individual judgments, because FRHI is in an EPA-designated non-attainment area for ozone levels; this rating is automatic whenever a park is located within a region that does not meet EPA standards for even one air quality category (NPS ARD 2015).

4.1.1. Ozone

Relevance

Ground-level ozone is produced by the reaction between sunlight and volatile organic compounds that are found in vehicle exhaust and industrial emissions (US EPA 2014). Inhaling significant quantities of ozone has been shown to have negative consequences on mammalian respiratory and cardiovascular systems, especially for children, the elderly, and people with asthma (US EPA 2014). While federal standards for relatively safe ozone levels exist, recent research demonstrates that the effects of ground-level ozone, even at concentrations below these standards, may still result in adverse 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) requires that

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

Long-term exposure to ground-level ozone also affects vegetation by injuring leaf tissues and thus hindering vegetative growth. When ozone enters a plant's stomata during respiration, it oxidizes the surrounding cells, causing damage and reducing likelihood of plant survival (NPS ARD n.d.; NPS ARD 2018a).

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 NPS 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 NPS 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 NPS 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).

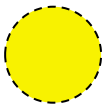
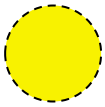
Status Category	W126* (ppm-hrs)
Warrants Significant Concern	> 13
Warrants Moderate Concern	7-13

* 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 FRHI, calculated using the appropriate method for determining the impact of ozone on human health, is 68.3 parts per billion (ppb) (NPS ARD 2017). Therefore, while the broader region around the park is an ozone non-attainment area, within the park this condition is rated as *resource warrants moderate concern*, based on the benchmarks in Table 4.1, above (Table 4.3).

Table 4.3. Status of ground-level ozone in Friendship Hill National Historic Site (NPS ARD 2018b).

Air Quality Indicator	Specific Measure	Condition Status/Trend*	Rationale
Ozone	Human Health: Annual 4th-highest 8hr concentration		• **Condition:** Human health risk from ground-level ozone warrants moderate concern at Friendship Hill NHS. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated ozone of 68.3 parts per billion (ppb). • **Trend:** No trend information is available because there are not sufficient on-site or nearby ozone monitoring data. • **Confidence:** The degree of confidence at Friendship Hill NHS is low because estimates are based on interpolated data from more distant ozone monitors.
	Vegetation Health: 3-month maximum12hr W126		• **Condition:** Vegetation health risk from ground-level ozone warrants moderate concern at Friendship Hill NHS. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated W126 metric of 8.6 parts per million-hours (ppm-hrs). A risk assessment concluded that plants in at Friendship Hill NHS were at high risk for ozone damage (Kohut 2007). See list of ozone-sensitive plant species. • **Trend:** No trend information is available because there are not sufficient on-site or nearby ozone monitoring data. • **Confidence:** The degree of confidence at Friendship Hill NHS 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 FRHI, calculated using the appropriate method for determining the impact of ozone on vegetative health, is 8.6 parts per million-hours (ppm-hrs) (NPA ARD 2017). Therefore, this condition is rated as *resource warrants moderate concern*, based on the benchmarks in Table 4.2, above (Table 4.3).

Trend Assessment

Based on long-term Clean Air Status and Trends Network (CASTNET) data from Laurel Hill State Park, located approximately 39 miles (63 km) northeast of FRHI, the condition of ozone in the region does not seem to be significantly improving nor deteriorating over the last few decades (Figure 4.1). However, as stated above, we cannot be sure of the exact concentration of ozone in FRHI, 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 unchanging in the region, we will not assign a trend rating for ozone in the park (Table 4.3).

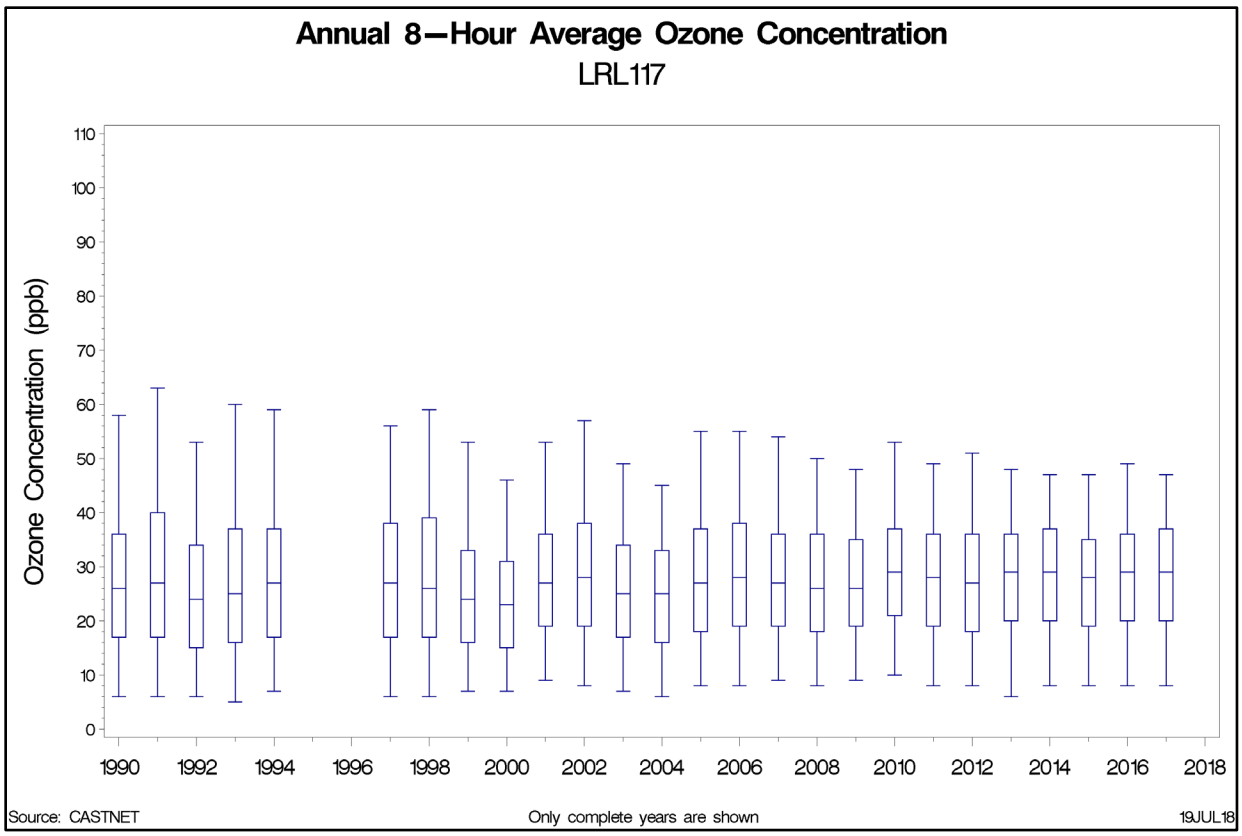


Figure 4.1. Annual 8-hour average ozone concentration recorded from 1990-2017 at Laurel Hill State Park, a Clean Air Status and Trends Network site located approximately 39 miles (63 km) northeast of Friendship Hill National Historic Site; there is no apparent trend of significance (US EPA 2018a).

Confidence Assessment

Confidence in the assessment is *medium* since ratings were based on interpolated data from distant monitoring stations (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).

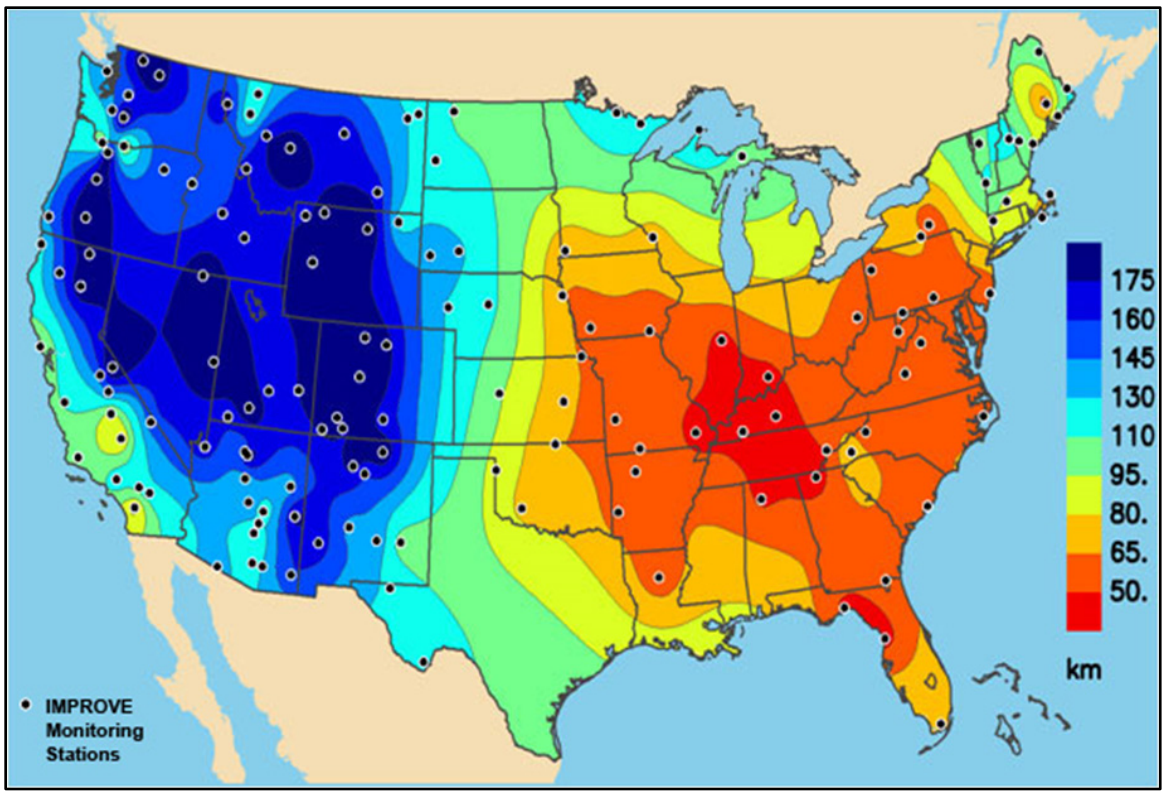


Figure 4.2. Location of Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring stations within the U.S. and their average visual range (in kilometers) based on data collected from 2005-2007 (NPS ARD 2009).

Methods and Data

Using data collected at IMPROVE sites, the NPS ARD compares the average recorded visibility to estimated natural visibility; the difference between these two values represents anthropogenic impact on visibility. Ideally, this difference should stay below 2 deciviews (dv) for all parks (NPS ARD 2015).

The comparison between average and natural visibility is made

> *"… using the average haze index on the 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 FRHI (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. Benchmark for visibility status (Taylor 2017).

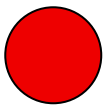
Status Category	Visibility (dv)*
Warrants significant concern	> 8
Warrants moderate concern	2-8
Resource in good condition	< 2

* 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 mid-range days in FRHI during the period from 2011-2015 was 15.7 dv; this is 8.5 dv above the estimated natural condition in the park of 7.2 dv (NPS ARD 2017). Based on the NPS ARD condition categories above, FRHI's air quality for visibility is assigned a rating of *resource warrants significant concern* (Table 4.5).

Table 4.5. Status of visibility in Friendship Hill National Historic Site (NPS ARD 2018b).

Air Quality Indicator	Specific Measure	Condition Status/Trend[1]	Rationale
Visibility	Haze Index[2]		• **Condition:** Visibility warrants significant concern at Friendship Hill NHS. 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.[3] • **Trend:** No trend information is available because there are not sufficient on-site or nearby visibility monitoring data. • **Confidence:** The degree of confidence at Friendship Hill NHS is medium because estimates are based on interpolated data from more distant visibility monitors.

[1] 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.

[2] Visibility trends and condition 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 (40th to 60th 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.

[3] Natural visibility conditions are those estimated to exist in a given area in the absence of human-caused visibility impairment. Estimated annual average natural condition on mid-range days equals 7.2 deciviews at Friendship Hill NHS.

Trend Assessment

Trend assessment of visibility data from the haziest days in national parks within the U.S. from 1999-2008 suggests that conditions in eastern parks are unchanging or possibly improving (NPS ARD 2010). However, as with the ozone assessments, none of the monitoring stations are close enough to FRHI to allow us to be certain of the visibility inside the park and estimating the temporal trend of an approximated spatial condition seems baseless; therefore, we will not assign a trend rating (Table 4.5).

Confidence Assessment

Confidence in the assessment is *medium* since ratings were based on interpolated data from distant monitoring stations (Table 4.5).

4.1.3. Atmospheric Deposition

Relevance

Nitrogen (N) and sulfur (S) most often enter the atmosphere as nitrogen oxides and sulfur dioxides released by industrial processes such as the generation of electricity through fossil fuel combustion, manufacturing, and the operation of vehicles and heavy equipment (US EPA 2017b). Once in the atmosphere, N and S can react with other molecules to return to Earth as dust or precipitation—also referred to as dry or wet deposition (US EPA 2017b). Both types of deposition can alter aquatic and terrestrial ecosystems by enriching and acidifying soil and water; consequences of such changes include harming aquatic and terrestrial invertebrates, stressing vegetation, shifting community composition, increasing insect and disease outbreaks, and disrupting ecosystem processes such as nutrient cycling and fire regimes (Schindler 1988, Schindler et al. 1989, Rusek and Marshall 2000, Driscoll et al. 2001, Mitchell et al. 2001, Horsley et al. 2002, Dupont et al. 2005, Thormann 2006, Wallace et al. 2007).

This report focuses on wet deposition exclusively as a measure of atmospheric deposition because 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).*

It is especially important to consider effects of N and S deposition for FRHI because the eastern U.S. has a higher rate of atmospheric deposition than the rest of the country; in the east, the total background deposition for both N and S is approximately 0.50 kilograms per hectare per year (kg/ha/yr), half of which falls as precipitation (Driscoll et al. 2003, NPS ARD 2010).

Methods and Data

Values for wet N and S deposition were based on interpolated values from NADP/NTN data collected by a monitoring station in Laurel Hill State Park in conjunction with NPS ARD sources; wet deposition conditions were assessed from 2011-2015 and wet deposition trends were assessed from 1990-2014.

Atmospheric wet deposition is evaluated for N by calculating the sum of N portions from nitrate and ammonium concentrations in precipitation, both reported in milligrams per liter (mg/L); similarly, the annual S precipitation-weighted mean concentration is the S portion derived from sulfate concentrations. In both cases, the means are normalized to minimize variation in data caused by interannual differences in precipitation. The weighted mean concentrations are averaged over a 5-year period with a minimum of 3 years of annual data that meet the following criteria:

- *Seasonal criterion 1: Percentage of time during the meteorological season for which valid samples are available ≥ 50%.*
- *Seasonal criterion 2: Percentage of time during the meteorological season for which valid precipitation amounts are available ≥ 75%.*
- *Seasonal criterion 3: Percentage of the total measured precipitation associated with valid samples ≥ 50% for the meteorological season* (NPS ARD 2015).

Since acidification and enrichment from nitrogen and sulfur inputs are the catalysts for other ecosystem-level changes, it was also important to include appraisals of the park's sensitivity to such changes.

The relative sensitivity of a park's resources to acidification can be measured on a national scale using a risk assessment by Sullivan et al. (2011a). This risk assessment considered three factors that influence the magnitude of a park's reaction to acidification from N and S deposition: pollutant exposure, ecosystem sensitivity, and park protection. In a report, Sullivan et al. (2011a) ranked 271 national parks by each factor, then summarized the overall risk to each park; the overall risk can be classified as *very low*, *low*, *moderate*, *high*, or *very high*.

A similar risk assessment was used to evaluate the relative sensitivity of a park's resources to enrichment because of N deposition; again, the assessment considered pollutant exposure, ecosystem sensitivity, and park protection to evaluate the extent to which a park may be affected by nutrient enrichment (Sullivan et al. 2011b). National parks were again ranked by each factor and by an overall risk rating.

Relative risk assessments are especially useful because critical loads have not been established in the Clean Air Act for N and S deposition. Consequently, the NPS is creating a critical load approach for wet deposition of N and S to protect and manage park ecosystems (NPS ARD 2010). As stated above, the NPS ARD has created a conditional assessment benchmark of 1.0 kg/ha/yr based on ecological responses documented in the scientific literature.

Condition Assessment

The 2011-2015 estimated wet N deposition was 4.0 kg/ha/yr, a level far exceeding the NPS ARD benchmark; we therefore consider the status of N deposition to be *resource warrants significant concern* (Table 4.6). This is supported by the acidification risk rankings in Sullivan et al (2011a) that describe FRHI's pollutant exposure as *very high*, ecosystem sensitivity as *moderate*, and park protection as *moderate*, leading to an overall *high* risk. Regarding nutrient enrichment, Sullivan et al.

(2011b) assigned FRHI a pollutant exposure category of *very high*, *low* ecosystem sensitivity, *moderate* park protection, and an overall risk of *high*.

Because S contributes to acidified precipitation too, wet S deposition was also considered in the acidification factors and overall high-risk rating given by Sullivan et al. (2011a) above. With a 2011-2015 deposition rate of 3.3 kg/ha/yr in the area near FRHI, we assign this metric a condition category of *resource warrants significant concern* as well (Table 4.6).

Table 4.6. Status of wet nitrogen and sulfur deposition in Friendship Hill National Historic Site (NPS-ARD 2015). Reporting units for wet deposition conditions and trends are different. Wet deposition trends are evaluated using pollutant concentrations in precipitation (micro equivalents/liter) so that yearly variations in precipitation amounts do not influence trends analyses. Wet deposition conditions are based on nitrogen and sulfur loading (kilograms per hectare per year) to ecosystems.

Air Quality Indicator	Specific Measure	Condition Status/Trend*	Rationale
Nitrogen	Wet Deposition		• **Condition:** Wet nitrogen deposition warrants significant concern at Friendship Hill NHS. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet nitrogen deposition of 4.0 kilograms per hectare per year (kg/ha/yr). Although Friendship Hill NHS receives high levels of nitrogen deposition, ecosystems in the park are not typical of nitrogen-sensitive systems and were rated as having low sensitivity to nutrient-enrichment effects relative to all Inventory & Monitoring parks (Sullivan et al. 2011a,b). • **Trend:** No trend information is available because there are not sufficient on-site or nearby deposition monitoring data. • **Confidence:** The degree of confidence at Friendship Hill NHS is medium because estimates are based on interpolated data from more distant deposition 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.

Table 4.6 (continued). Status of wet nitrogen and sulfur deposition in Friendship Hill National Historic Site (NPS-ARD 2015). Reporting units for wet deposition conditions and trends are different. Wet deposition trends are evaluated using pollutant concentrations in precipitation (micro equivalents/liter) so that yearly variations in precipitation amounts do not influence trends analyses. Wet deposition conditions are based on nitrogen and sulfur loading (kilograms per hectare per year) to ecosystems.

Air Quality Indicator	Specific Measure	Condition Status/Trend*	Rationale
Sulfur	Wet Deposition		• **Condition:** Wet sulfur deposition warrants significant concern at Friendship Hill NHS. This status is based on NPS Air Resources Division benchmarks and the 2011–2015 estimated wet sulfur deposition of 3.3 kilograms per hectare per year (kg/ha/yr). Ecosystems in the park were rated as having moderate sensitivity to acidification effects relative to all Inventory & Monitoring parks (Sullivan et al. 2011a, b). Acidification effects can include changes in water and soil chemistry that impact ecosystem health. Plants sensitive to the effects of acidification in the park include *Acer saccharum* (sugar maple) and *Picea rubens* (red spruce) trees. • **Trend:** No trend information is available because there are not enough on-site or nearby deposition monitoring data. • **Confidence:** The degree of confidence at Friendship Hill NHS is high because estimates are based on interpolated data from more distant deposition 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.

Trend Assessment

The nearest NADP/NTN and CASTNET stations to FRHI are in Laurel Hill State Park, approximately 39 mi (63 km) northeast of FRHI; 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 an area than ozone or visibility, and with more certainty that regional values accurately reflect park conditions, we feel comfortable assigning a trend rating for this air quality metric. Based upon data from 2000-2016, there appears to be a substantial decline in overall nitrogen and sulfur deposition in the region over the past 17 years (US EPA 2018a). We therefore rate N and S wet deposition as *condition is improving*.

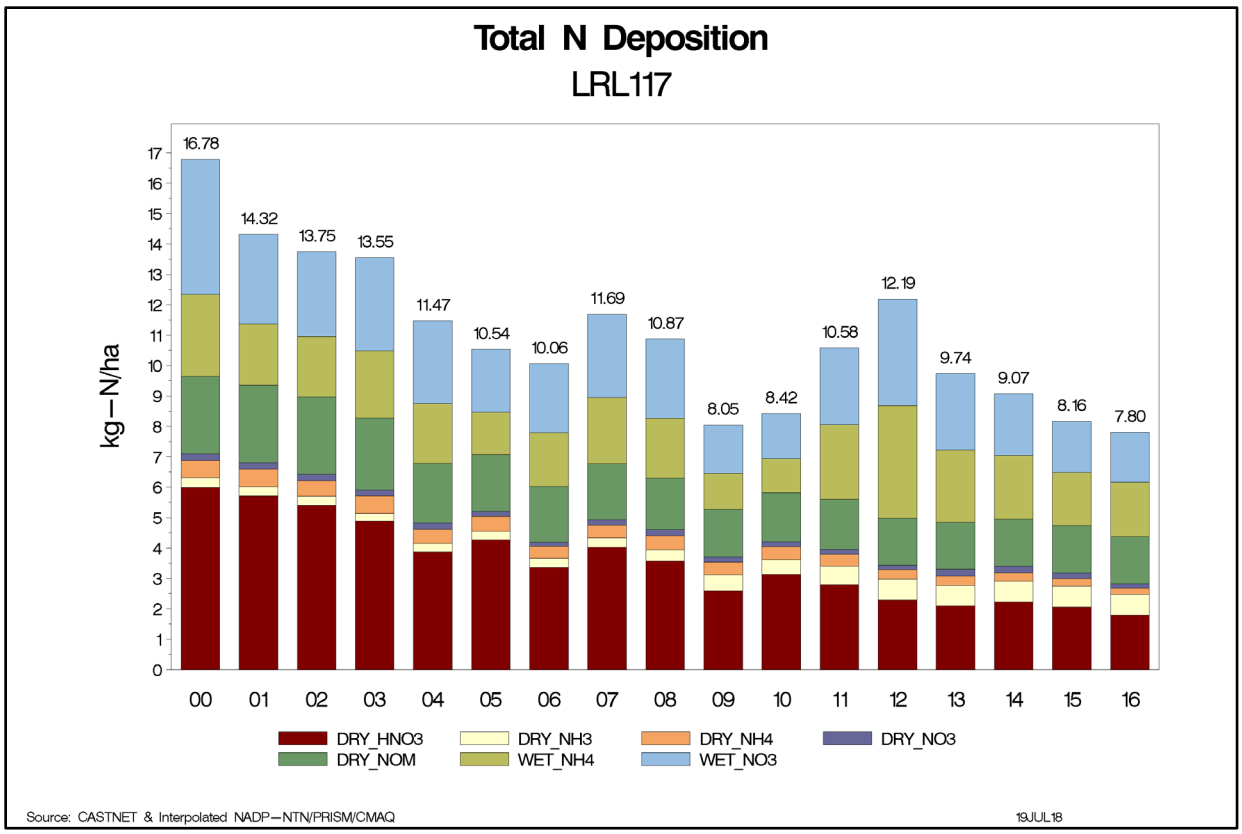


Figure 4.3. Total nitrogen deposition recorded at Laurel Hill State Park, a Clean Air Status and Trends Network site located approximately 39 miles (63 km) northeast of Friendship Hill National Historic Site; there is an overall decline in deposition from 2000-2016 (US EPA 2018a).

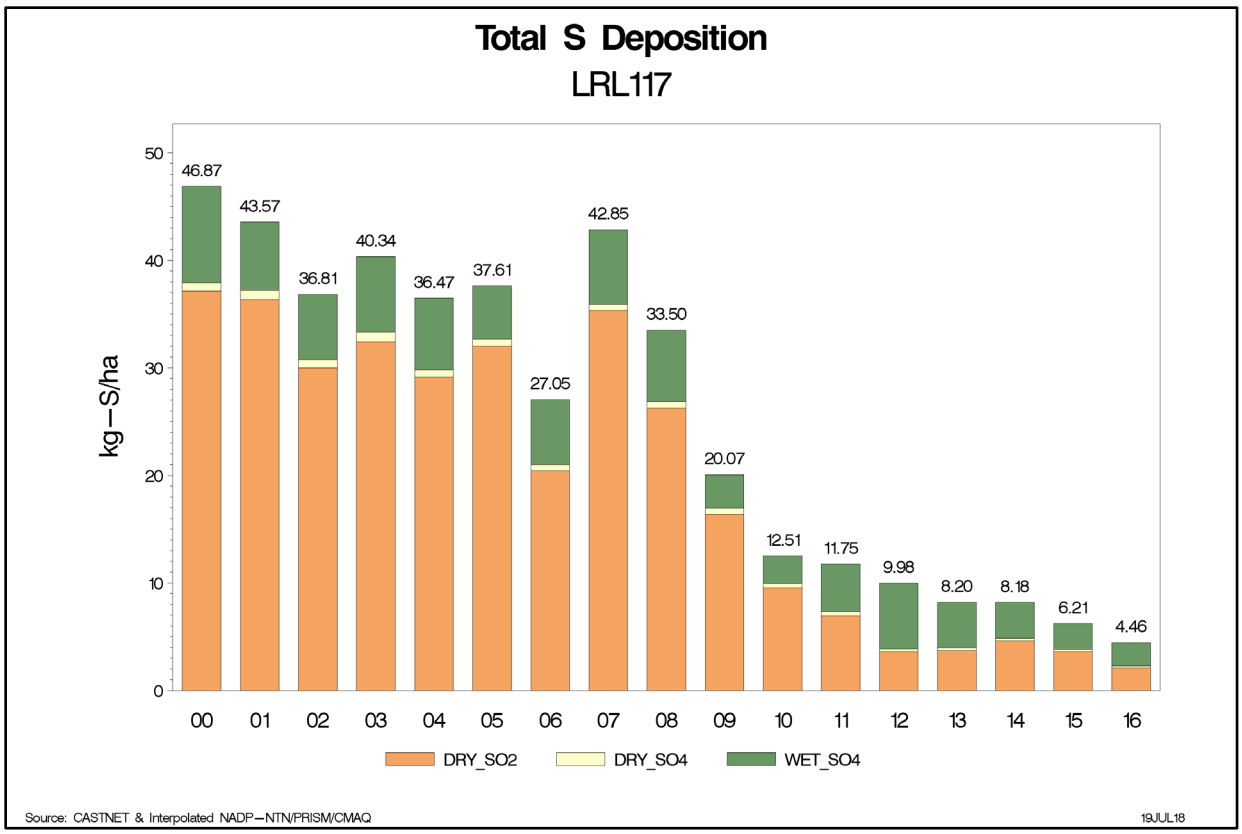


Figure 4.4. Total sulfur deposition recorded at Laurel Hill State Park, a Clean Air Status and Trends Network site located approximately 39 miles (63 km) northeast of Friendship Hill National Historic Site; there is an overall decline in deposition from 2000-2016 (US EPA 2018a).

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 FRHI; therefore, confidence in the assessment is *high* (Table 4.6).

4.2. Water Quality

4.2.1. Relevance

As it is located beside the Monongahela River, water is an important cultural resource for FRHI. There are also four main streams that run through the park to join the Monongahela— South Run, Rhododendron Run, Dublin Run, and Ice Pond Run; these streams contribute to the recreational value of FRHI. Maintaining high water quality in the river and streams is vital to the natural resources in the park as well, since aquatic species such as fish and macroinvertebrates, insects, amphibians, and waterfowl rely on these habitats for food and shelter; furthermore, properly functioning streams and rivers can filter pollutants, thus improving the quality of water that enters the park (US EPA 2013).

Unfortunately, several reports found evidence of acid mine drainage (AMD) in the park and its surroundings (Boone and Lisk 2002, Sibrell et al. 2003, Tzilkowski and Sheeder 2006, Thornberry-Ehrlich 2008, NPS 2013, Tzilkowski et al. 2015). AMD is highly acidic water, laden with heavy metals, that became polluted as a result of mining activity; when AMD mixes with groundwater, surface water, and soil, it can have negative consequences on humans, wildlife, and vegetation (US EPA 2018b). Tzilkowski et al. (2015) found both Ice Pond Run and Dublin Run to be classified as warm water fisheries, and only Dublin Run supported that status.

4.2.2. Methods and Data

For this assessment we relied on data reported by Tzilkowski and Sheeder (2006) and Tzilkowski et al. (2015). Tzilkowski and Sheeder (2006) measured temperature, pH, dissolved oxygen, and conductivity; we also considered the data presented on fish and macroinvertebrate communities as way of ascertaining the state of the aquatic habitat. The authors sampled eight locations throughout FRHI (Figure 4.5).

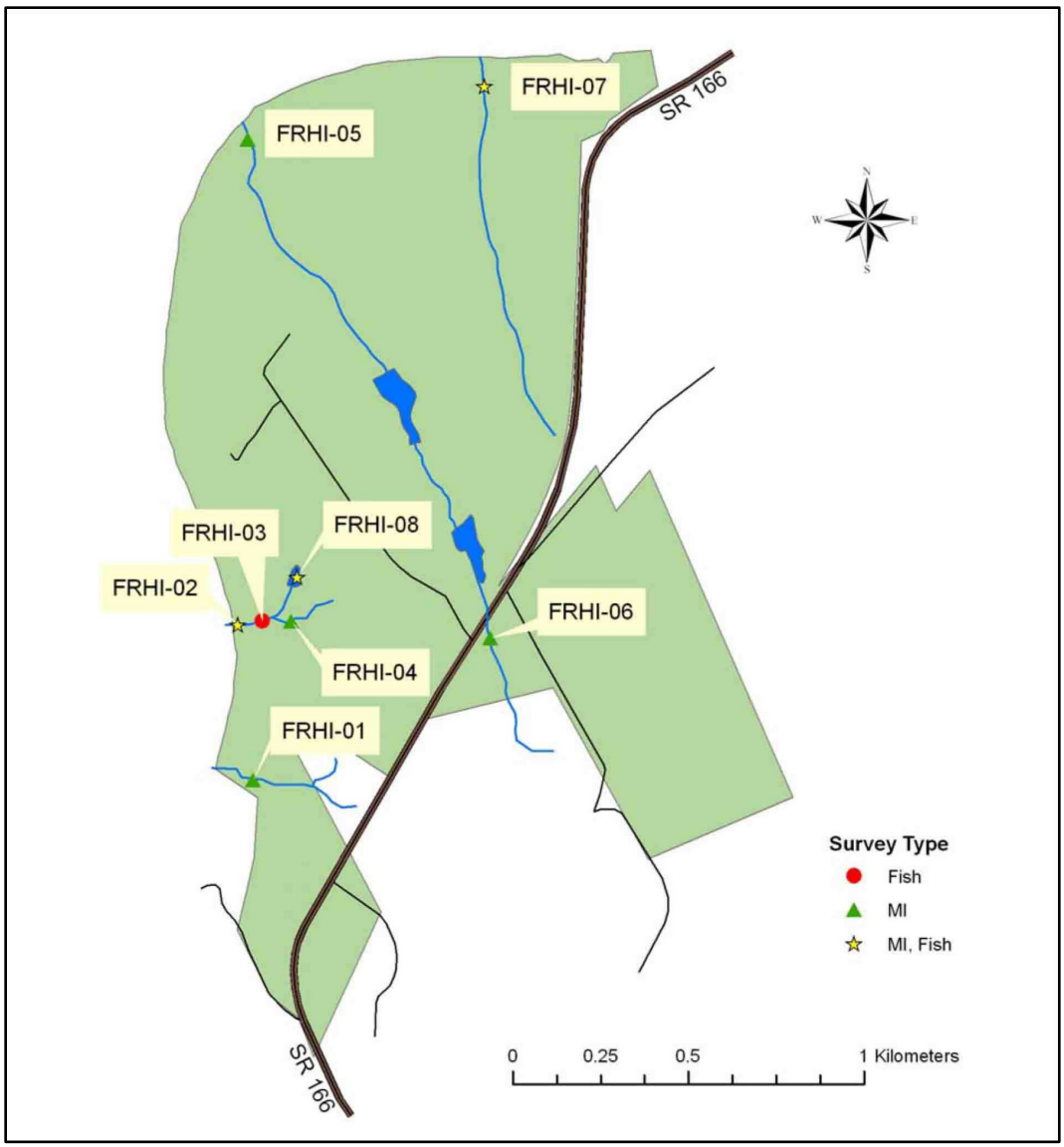


Figure 4.5. Sampling locations of Tzilkowski and Sheeder (2006) at Friendship Hill National Historic Site.

4.2.3. Condition Assessment

Data collected by Tzilkowski and Sheeder (2006) on temperature, pH, dissolved oxygen, and conductivity are presented in Table 4.7. The most concerning result was the low pH measured in Ice Pond Run upstream of the Main Loop Trail; while other sample location had pH values between 6.45-8.70, this spot in Ice Pond Run registered a pH of 2.99 - extremely acidic. Such a low pH is not known to occur under normal circumstances, and therefore indicates impairment due to AMD. Tzilkowski et al. (2015) assessed two streams within FRHI: Dublin Run and Ice Pond Run. Dublin Run was seen as supporting its designated use while Ice Pond Run failed due to AMD issues. They found conductivity in Ice Pond Run much higher than the 2006 data showed (> 1400 µs/cm vs. 185 µs/cm maximum, see Table 4.7) while Dublin Run values were roughly the same. Dissolved oxygen was also relatively the same between the two sample dates.

Table 4.7. Water quality data collected by Tzilkowski and Sheeder (2006) for eight locations in Friendship Hill National Historic Site. FRH103 not sampled.

Site	Description	Date	T (°C)	pH	DO%	DO (mg)	Conductivity	Specific Conductivity
FRHI01	South Run, upstream of Main Loop Trail	12/05/2005	3.2	8.70	88.0	11.45	185.5	317.5
FRHI02	Rhododendron Run, centered on Main Loop Trail	11/04/2002, 12/05/2005	9.1 2.2	7.49 7.48	91.8 88.9	10.56 12.23	132.7 86.2	190.6 152.6
FRHI03	Rhododendron Run, upstream of downstream-most waterfall	–	–	–	–	–	–	–
FRHI04	Rhododendron Run, South Branch	12/05/2005	3.7	6.45	71.3	9.17	79.1	132.6
FRHI05	Ice Pond Run, upstream of Main Loop Trail	12/05/2005	2.1	2.99	86.0	11.73	75.5	132.9
FRHI06	Ice Pond Run, upstream of SR 166	12/05/2005	4.2	7.31	81.3	10.56	118.2	196.3
FRHI07	Dublin Run, centered on Main Loop Trail	11/04/2005, 12/05/2005	10.9 2.0	7.40 7.43	88.0 88.0	9.65 12.07	155.6 114.8	213.5 202.9
FRHI08	Sophia's Pond	11/04/2005, 12/05/2005	8.5 4.0	7.19 7.15	88.0 57.0	9.60 7.40	94.0 84.0	137.7 140.5

The macroinvertebrate community surveys indicated that there may also be some habitat impairment in all sampled sites as all fall within or below the impaired ranged (Figure 4.6). Impairment appears to be from historical conditions rather than current problems (Tzilkowski and Sheeder 2006). Three streams (Dublin Run (FRHI07); South Run (FRHI01); and Rhododendron Run (FRHI02)) were least impaired and with the best opportunity for restoration work. Later assessment by Tzilkowski et al. (2015) found MBII values to be very low in Ice Pond Run, again due to issues with AMD, while Dublin Run was in much better condition.

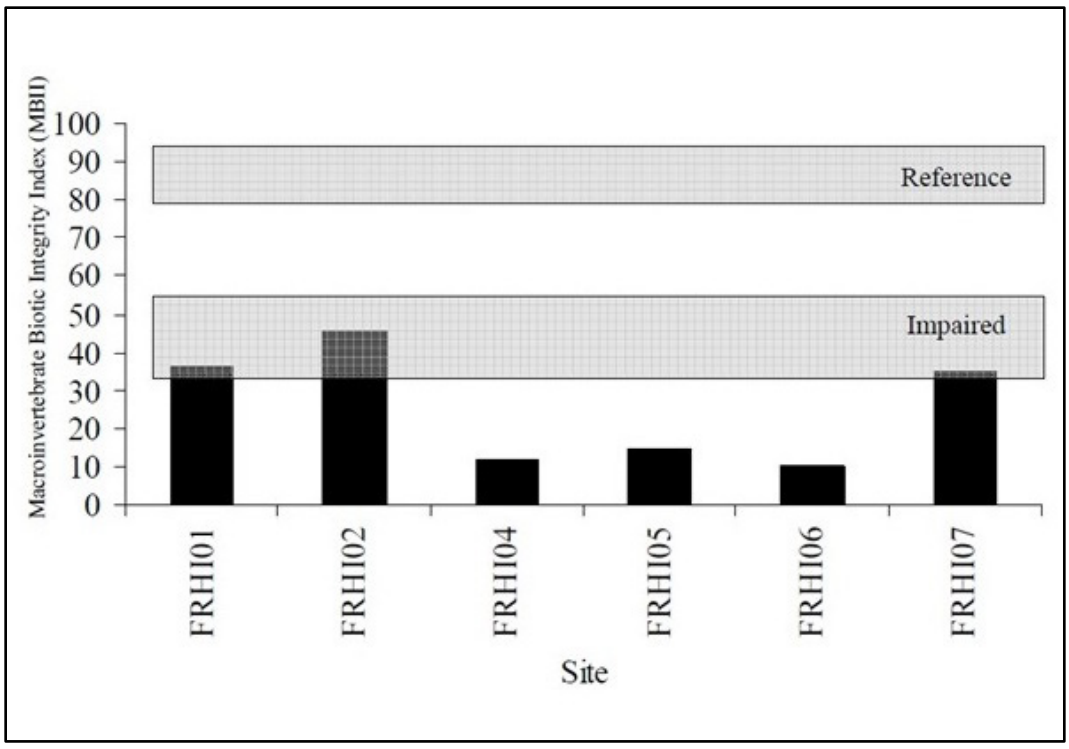


Figure 4.6. Macroinvertebrate Biotic Integrity Index (MBII) scores for stream sample sites in Friendship Hill National Historic Site (FRHI). Shaded areas represent range of values reported for reference and impaired streams in uplands of the region (Tzilkowski and Sheeder 2006).

Given the prevalence of AMD in and around the park continues (Tzilkowski et al. 2015), and Tzilkowski and Sheeder's (2006) earlier call for stream restoration in FRHI, we rate water quality as *resource warrants significant concern* (Table 4.8).

Table 4.8. Water quality status at Friendship Hill National Historic site; only pH was considered as it was outside the bounds of recommended water quality standards.

Water Quality Indicator	Specific Measure	Condition Status/Trend	Rationale
Temperature, pH, dissolved oxygen, conductivity	pH		• **Condition**: Given the presence of AMD in Ice Pond Run and the unknown reasons for impairment in the other streams, we rate this as warrants significant concern. • **Trend**: Trends in pH in Ice Pond Run do not appear to be improving. • **Confidence**: Repeated assessments indicate no change in quality over time, but data are limited, so confidence is low.

4.2.4. Trend Assessment

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

4.2.5. Confidence Assessment

Long-term and repeatable data are scarce for FRHI. This leaves us with *low* confidence in any statement about the quality of water within FRHI (Table 4.8). Furthermore, there are no 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 FRHI.

4.3. Wetlands

4.3.1. 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"* (33 CFR 328.3).

The U.S. National Park System encompasses 408 areas totaling 33,993,593 ha of lands which are also home to more than 6 million ha of wetland habitat, ranging from tidal salt marshes along the coasts to non-tidal palustrine and riverine wetlands in the continental interior. These habitats provide valuable ecosystem services that include structural benefits for storm surge protection, stream and river channel stabilization, and water-quality treatment, as well as other services such as carbon sequestration, endangered species habitat, and biodiversity maintenance. In 1977, President Carter issued Executive Order 11990: Protection of Wetlands (42 Federal Register 26961), which required avoiding adverse impacts to wetlands on NPS-managed lands to the greatest extent possible. In addition to this executive order, NPS activities that involve the discharge of dredged or fill material into wetlands or other waters of the United States must comply with regulations under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act (33 CFR 320–331) (Sharpe et al. 2016).

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.

FRHI includes almost 5 acres of wetlands within its boundaries (Figure 4.7); though they are located at an elevation that does not typically flood, they are impacted by fluvial erosion from the Monongahela River and support hydrophilic plants on hydric soils (NPS 2005). Two large wetlands are in the northern part of the park, and three more are along Ice Pond Run. Perles et al. (2006) describe a mixed forb marsh as one of the vegetation types within FRHI. They noted it to be along an unnamed stream running through the center of FRHI (likely Ice Pond Run). Dominant plants included *Polygonum sagittatum*, *Leersia oryzoides*, *Phalaris arundinacea*, *Scirpus cyperinus*, and *Typha latifolia*.

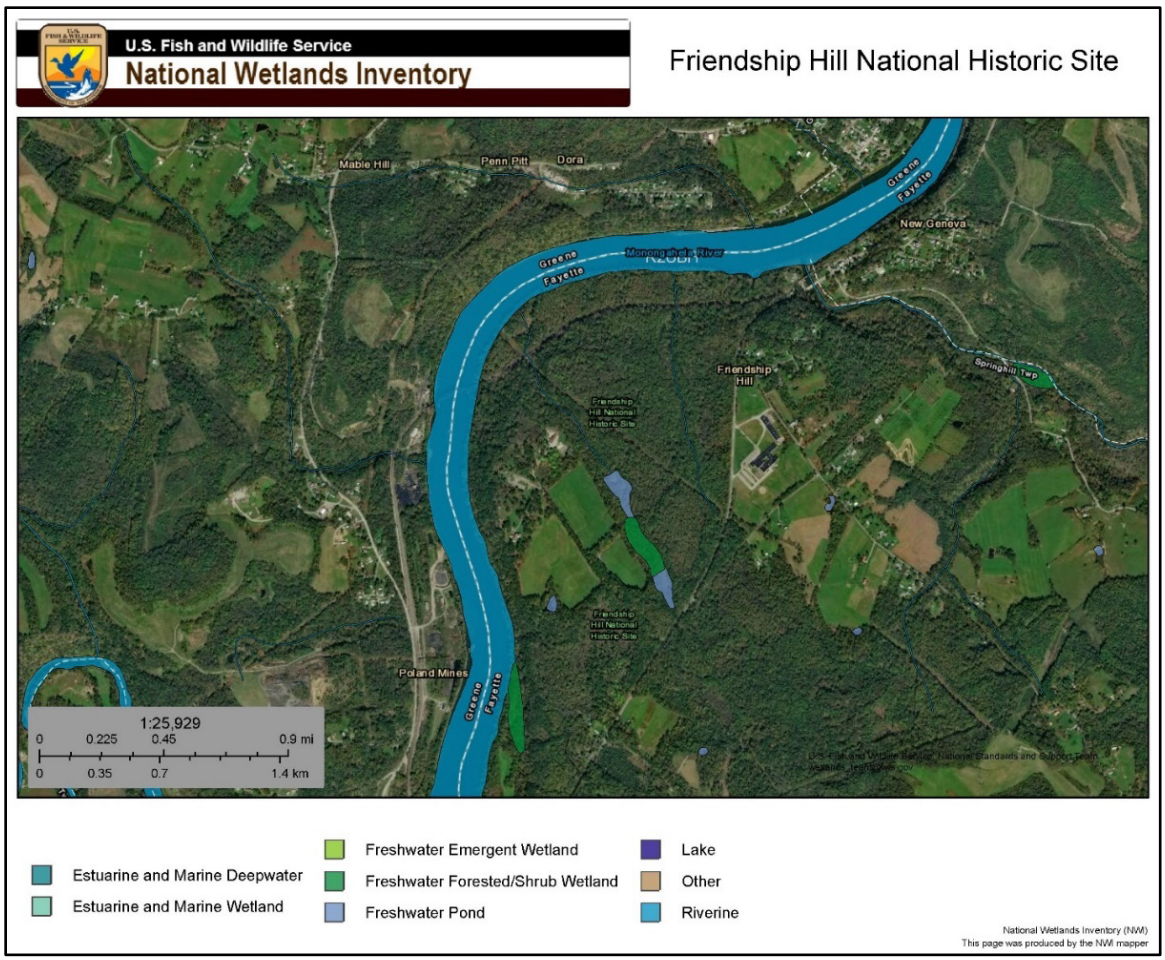


Figure 4.7. National Wetlands Inventory map of wetland sites at Friendship Hill National Historic Site. (https://www.fws.gov/wetlands/data/mapper.html).

Delineation of historic wetlands in the park was done as per the *Wetland Regulatory Compliance: A Guidance Manual for the National Park Service Mid-Atlantic Region* (Wagner 1989) based on the criteria of areas containing hydric soils and vegetation characteristic of a wetland (Boone and Lisk 2002).

Some of the FRHI's wetlands are man-made, having been constructed to reduce the impact of AMD; wetlands have the potential to remediate contaminated water because of their ability to retain and filter water slowly through organic matter (Klusman et al. 1993). The earliest created wetlands were two pilot-scale projects designed in 1986 and 1988 (Hedin et al. 1991); later versions, built with help from the NPS Disturbed Land Restoration Program, connected a series of small ponds along the park's streams, including Ice Pond Run (Thornberry-Ehrlich 2008).

4.3.2. Methods and Data

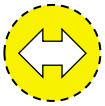
There are no standard methods for determining the quality of wetlands, as no federal nor state standards have been developed against which to judge a site. Instead of a written standard, a largely undisturbed wetland nearby may be designated as a reference wetland for the sake of comparison.

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 FRHI and are therefore not suitable for comparison. Another method for assessing wetland condition was used at Richmond National Battlefield (Schneider et al. 2012), with a GIS analysis of land cover, vegetated buffers, and buffer width. We did not attempt this and relied on best professional judgement.

4.3.3. Condition Assessment

As stated previously, FRHI is in a region known to be affected by AMD. The constructed wetlands have attenuated some of the influence of AMD in the park's streams, but they must be monitored and maintained to continue to be effective. Additionally, overflow and wastewater from a nearby, active AMD treatment facility has led to concerns about the water quality of one historic wetland, called the Sulfur Swamp (Boone and Lisk 2002). After a comprehensive inventory and assessment of abandoned mineral lands in national parks, Burghardt et al. (2014) concluded that the wetlands at FRHI require some remedial action based on possible hazards to cultural and natural resources. Other reports indicate that only Ice Pond Run has AMD issues (Tzilkowski and Sheeder 2006). Given the paucity of data on wetlands, we therefore consider the condition of wetlands in FRHI to be *resource warrants moderate concern* (Table 4.9).

Table 4.9. Status of wetlands in Friendship Hill National Historic Site.

Indicator	Specific measure	Condition status / Trend	Rationale
Ecological integrity - wetlands	Hydrologic modification		• **Condition:** Wetlands form an opportunity for remediation of acid mine drainage in the FRHI national park and are in a state of moderate concern. • **Trend:** While several steps have been taken to create inventories and assessment for wetland construction and threats to historic wetlands, they still need effective monitoring and remediation. • **Confidence:** The log-term trend is unknown, and the degree of confidence is low.

4.3.4. Trend Assessment

We have no data upon which to assess a trend, but there does not seem to be any further effects on wetlands other than those in Ice Pond Run.

4.3.5. Confidence Assessment

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

4.4. Aquatic Species

4.4.1. Macroinvertebrates

Relevance

Aquatic macroinvertebrates are aquatic or semi-aquatic invertebrates larger than microscopic size; they are vital components in food webs and essential in healthy nutrient and carbon cycling (Webster 1983; Tzilkowski et al. 2010). Aquatic macroinvertebrate assemblage patterns are sensitive to a variety of stream, riparian, and landscape changes such as altered stream channel characteristics, water quality, water quantity, aquatic vegetation communities, and landscape. The most recent documentation was completed by Tzilkowski et al. (2015) on the two perennial streams (Ice Pond Run and Dublin Run) (Figure 4.8), but the ERMN has even more up-to-date, unpublished data.

Methods and Data

The most recent publication on macroinvertebrates summarized data from 2008-2013, though only from two streams within FRHI (Tzilkowski et al. 2015). Tzilkowski and Sheeder (2006) covered more sites within FRHI. In all cases, a multimetric index of biotic integrity (MIBI) was calculated based upon the species present. No reference conditions were calculable because the methods used in the park to assess macroinvertebrate health were developed for streams with characteristics that FRHI streams do not share; therefore, judgement on condition of benthic macroinvertebrates in relation to water quality was based on best professional judgement.

Condition Assessment

Condition scores were more numerous for 2006 as more sites were sampled. Scores were all in the impaired range (Figure 4.6) as compared to regional reference data (Tzilkowski and Sheeder 2006). Tzilkowski et al. (2015) noted that Dublin Run (refer to FRH107 in Figure 4.6) was supporting of its status as a warm water fishery while Ice Pond Run was not (FRH105, FRH106 below). Ice Pond Run is known to be AMD impacted and that has limited the water quality for a long while. Based on the limited data available, our estimation is that the overall aquatic macroinvertebrate community merits a rating of *resource warrants moderate concern* (Table 4.10).

Trend Assessment

There is very limited data upon which to assess a trend. Tzilkowski and Sheeder (2006) felt that these sites, while impaired, were certainly better than they had been in the past as some disturbances (e.g., agriculture) have ceased. However, the later data do not support that conclusion (Tzilkowski et al. 2015) so we cannot state with much confidence a strong trend in any direction.

Confidence Assessment

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

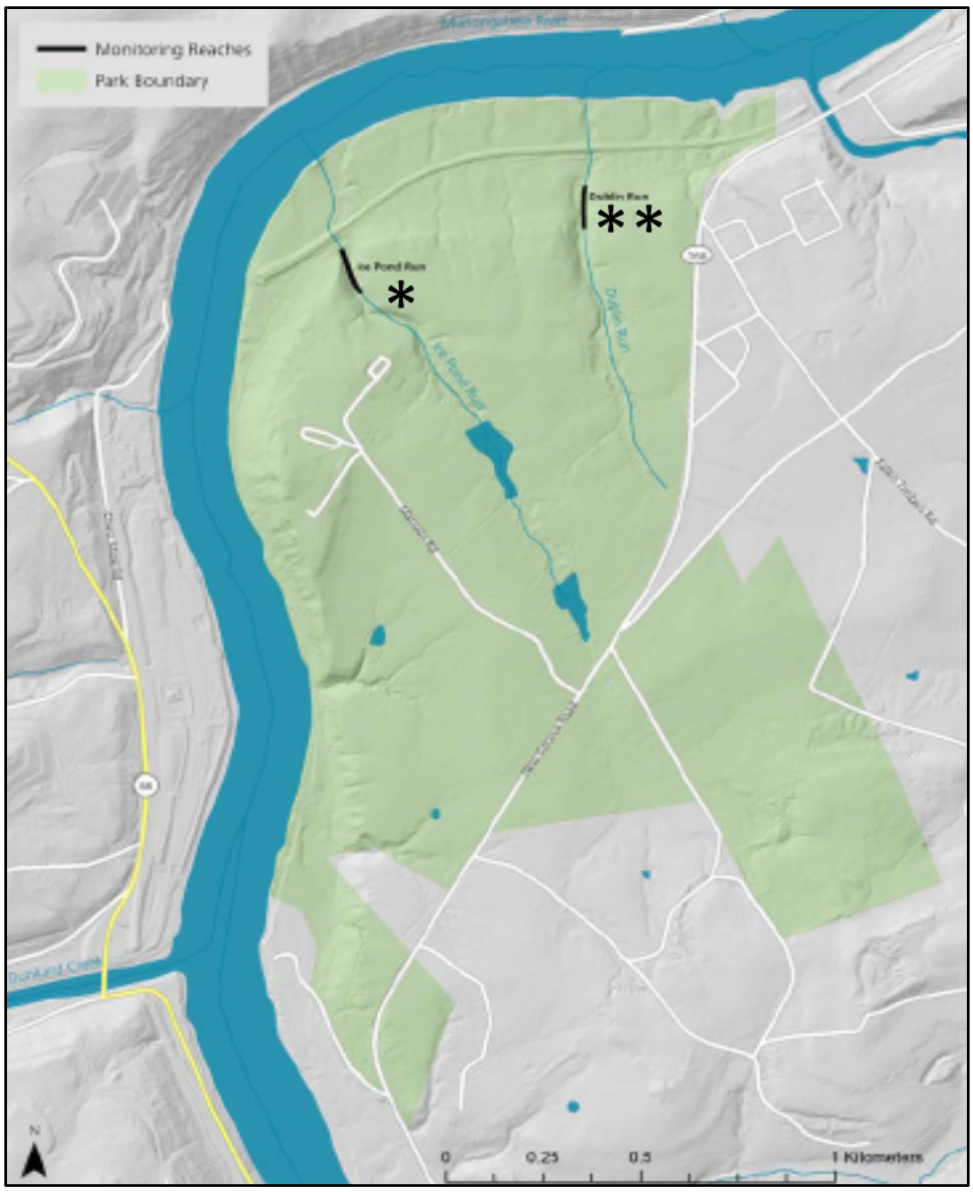
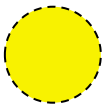


Figure 4.8. Streams sampled for macroinvertebrates at Friendship Hill National Historic Site (Tzilkowski et al. 2015). Ice Pond Run = *, Dublin Run = **

Table 4.10. Status of aquatic macroinvertebrates at Friendship Hill National Historic Site.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological Integrity	Macro-invertebrate IBI		• **Condition:** Macroinvertebrate data indicate that most of the streams and ponds are depauperate with respect to diversity and species indicative of high-quality streams. • **Trend:** Information is lacking. • **Confidence:** The degree of confidence at FRHI is low due to limited data.

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 interest to the public. Fish assemblages are influenced by a wide range of stream, riparian, and landscape features. Like macroinvertebrates, fish assemblages are affected by changes in stream, riparian, and landscape features.

Methods and Data

All streams in FRHI are designated as warm water fishes. These are defined by Chapter 93 of the Pennsylvania Bulletin as:

> *"Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat."*

The most recent fish sampling at FRHI came from Tzilkowski and Sheeder (2006) and Faulk and Weber (2017). In neither case were many fish species caught. Tzilkowski and Sheeder (2006) found common carp (*Cyprinus carpio*), creek chub (*Semotilus atromaculatus*), and blacknose dace (*Rhinichthys atratulus*). Faulk and Weber (2017) only sampled at Dublin Run and found two additional species - white sucker (*Catostomus commersonii*) and largemouth bass (*Micropterus salmoides*) – as well as blacknose dace and creek chub. The Blacknose dace and creek chub comprised 96% of fish caught by Faulk and Weber (2017).

Condition Assessment

Although Dublin Run appears to be in good condition, Ice Pond Run was not even sampled due to AMD issues. As such, we cannot state that the fish communities in the park are in good condition overall. Our estimation is that the overall fish community merits a rating of *resource warrants moderate concern.*

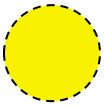
Trend Assessment

We cannot identify trends due to a lack of data (Table 4.11)

Confidence Assessment

Confidence in the assessment is medium as the data are recent, even if lacking in a time series (Table 4.11).

Table 4.11. Status of fish at Friendship Hill National Historic Site.

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological Integrity	Fish Diversity		• **Condition:** Fish data only from one stream. • **Trend:** Information is lacking. • **Confidence:** The degree of confidence at FRHI is medium as the data, while lacking a time series, are relatively recent.

4.5. Wildlife

4.5.1. Relevance

Natural landscapes are increasingly being fragmented by urbanization, agriculture, and other land use zones like industries. National parks hold key positions in maintaining the ecological integrity of these regions as well as protecting the diversity of animals and bird species (Yahner et al. 2004). Comprehensive inventories and assessment reports on condition of faunal population and distribution across national parks will help address this challenge by providing useful information which can guide future allocation of land use as well as means to monitor and conserve natural resources (Ambrose and Bratton 1990, Yahner 1995).

4.5.2. Methods and Data

This study is based on Yahner et al.'s (2004) comprehensive inventory of birds and mammals, Kowalski et al.'s (2005) inventory of amphibians and reptile species, and inventories of bats created by Gates and Johnson (2007) and Nagel and Gates (2018). For a wide-ranging list of species that have historically been identified at FRHI we obtained the database from NPSpecies (Appendix A).

4.5.3. Condition Assessment

Birds

According to Yahner et al. (2004), there were 162 species of birds recorded historically in FRHI out of which the authors could detect 131 (80.8%) during their study. They also detected 11 additional species that were not previously included in the historic documentation. Among these, 21 species were identified as ones of special concern, out of which 11 were believed to breed within the park (Table 4.12). In this list the authors also included the bald eagle (*Haliaeetus leucocephalus*), which was designated as 'threatened' at a federal level and 'endangered' at the state level (the bald eagle was subsequently federally delisted in 2007 and its status changed to "Protected" in Pennsylvania in 2014).

Streamside Birds

The ERMN monitors the bird community in FRHI as part of the Streamside Bird Monitoring Protocol (Marshall et al. 2016). "Streamside birds" refers to the breeding bird community surrounding streams. The area sampled in this protocol is along park wadeable streams which are typically (but not always) forested including a closed canopy over the stream. The purpose of including the term "streamside" is not the bird community *per se*, rather the physical area sampled (and area of inference) is limited to the land area surrounding wadeable streams in each park. The primary rationale was to co-locate bird monitoring sites with other monitoring protocols such as benthic macroinvertebrates (Tzilkowski et al. 2015) and stream fish (Faulk and Weber 2017). Additional rationale for focusing monitoring on the bird community along streams, a description of the wadeable stream target sampling area for each park, and how sampling sites were selected are described in Marshall et al. (2016).

Each year from 2008-2012 the ERMN sampled two sites in FRHI with a total of nine point-count stations (4 or 5 point-count stations per site). These data and maps of the sampling locations and methods are summarized in Marshall et al. (2013). Beginning in 2013 (and currently) the ERMN

samples the same two sites within FRHI but with only three point-count stations per site (a subset of the original stations). These sites are sampled every other year. The current sampling locations (and overlap between time periods) and methods are summarized in Marshall et al. (2016).

Table 4.12. The list of birds of special concern that were spotted at Friendship Hill National Historic Site. The status of birds of special concern was obtained from the following sources: bird of conservation concern (BCC) (http://migratorybirds.fws.gov/reports/bcc2002); state vulnerable (SV) (http://www.dcnr.state.pa.us/forestry/pndi/pndiweb.htm); Audubon Watchlist (AW) (http://www.audubon.org/bird/watch).

Species	Status
Great blue heron	AW
American black duck	AW
Osprey	SV
Northern bobwhite	SV
American woodcock	AW
Black-billed cuckoo	BCC
Yellow-bellied sapsucker	BCC
Acadian flycatcher	BCC
Wood thrush	BCC & AW
Swainson's thrush	SV
Blue-winged warbler	AW
Cerulean warbler	BCC & AW
Prairie warbler	BCC & AW
Bay-breasted warbler	BCC & AW
Kentucky warbler	BCC & AW
Canada warbler	BCC & AW
Worm-eating warbler	BCC & AW
Louisiana waterthrush	BCC
Summer tanager	SV
Grasshopper sparrow	BCC

Bird Guilds as Indicators of Ecological Condition

Birds are often used as indicators of ecological health or integrity and summarizing the "condition" of the bird community and reporting changes in the bird community over time is a primary objective of this protocol (Marshall et al. 2016). The Bird Community Index (BCI) is an index of biotic integrity based on the breeding bird communities of the central Appalachians (O'Connell et al. 1998a, 1998b, 2000). The BCI is based on 16 response guilds with each guild broadly classified as "specialist" or "generalist" depending on each guild's relationship to specific elements of biotic integrity. Each 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 (indicating higher biotic integrity) describe a community in which specialists are well-represented relative to generalists.

Marshall et al. (2013) calculated the BCI for FRHI and demonstrated that the ecological condition of the bird community was "high" integrity at both sites at FRHI. No sites were "low" integrity. This means that the bird community is comprised of 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 (2008-2012) condition within the park was generally better than the average condition throughout the Mid-Atlantic region (O'Connell et. al 2000) and like the other parks within the ERMN.

The birds at FRHI included several species of birds which thrive in riparian environments like this park located on the banks of the Monongahela River, including double-crested cormorant, wood duck, American black duck, canvasback, hooded merganser, osprey, spotted sandpiper, cliff swallow, and northern rough-winged swallow. While the river provides the birds with necessary resources, Yahner et al. (2004) suggested that the recent closure of the AMD facility in the region may have directly or indirectly influenced the increased bird populations. In addition, the grasslands and forested lands at FRHI provide the bird population with necessary resources as well as places for breeding, thereby helping the community thrive.

Mammals

Yahner et al. (2004) detected 12 mammals in FRHI and added 6 more species which were not already documented. Other species that may have been present in the park but not included in the inventory are least shrew (*Cryptotis parva*), pygmy shrew (*Microsorex hoyi*), rock shrew (*Sorex dispar*), smoky shrew (*S. fumeus*), water shrew (*S. palustris*), ermine (*Mustela erminea*), least weasel (*M. nivalis*), mink (*M. vision*), and long-tailed weasel. The authors noted that no species of special concern was identified at FRHI (Yahner et al., 2004). Gates and Johnson (2007) captured 118 bats, including 35 big brown bats, 30 little brown myotis, 14 northern long-eared myotis, six tri-colored bats (eastern pipistrelles), and two eastern red bats. However, it should be noted here that the Gates and Johnson (2007) report predated the arrival of white-nose syndrome (more later on WNS). The streams, wetlands and ponds at FRHI provide bats with water, and aquatic insects as food. Aquatic locations were popular among bats, Sophia's Pond having the highest bat activity. The Gallatin House did not show signs of roosting bats and hence should pose no concern for the safety of visitors (Gates and Johnson, 2007). A list of mammals recorded for FRHI is given in Table 4.13.

Table 4.13. The list of mammals that were detected at Friendship Hill National Historic Site. Sources: Yahner (2004), Gates and Johnson (2007), Nagel and Gates (2018), and recorded in NPSpecies (accessed October 2, 2018).

Common Name	Scientific Name
Deer mouse	*Peromyscus maniculatus*
White-footed mouse	*Peromyscus leucopus*
Meadow vole	*Microtus pennsylvanicus*
Masked shrew	*Sorex cinereus*

Table 4.13 (continued). The list of mammals that were detected at Friendship Hill National Historic Site. Sources: Yahner (2004), Gates and Johnson (2007), Nagel and Gates (2018), and recorded in NPSpecies (accessed October 2, 2018).

Common Name	Scientific Name
Short-tailed shrew	*Blarina brevicauda*
Hairy-tailed mole	*Parascalops breweri*
Norway rat	*Rattus norvegicus*
Woodland jumping mouse	*Napaeozapus insignis)*
Muskrat	*Ondatra zibethicus*
Beaver	*Castor canadensis*
Virginia opossum	*Didelphis virginiana*
Woodchuck	*Marmota monax*
Gray squirrel	*Sciurus carolinensis*
Fox squirrel	*Sciurus niger*
Eastern flying squirrel	*Glaucomys volans*
Red squirrel	*Tamiasciurus hudsonicus*
Eastern chipmunk	*Tamias striata*
Eastern cottontail	*Sylvilagus floridanus*
Red fox	*Vulpes vulpes*
Gray fox	*Urocyon cinereoargenteus*
Common raccoon	*Procyon lotor*
Striped skunk	*Mephitis mephitis*
White-tailed deer	*Odocoileus virginianus*
Big brown bat	*Eptesicus fuscus*
Eastern red bat	*Lasiurus borealis*
Little brown bat	*Myotis lucifugus*
Northern long-eared myotis	*Myotis septentrionalis*
Tri-colored bat	*Perimyotis subflavus*

White-nose syndrome (WNS) has become a serious health factor for bats in the eastern United States and this fungal disease has led to a precipitous decline in many bat populations. Nagel and Gates (2018) documented substantial declines in several bat species in FRHI. Three species disappeared entirely between 2005-6 and 2015 (*Myotis lucifugus*, *Myotis septentrionalis*, and *Perimypotis subflavus*), all small cave-dwelling bats susceptible to WNS. . Others were seemingly stable (*Lasiurus borealis*) or increasing (*Eptesicus fuscus*).

Amphibians and Reptiles

This section is based on an inventory of reptiles and amphibians created by Kowalski et al. (2005) (Table 4.14). The authors carried out a survey during 1999-2001 and their methods of detection of species included auditory-call counts, drift-fence arrays, funnel-trap arrays, turtle traps, seine nets, dip nets, rappelling and rock searching, coverboards, and other general survey methods. At FRHI

surveys were conducted in eight locations, including wetlands, ponds, vernal ponds, and deciduous forests (Kowalski et al. 2005). It should be noted that stream visual-encounter surveys at FRHI showed no detection of reptiles or amphibians in the Ice Pond Run, likely due to impact by acid-mine-drainage.

Table 4.14. List of species of amphibians and reptiles identified at Friendship Hill National Historic Site in 1999-2001 (Kowalski et al. 2005).

Common Name	Scientific Name
Northern copperhead	*Agkistrodon contortrix*
Northern black racer	*Coluber constrictor*
Northern ringneck snake	*Diadophis punctatus*
Eastern hognose snake	*Heterodon platirhinos*
Eastern garter snake	*Thamnophis sirtalis*
Black rat snake	*Pantherophis obsoletus*
Northern water snake	*Nerodia sipedon*
Painted turtle	*Chrysemys picta*
Common snapping turtle	*Chelydra serpentina*
Jefferson salamander	*Ambystoma jeffersonianum*
Northern dusky salamander	*Desmognathus fuscus*
Seal salamander	*Desmognathus monticola*
Mountain dusky salamander	*Desmognathus ochrophaeus*
Two-lined salamander	*Eurycea bislineata*
Northern spring salamander	*Gyrinophilus porphyriticus*
Red-spotted newt	*Notophthalmus viridescens*
Redback salamander	*Plethodon cinereus*
Northern slimy salamander	*Plethodon glutinosus*
Eastern American toad	*Anaxyrus americanus*
Fowler's toad	*Anaxyrus fowleri*
Grey treefrog	*Hyla versicolor*
Northern spring peeper	*Pseudacris crucifer*
Bullfrog	*Lithobates catesbeianus*
Green frog	*Lithobates clamitans*
Pickerel frog	*Lithobates palustris*
Northern leopard frog	*Lithobates pipiens*
Wood frog	*Lithobates sylvaticus*

Other than WNS issues with bats, wildlife populations look to be in good health. Without an objective measure to use, and using best professional judgment, we rate this as *resource is in good condition* (Table 4.15).

Table 4.15. Status of wildlife in Friendship Hill National Historic Site.

Indicator	Specific measure	Condition Status / Trend	Rationale
Biological integrity	Mammals, birds, reptiles, and amphibians		• **Condition:** Data indicate that species are generally in good condition (with a cautionary note regarding bats due to WNS). • **Trend:** No trend information is available because there are not sufficient on-site monitoring data (other than birds). • **Confidence:** The degree of confidence at FRHI is low due to lack of data.

4.5.4. Trend Assessment

Marshall et al. (2016; Appendix D) evaluated the change or trend in condition at each site over time for the period 2011-2015 (when sampling methods and locations were identical). The 2017 data (Marshall unpublished data) is added here (Figure 4.9). Based on a simple linear regression of the BCI scores over time, 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 when the ERMN finalized the locations and methods of this monitoring protocol for FRHI. 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 4.15).

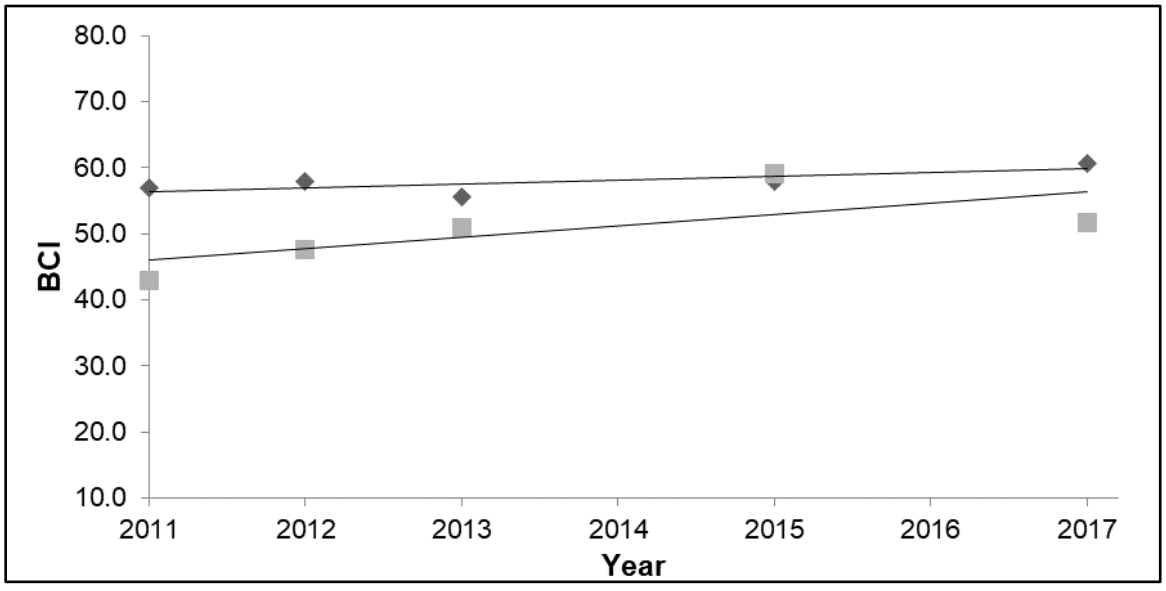


Figure 4.9. Simple linear regression of Bird Community Index (BCI) scores (from 2011-2017) at two Friendship Hill NHS sites (diamonds = Dublin Run; squares = Ice Pond Run).

4.5.5. 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

4.6.1. 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 2017).

4.6.2. Methods and Data

The data presented here come from the NPSpecies web site.

4.6.3. Condition Assessment

There is currently one mammal (Northern long-eared myotis (*Myotis septentrionalis*)) that is federally threatened within FRHI. Several species of plants, mammals, and birds are federal species of concern. Two plants are listed as Threatened in Pennsylvania (Blue monkshood (*Aconitum uncinatum*), Harbinger-of-spring (*Erigenia bulbosa*)). One bird, the yellow-bellied flycatcher (*Empidonax flaviventris*), is listed as endangered by the Commonwealth of Pennsylvania. A full list of vulnerable organisms present, or probably present, in FRHI is presented in Table 4.16. Since only one of the species in the park is federally listed as threatened or endangered, we assign vulnerable species in FRHI a rating of *resource is in good condition* (Table 4.17).

Table 4.16. Vulnerable species present, or probably present, in Friendship Hill National Historic Site (NPSpecies, n.d.). Note-much of the data in NPSpecies is quite dated and this list likely reflects that concern.

Category	Common Name	Scientific Name	Classification[2]
Plant	Blue monkshood	*Aconitum uncinatum*	PT
	Harbinger-of-spring	*Erigenia bulbosa*	PT
	Indian-pipe	*Monotropa uniflora*	SC
Mammal	Big brown bat	*Eptesicus fuscus*[1]	SC
	Little brown bat	*Myotis lucifugus*	PE

[1] Probably present

[2] Classification codes: PE – PA Endangered, PT – PA Threatened, FE- Federal Endangered, FT-Federal Threatened, SC – Federal/PA Species of Concern

Table 4.16 (continued). Vulnerable species present, or probably present, in Friendship Hill National Historic Site (NPSpecies, n.d.). Note-much of the data in NPSpecies is quite dated and this list likely reflects that concern.

Category	Common Name	Scientific Name	Classification[2]
Mammal (continued)	Northern long-eared myotis	*Myotis septentrionalis*	FT
	Tri-colored bat	*Perimyotis subflavus*	PE
Bird	Coopers hawk	*Accipiter cooperii*	SC
	Sharp-shinned hawk	*Accipiter striatus*	SC
	Grasshopper sparrow	*Ammodramus savannarum*	SC
	Great blue heron	*Ardea herodias*	SC
	Rough-legged hawk	*Buteo lagopus*	SC
	Red-shouldered hawk	*Buteo lineatus*	SC
	Turkey vulture	*Cathartes aura*	SC
	Brown creeper	*Certhia americana*	SC
	Black-billed cuckoo	*Coccyzus erythropthalmus*	SC
	Olive-sided flycatcher	*Contopus cooperi*[1]	SC
	Pileated woodpecker	*Dryocopus pileatus*	SC
	Yellow-bellied flycatcher	*Empidonax flaviventris*[1]	PE
	Traill's flycatcher, willow flycatcher	*Empidonax traillii*[1]	SC
	Yellow-breasted chat	*Icteria virens*	SC
	Lincoln's sparrow	*Melospiza lincolnii*[1]	SC
	Osprey	*Pandion haliaetus*	SC
	Downy woodpecker	*Picoides pubescens*	SC
	Summer tanager	*Piranga rubra*	SC
	Purple martin	*Progne subis*[1]	SC
	Bank swallow	*Riparia riparia*[1]	SC
	Yellow-bellied sapsucker	*Sphyrapicus varius*	SC
	Tree swallow	*Tachycineta bicolor*	SC
	Nashville warbler	*Vermivora ruficapilla*	SC
	Wilson's warbler	*Wilsonia pusilla*	SC
Reptiles & Amphibians	Fowler's toad	*Anaxyrus fowleri*	SC
	Eastern hognose snake	*Heterodon platirhinos*	SC

[1] Probably present

[2] Classification codes: PE – PA Endangered, PT – PA Threatened, FE- Federal Endangered, FT-Federal Threatened, SC – Federal/PA Species of Concern

Table 4.17. Status of threatened and endangered species at Friendship Hill National Historic Site (FRHI).

Indicator	Specific Measure	Condition Status/Trend	Rationale
Biological Integrity	Vulnerable species listed by the government		• **Condition:** One species is federally threatened or endangered, and there are three species listed as PA endangered or threatened. • **Trend:** Unknown • **Confidence:** The degree of confidence at FRHI is low due to lack of data.

4.6.4. Trend Assessment

We do not have a long data series upon which to make a good trend assessment for most species, with the possible exception of bats.

4.6.5. Confidence Assessment

Confidence in this assessment is low (Table 4.17).

4.7. Invasive Species

4.7.1. 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.).

4.7.2. Methods and Data

For this section we rely on invasive species data collected as part of: 1) the park's vegetation classification and mapping project (Perles et al. 2006, Zimmerman and Yoder 2006), 2) ERMN Forest Health Monitoring Data (Perles et al. 2014, Perles et al. 2016), and 3) ERMN's Invasive Species Early Detection (ISED) program (Keefer et al. 2010, Manning 2016). The ERMN Forest Health Monitoring program has established 20 permanent long-term monitoring plots in FRHI at which data for numerous forest health metrics are collected, including invasive species abundance and richness. ISED relied on four major components as methods for detection of invasive species in the region (Manning 2016): 1) creating a compiled list of all invasive species and pests from existing datasets and literature review, 2) elimination of common and already identified species from the criterion of 'early detection', 3) datasets from neighboring parks, towns, counties, and states, and 4) shortlisting of species that match the criteria for ISED based on comprehensive research and recommendations of park natural resource managers. The ISED program focuses on surveillance of targeted invasive species which have not yet been observed in FRHI but could likely become established in the park based on their known patterns of spread.

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).

4.7.3. Condition Assessment

FRHI has been identified among the most affected parks in the ERMN region from invasive species (Perles et al. 2006, 2016). Comparison between FRHI and the other ERMN parks can provide a frame of reference for conditions within FRHI. Compared with other ERMN parks, FRHI ranks highest in invasive plant species metrics (Figure 4.10, Figure 4.11), containing more invasive plant species per plot and higher cover of invasive species than all other ERMN parks.

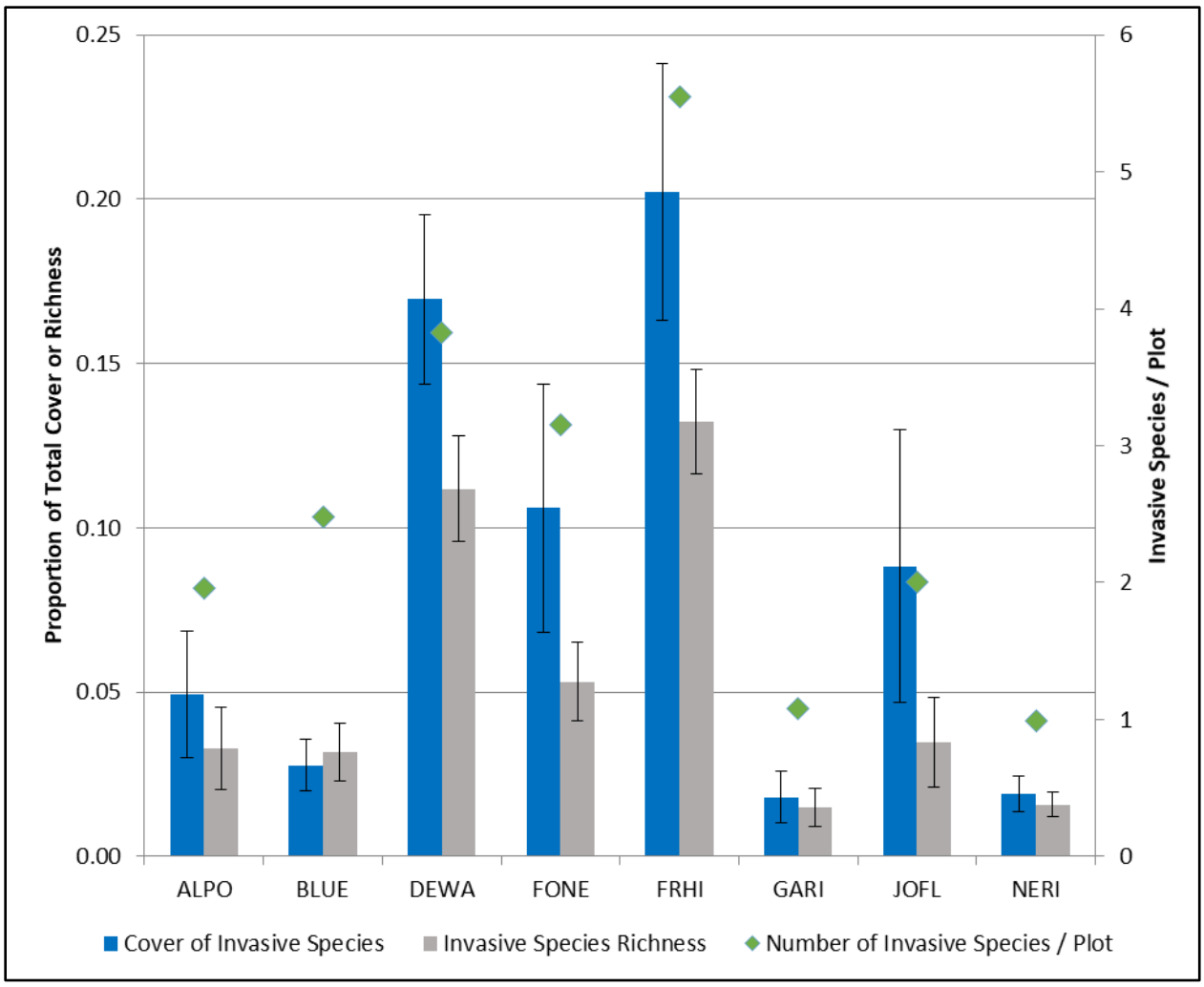


Figure 4.10. Average (± standard error) proportion of the total cover (blue bars) and species richness (brown bars) held by invasive exotic plant species as measured in monitoring quadrats in Eastern Rivers and Mountains Network parks. The orange diamonds show the average number of invasive species/plot for each park, using all species data collected on each plot (Perles et al. 2014).

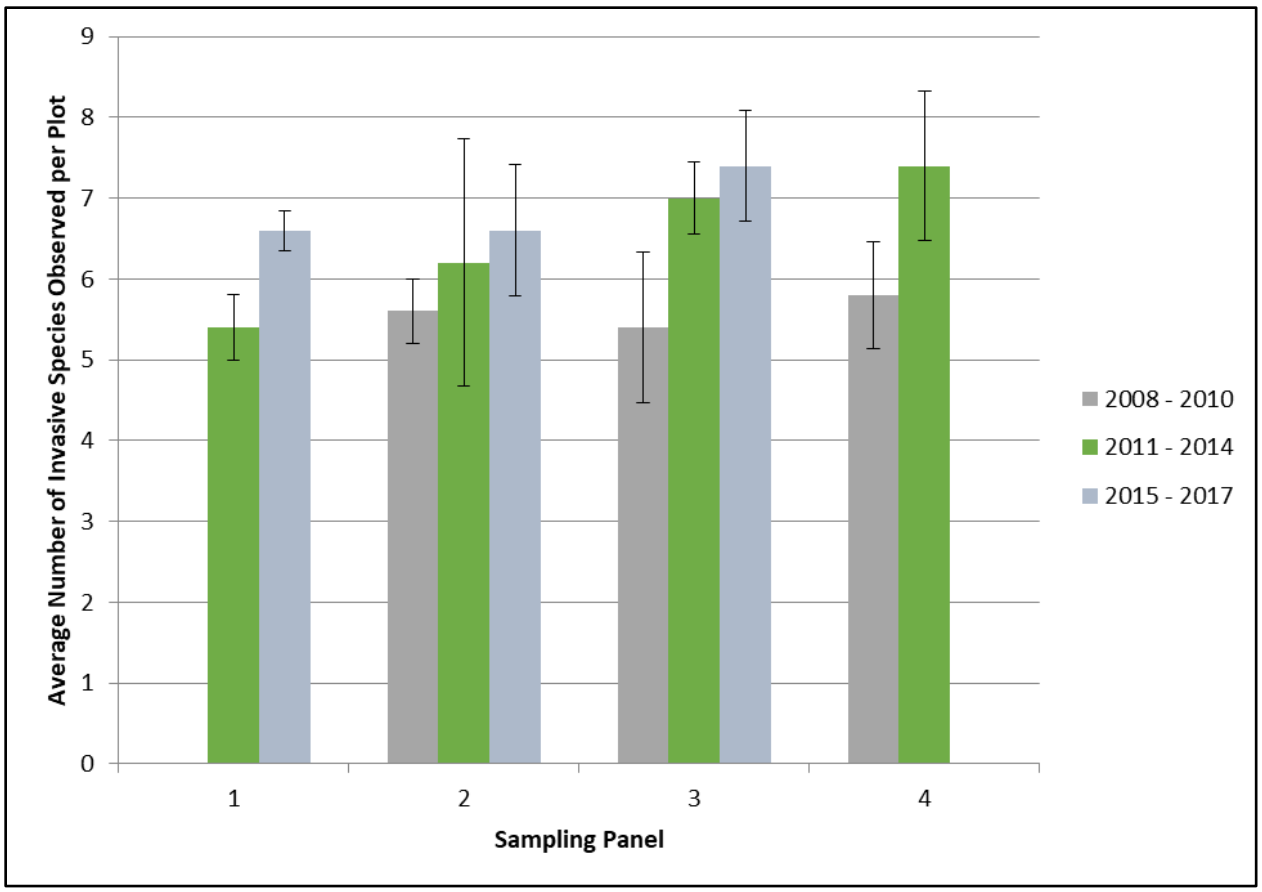


Figure 4.11. Average (± standard error) number of invasive plant species observed per plot in Eastern Rivers and Mountains Network's Forest Health monitoring plots at Friendship Hill National Historic Site (2008 – 2017).

Of the 445 plant species known to occur in FRHI (NPSpecies, n.d.), 35 species are considered to be invasive by ERMN (Table 4.18). The most abundant invasive species in FRHI include: multiflora rose (*Rosa multiflora*), Japanese stiltgrass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), Oriental lady's-thumb (*Polygonum caespitosum*), tree of heaven (*Ailanthus altissima*), ground ivy (*Glechoma hederacea*), autumn olive (*Elaeagnus umbellata*), Japanese barberry (*Berberis thunbergii*), and Morrow's honeysuckle (*Lonicera morrowii*) (Perles et al. 2014, Zimmerman and Yoder 2006). Old fields, successional forests, and floodplain forests hold the highest numbers of non-native plants, whereas mature oak forest contains the fewest (Zimmerman and Yoder 2006). Zimmerman and Yoder (2006) also found roads and pathways to be major routes of non-native plant invasion into FRHI. The following species have been included in the list of invasive species and nonnative pests in the 2013-2015 ISED program (Manning 2016).

Table 4.18. List of invasive plant species known to occur at Friendship Hill National Historic Site as of 2018, with frequency of occurrence in the park. Species with 0% frequency listed in both columns have been documented from other sources cited in NPSpecies (n.d.) or the Eastern Rivers and Mountains Network's Invasive Species Early Detection program.

Scientific Name	Frequency in ERMN Forest Health Monitoring Plots (2007 - 2018)	Frequency in Assessment Points (Zimmerman and Yoder 2006)
Rosa multiflora	88%	79%
Microstegium vimineum	82%	49%
Lonicera japonica	75%	55%
Polygonum caespitosum	73%	46%
Ailanthus altissima	53%	12%
Glechoma hederacea	38%	30%
Elaeagnus umbellata	35%	8%
Berberis thunbergii	32%	13%
Lonicera morrowii	32%	6%
Alliaria petiolata	12%	6%
Celastrus orbiculatus	12%	0%
Ligustrum sp.	12%	0%
Duchesnea indica	7%	0%
Lonicera sp.	7%	0%
Anthoxanthum odoratum	5%	11%
Lonicera maackii	3%	0%
Festuca elatior	2%	7%
Cirsium arvense	2%	1%
Lysimachia nummularia	2%	1%
Verbascum thapsus	2%	1%
Cardamine impatiens	2%	0%
Polygonum persicaria	2%	0%
Hesperis matronalis	0%	2%
Ornithogalum umbellatum	0%	2%
Cirsium vulgare	0%	1%
Polygonum cuspidatum	0%	1%
Polygonum sachalinense	0%	1%
Frangula alnus	0%	0%
Lespedeza cuneata	0%	0%
Pastinaca sativa	0%	0%
Ranunculus ficaria	0%	0%
Rhodotypos scandens	0%	0%
Securigera varia	0%	0%
Tussilago farfara	0%	0%
Vinca minor	0%	0%

Of the long-term forest health monitoring plots established by ERMN in FRHI, all 20 plots have contained at least one invasive plant species since monitoring began in 2007 (Perles et al. 2014, ERMN Forest Health Monitoring Data). Furthermore, ERMN monitoring data strongly suggest that invasive plants are a growing problem in the park as these species continue to spread (Figures 4.11, 4.12, and 4.13, ERMN Forest Health Monitoring Data). The number of invasive species observed in each monitoring plot appears to be increasing over time (Figure 4.11). In addition, the proportion of the ground story cover and plant species richness occupied by invasive species may also be increasing (Figures 4.12 and 4.13). After monitoring data are collected in 2019, these data will be analyzed for statistically significant trends in invasive species abundance and trends will be reported to park managers.

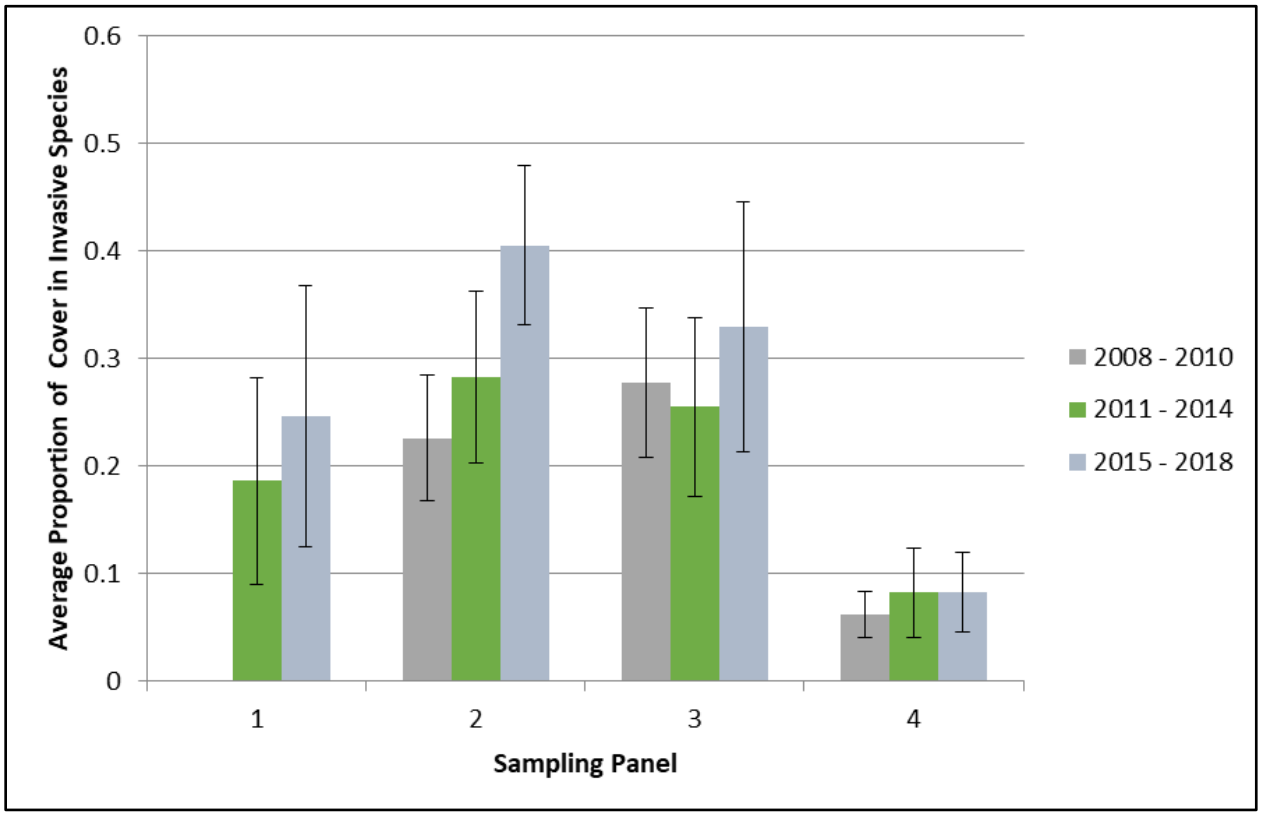


Figure 4.12. Average (± standard error) proportion of ground story cover in invasive plant species (2008 – 2018), from Eastern Rivers and Mountains Network's Forest Health monitoring plots at Friendship Hill National Historic Site.

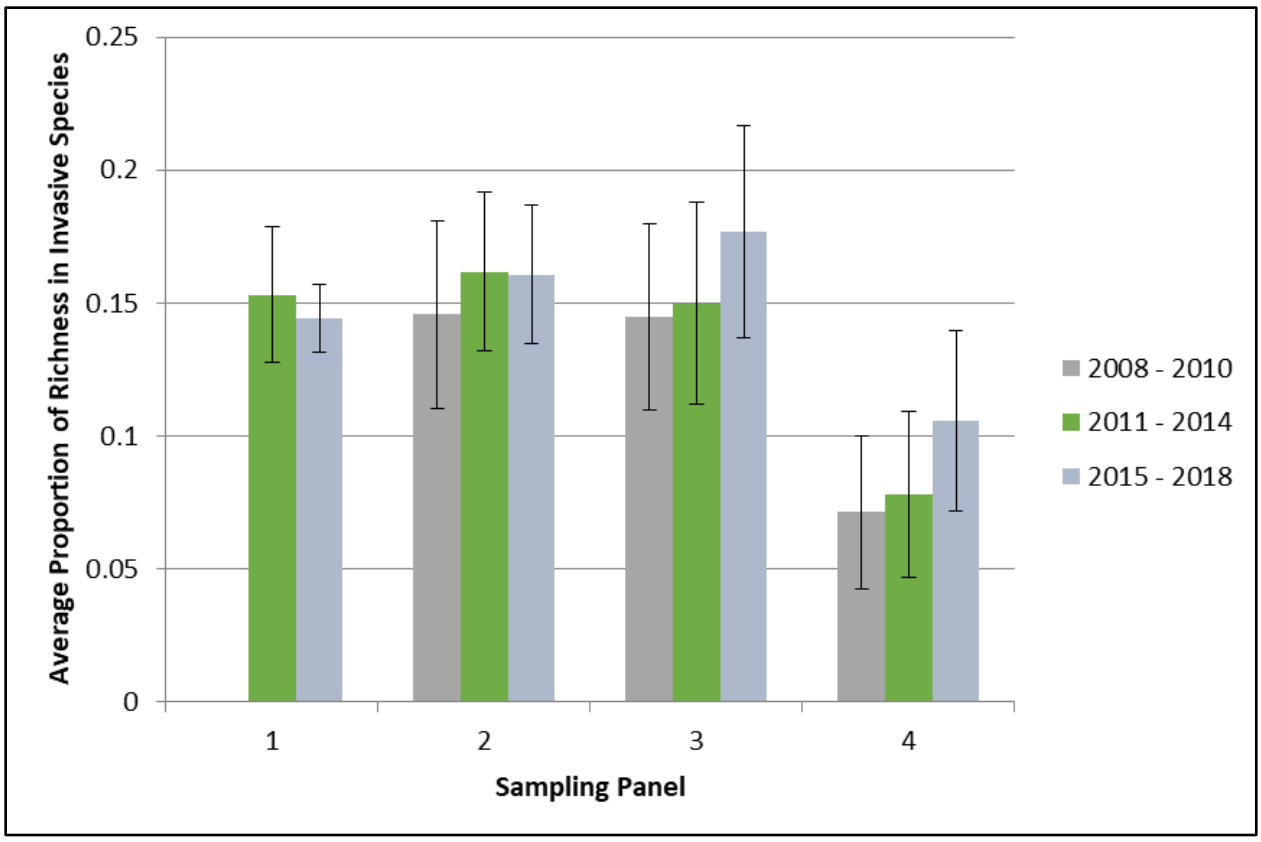


Figure 4.13. Average (± standard error) proportion of ground story species richness in invasive plant species (2008 – 2018), from Eastern Rivers and Mountains Network's Forest Health monitoring plots at Friendship Hill National Historic Site.

Over the past 10 years, six invasive species that are new to FRHI have been observed in the park through the ERMN ISED program (Table 4.19, Manning 2016), providing further evidence of the growing invasive species problem in FRHI. We note that the *resource warrants concern.*

Table 4.19. Invasive plant species and invertebrate pests included in the Invasive Species Early Detection list as part of its 2013-2015 program. X=detected at Friendship Hill National Historic Site (FRHI).

Common Name	Scientific Name	Taxa Category	Detected in FRHI
Hemlock woolly adelgid	*Adelges tsugae*	PEST	–
Emerald ash borer	*Agrilus planipennis*	PEST	–
Asian long-horned beetle	*Anoplophora glabripennis*	PEST	–
Bot canker	*Diplodia corticola*	PEST	–
Thousand cankers disease	*Geosmithia morbida*	PEST	–
Viburnum leaf beetle	*Pyrrhalta viburni*	PEST	X
Sirex woodwasp	*Sirex noctilio*	PEST	–
Spicebush decline	Unnamed spicebush decline	PEST	X

Table 4.19 (continued). Invasive plant species and invertebrate pests included in the Invasive Species Early Detection list as part of its 2013-2015 program. X=detected at Friendship Hill National Historic Site (FRHI).

Common Name	Scientific Name	Taxa Category	Detected in FRHI
Didymo	*Didymosphenia geminata*	AQUATIC PLANT	–
Amur peppervine	*Ampelopsis brevipedunculata*	PLANT	X
Narrowleaf bittercress	*Cardamine impatiens*	PLANT	–
Winged burning-bush	*Euonymus alatus*	PLANT	–
Giant hogweed	*Heracleum mantegazzium*	PLANT	–
Japanese hop	*Humulus japonicus*	PLANT	–
Privet	*Ligustrum* spp.	PLANT	X
Chinese silvergrass	*Miscanthus sinensis*	PLANT	–
Wavyleaf basketgrass	*Oplismenus hirtellus* ssp. *undulatifolius*	PLANT	–
Phragmites	*Phragmites australis*	PLANT	–
Mile-a-minute	*Polygonum perfoliatum*	PLANT	–
Kudzu	*Pueraria montana* var. *lobata*	PLANT	–
Lesser celandine	*Ranunculus ficaria*	PLANT	X
Common buckthorn	*Rhamnus cathartica*	PLANT	–
Jetbead	*Rhodotypos scandens*	PLANT	X
Linden arrowwood	*Viburnum dilatatum*	PLANT	–

4.7.4. Trend Assessment

Monitoring data suggest that invasive species are spreading within the park, degrading natural resource condition. Once three full panels of sampling have been completed in 2019, monitoring data will be analyzed for statistically significant trends.

4.7.5. Confidence Assessment

Given the large data set, confidence is *medium* (Table 4.20).

Table 4.20. Status of invasive plant species in Friendship Hill National Historic Site.

Indicator	Specific Measure	Condition Status / Trend	Rationale
Invasive plants	Prevalence of invasive plant species		• **Condition**: Invasive plants are a major concern at FRHI, which requires thorough monitoring, and systemic removal of the invasive species from the park to prevent further spread. • **Trend**: Monitoring data suggest that invasive species are spreading within the park, degrading natural resource condition. • **Confidence:** The degree of confidence at FRHI is medium until monitoring data can be analyzed for statistically significant trends in 2019.

4.8. Forest Health

4.8.1. Relevance

Much of the Eastern Rivers and Mountains Network is forested, thus making forest health a parameter of importance. Most (if not all) of the northeastern United State has been logged, many areas more than once, and the recovering forest has been subject to disturbances from invasive pests as well as anthropogenic impacts. Forest health is, therefore, of considerable importance to FRHI and other parks in the region.

4.8.2. Methods and Data

Perles et al. (2014, 2016) conducted a forest health assessment of the ERMN and based park assessments on tree growth, mortality, and regeneration; surrounding land use; invasive species (see above), and other indicators. These were repeated measurements as the site had been sampled regularly since 2007.

4.8.3. Condition Assessment

Perles et al. (2014, 2016) found the forests of FRHI to be young and in early successional stages following abandonment from agricultural fields. These young trees are growing rapidly on rich mesic soils, giving the park the fastest growth rate in the network. These young trees are also competing with each other for a place in the future canopy, leading to a high mortality rate as some trees are out-competed. The current canopy composition, dominated by tuliptree, red maple, black cherry, sugar maple, and boxelder, is relatively stable (Figure 4.14). Pin oak showed very strong growth as a result of some trees established in the former agricultural land growing in full sun, on fertile soil, and with limited competition. Most of the park's ash trees will likely die in the next few years from emerald ash borer infestation, so hazard ash trees in high visitor use areas should be assessed.

High browse pressure from deer has left most plots with insufficient regeneration (Figure 4.15). FRHI had the highest percentage of agricultural lands surrounding any ERMN park, though overall acreage was small (Figure 4.16).

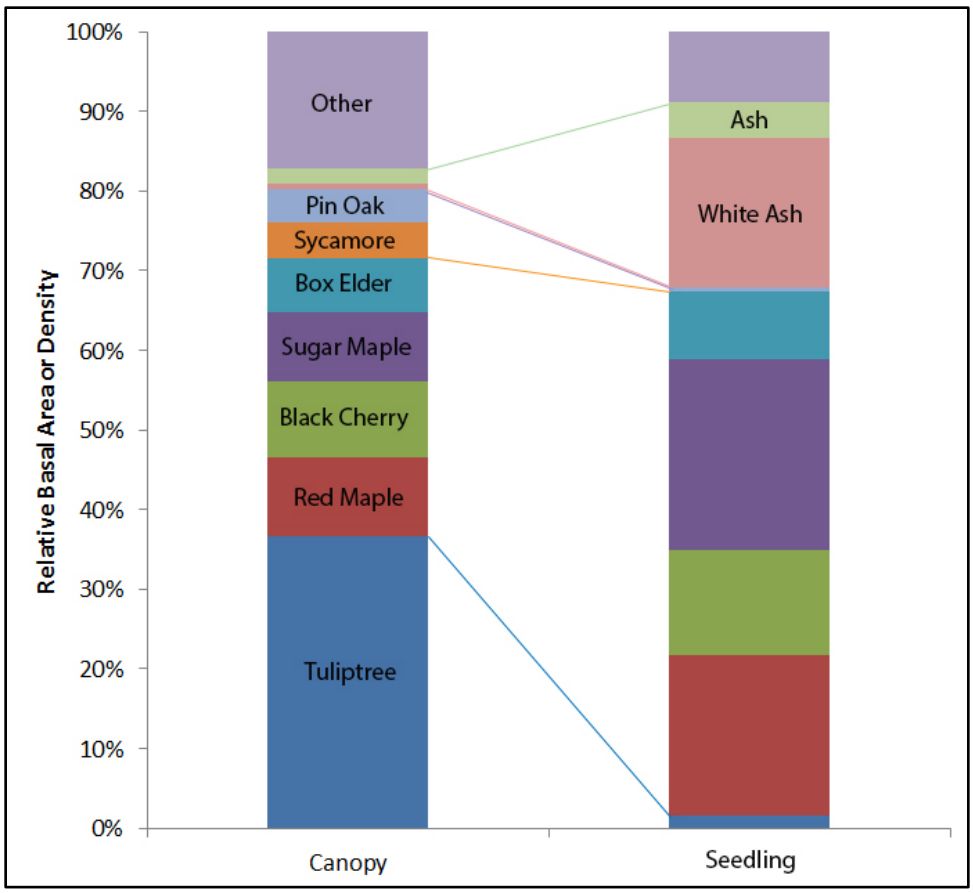


Figure 4.14. Percentage of plots in three categories of deer browse intensity (from Perles et al. 2014).

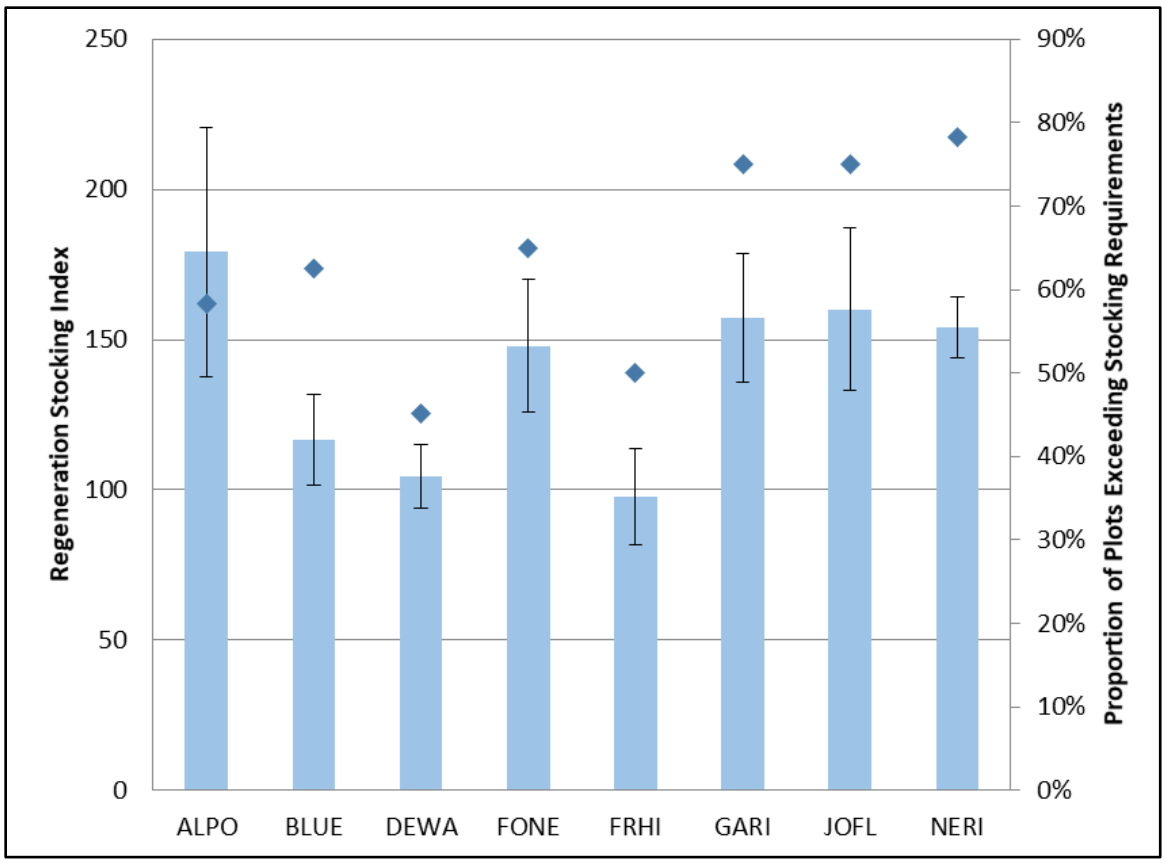


Figure 4.15. Blue bars represent average (± standard error) tree regeneration stocking index for Eastern Rivers and Mountains Network parks. Blue diamonds represent the proportion of the parks' plots which exceed the tree seedling stocking requirements set by the US Forest Service (see Perles et al 2014 for details).

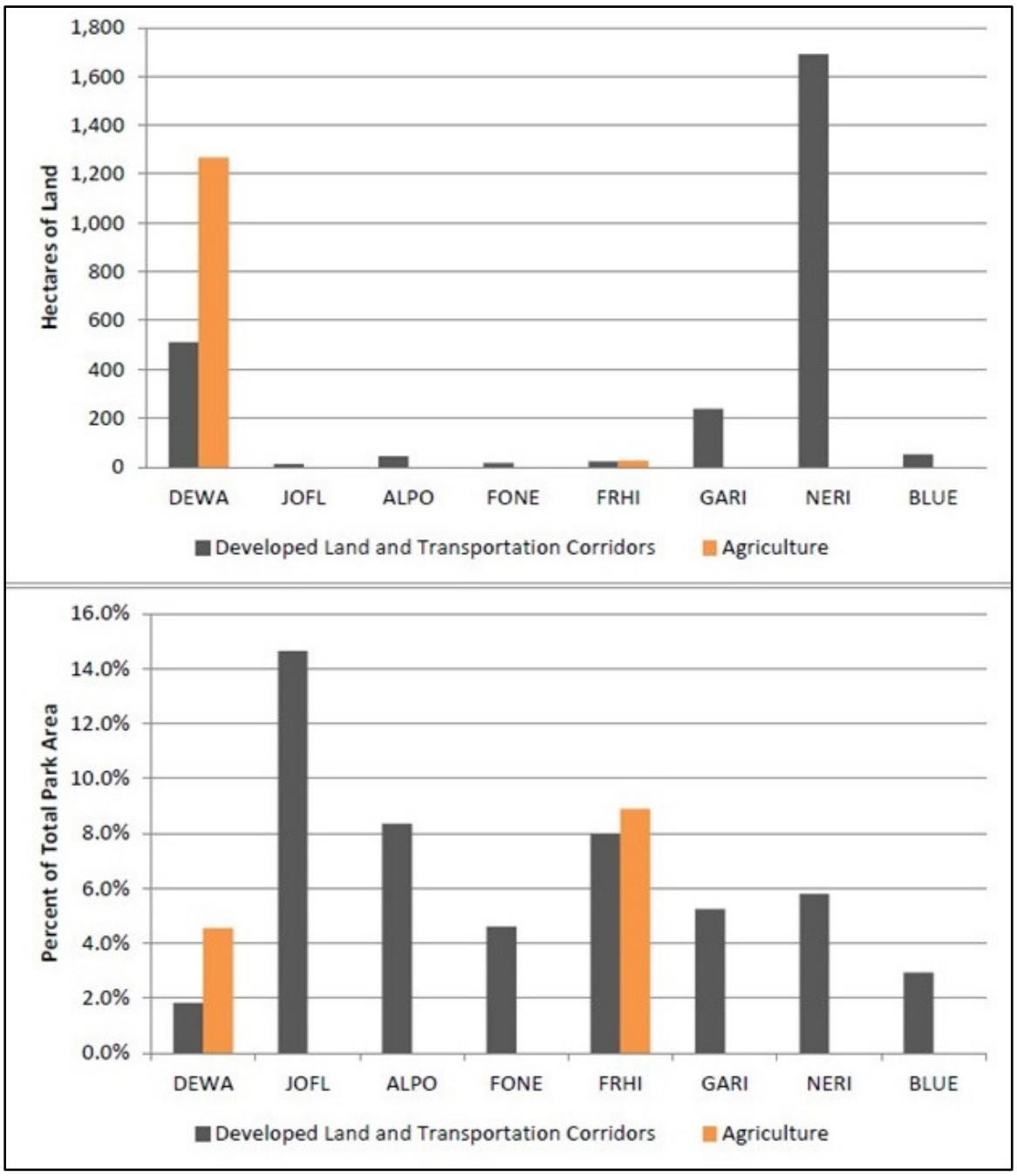


Figure 4.16. Total hectares of land and percent of total park area in developed land, transportation corridors, and agriculture in Eastern Rivers and Mountains Network parks (from Perles et al. 2014).

4.8.4. Trend Assessment

Although, forest composition appears to be stable, ERMN monitoring data will report trends in tree regeneration, growth, and mortality as more data are collected. (Table 4.21).

4.8.5. Confidence Assessment

Confidence in this assessment is medium (Table 4.21).

Table 4.21. Forest dynamics at Friendship Hill National Historic Site (FRHI).

Indicator	Specific Measure	Condition Status/Trend	Rationale
Forest health	Forest Dynamics		• **Condition:** Forest composition appears to be stable despite high tree growth and mortality rates typically of young forests; however, tree regeneration is insufficient in most forest stands. • **Trend:** In future years, Eastern Rivers and Mountains Network monitoring data will report trends in tree regeneration, growth, and mortality. • **Confidence:** The degree of confidence in FRHI is medium, though monitoring data are increasingly available.

4.9. Landscape

4.9.1. Relevance

Transformations in the landscape due to natural and anthropogenic changes within and surrounding FRHI 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 (Wilcove et al. 1998, Luck 2007, Heinz Center 2008).

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).

4.9.2. Methods and Data

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

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 FRHI. Land cover/use for FRHI was assessed by using data that explained the type of land cover and land use conversion occurring around FRHI 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.

4.9.3. Condition Assessment

Based on 2010 land cover remote sensing data, FRHI is mostly surrounded by forest and agriculture (Figure 4.17). Most of the forest towards the west is intact and viewed as core forest. 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 4.22).

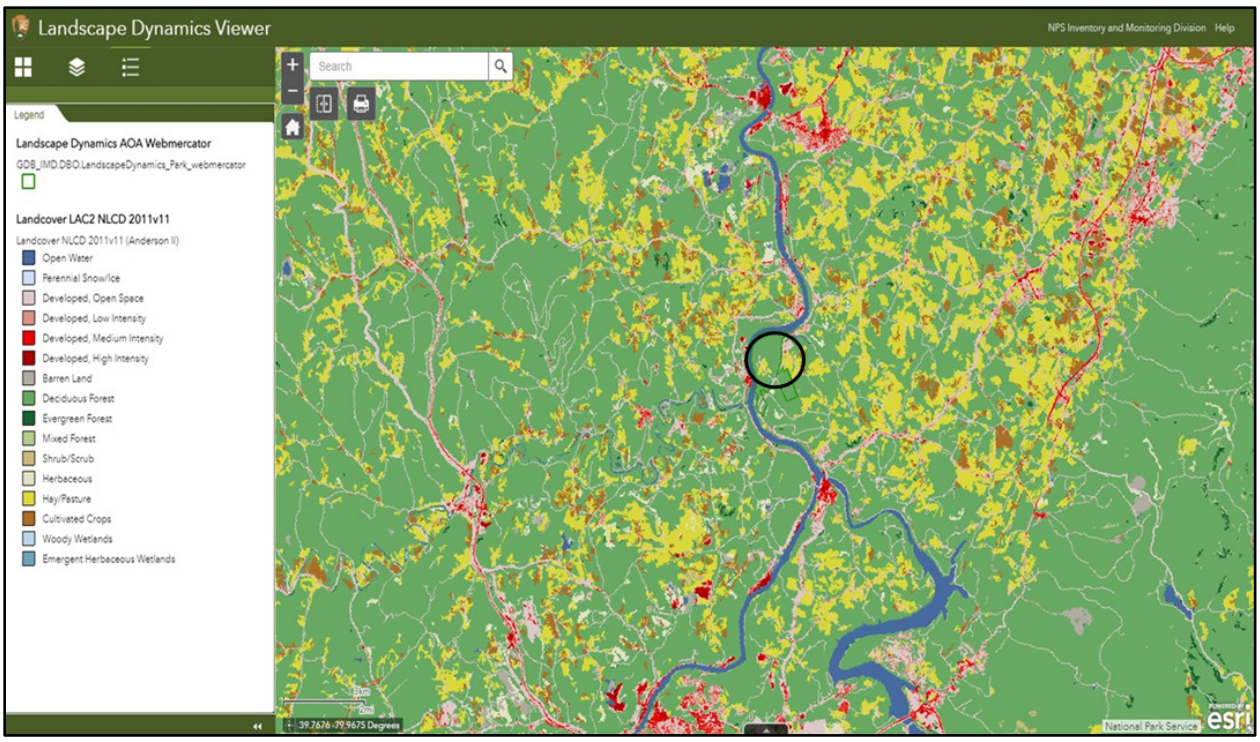


Figure 4.17. Land use surrounding Friendship Hill National Historic Site (black circle) in 2011, with green representing deciduous forest and yellow representing hay pasture; Uniontown, PA is the urban area to the west, in red. (NPScape 2016).

Table 4.22. Status of landscape surrounding Friendship Hill National Historic Site (FRHI).

Indicator	Specific Measure	Condition Status/Trend	Rationale
Land Use	Forest Cover and Land Use		• **Condition:** The area surrounding FRHI 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 FRHI is high.

4.9.4. Trend Assessment

There has been little change in land use surrounding FRHI since 2001, and thus we assign the landscape trend a status of *condition is unchanging* (Table 4.22).

4.9.5. Confidence Assessment

Confidence in the assessment was *high* (Table 4.22).

4.10. Soundscape

4.10.1. 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 (Selye 1956, Clough 1982, Hartmann et al. 1992, Anderssen et al. 1993).

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 (McDonald et al. 1995, Haas and Wakefield 1998). 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. 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 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 that comprises cultural and historic sounds such as battle reenactments and tribal ceremonies (NPS 2006). 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 FRHI 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 FRHI's soundscape will help determine the need, if any, for management and restoration efforts.

4.10.2. 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 FRHI, 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 (US EPA 1971, Schomer et al. 2011). 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 FRHI, 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).

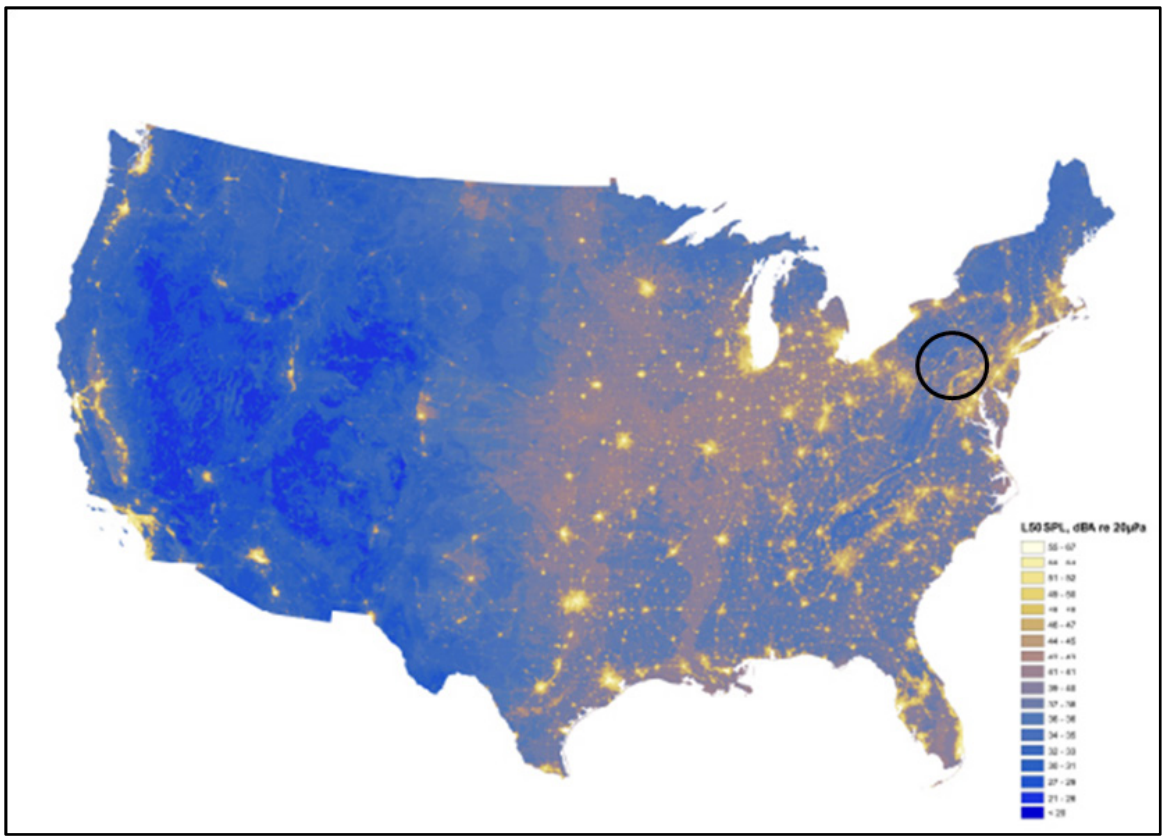


Figure 4.18. Ambient sound conditions for the United State; Friendship Hill National Historic Site is located within the black circle (nps.gov/subjects/sound/soundmap.htm).

4.10.3. Condition Assessment

Based upon the NPS NSNSD sound map above, we assign FRHI's soundscape a rating of *resource is in good condition* (Table 4.23).

Table 4.23. Status of soundscape in Fort Necessity National Battlefield (FRHI).

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

4.10.4. Trend Assessment

No trend data are available since direct measurements have not been taken at FRHI, meaning that we cannot assign trend rating (Table 4.23). 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.

4.10.5. Confidence Assessment

Confidence in the assessment for FRHI's soundscape was *low* due to a lack of reference data specific to the park (Table 4.23). 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.

4.11. Lightscape

4.11.1. Relevance

The NPS uses the term ‘natural lightscape’ to describe the environment that exists in the absence of anthropogenic light at night (NPS 2006). 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 (Svensson and Rydell 1998, Black 2005, Miller 2006, Rich and Longcore 2006, Boldogh et al. 2007, Lorne and Salmon 2007, Stone et al. 2009, Santos et al. 2010, Buglife 2011).

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.

4.11.2. Methods and Data

The NPS has measured light intensity at more than 100 park sites across the U.S., but FRHI 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 FRHI.

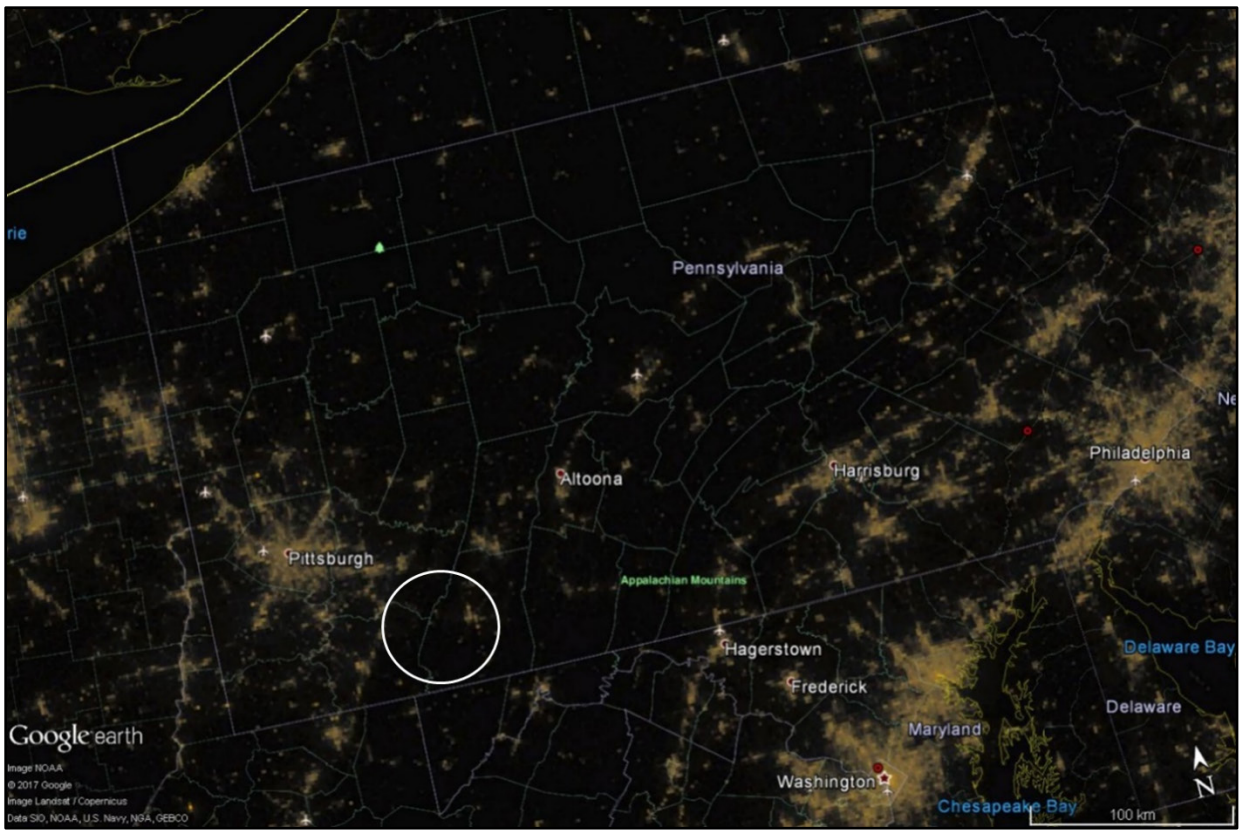


Figure 4.19. Nighttime light conditions for Friendship Hill National Historic Site (white circle) (www.nps.gov/subjects/nightskies/index.htm).

4.11.3. Condition Assessment

Based on the NPS NSNSD map above, it seems that FRHI 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 FRHI's lightscape as *resource is in good condition* (Table 4.24).

Table 4.24. Status of lightscape in Friendship Hill National Historic Site (FRHI).

Indicator	Specific Measure	Condition Status/Trend	Rationale
Light	Light at night		• **Condition:** Based on the sound map, FRHI 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.

4.11.4. Trend Assessment

With little development occurring around FRHI, it seems unlikely that light pollution would be increasing; however, without quantitative light data from the region, we cannot assign a trend rating (Table 4.24)

4.11.5. Confidence Assessment

Confidence in the assessment was *low* due to the lack of light measurements in or around FRHI (Table 4.24). 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.

4.12. Visitor Usage

4.12.1. Relevance

From 1983-2016, FRHI has received 875,702 recreational visitors (NPS Stats 2018). Hosting many people in a small park has consequences for FRHI's natural resources. To accommodate visitors and facilitate their enjoyment of the park, roads, parking lots, a visitor's center and other infrastructure have 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.

4.12.2. Methods and Data

NPS Stats (2018) 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 to assess their possible impact to sensitive habitats within FRHI.

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

4.12.3. Condition Assessment

Friendship Hill has seen an increase in visitation over the past two decades, roughly doubling the number of visits that were typical during the 1990's (Figure 4.20). Most visits occur in late summer. With many trails accessible to visitors year-round in FRHI, 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 FRHI from public use, but recommend the creation and continuation of proactive recreation rules to preserve the integrity of natural resources in FRHI (NPS 2006).

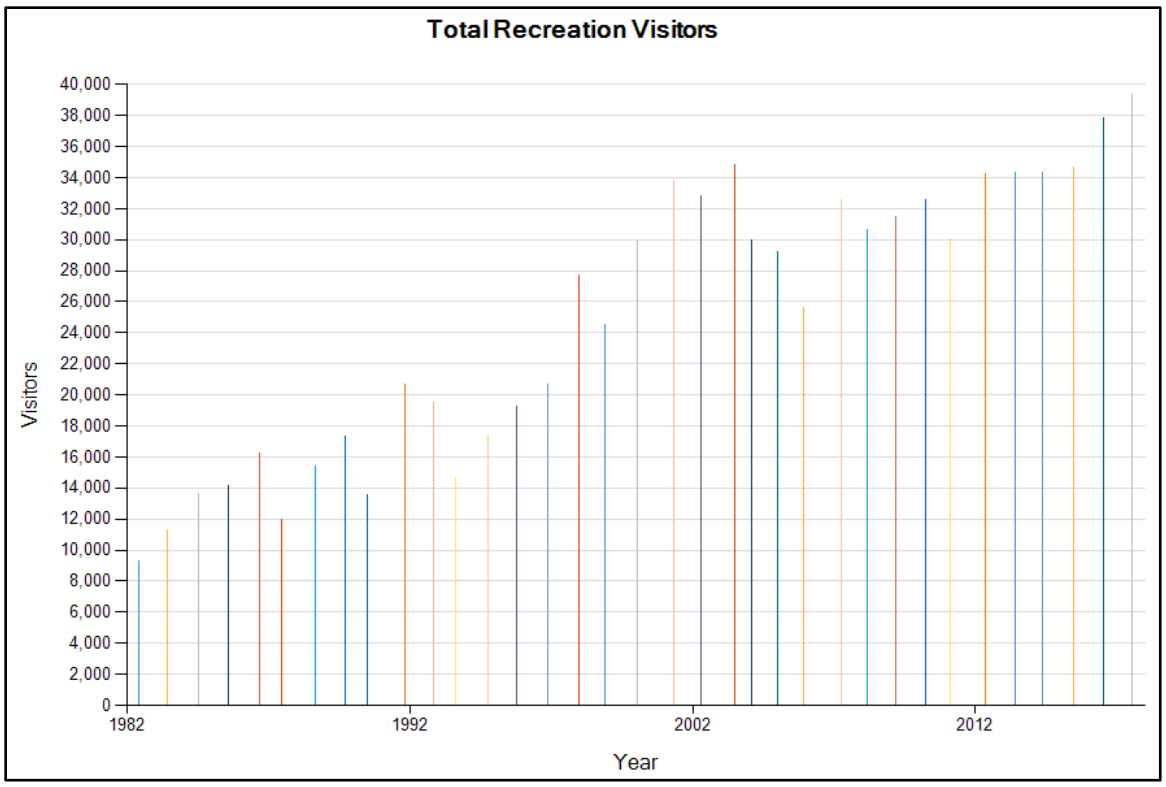


Figure 4.20. Visitation to Friendship Hill National Historic Site, 1982-2017.

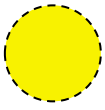
4.12.4. Trend Assessment

While visitation rate has increased since the 1980'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 4.25).

4.12.5. Confidence Assessment

Little quantitative data are available regarding impacts in FRHI due to visitor usage; assessing visitor impacts on trails and natural resources should therefore be of moderate priority for FRHI. Accordingly, our confidence in this assessment is *low* (Table 4.25).

Table 4.25. Status of visitor usage at Friendship Hill National Historic Site.

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 FRHI is low due to lack of data.

Chapter 5. Discussion

Table 5.1 shows a compilation of the natural resource condition assessments for FRHI. 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. 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. FRHI is part of the Eastern Rivers and Mountains Network which monitors forest health including invasive plants, stream condition using benthic macroinvertebrates as indicators, and the bird community as several locations within FRHI. 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 FRHI 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 FRHI.

Table 5.1. Summary of natural resource condition and trends at Friendship Hill National Historic Site.

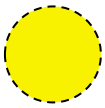
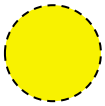
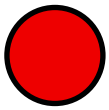
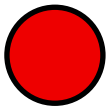
Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status/Trend	Rationale and Data Sources for Resource Condition	Reference Condition
Air Quality	Ozone	Human Health		NPS ARD 2011-2015 ozone level of 68.4 ppb	Exceeds NPS ARD *good* rating of ≤60 ppb
Air Quality	Ozone	Vegetation 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
Water Quality	pH	pH		Acid mine drainage (AMD) conditions within the park.	<5.5. Much too acidic in Ice Pond Run.

Table 5.1 (continued). Summary of natural resource condition and trends at Friendship Hill National Historic Site.

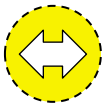
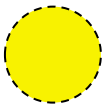
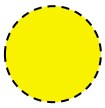
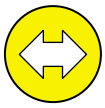
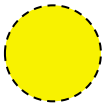
Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status/Trend	Rationale and Data Sources for Resource Condition	Reference Condition
Wetlands	Biological Integrity	Hydrologic Modification		Impacts from AMD in Ice Pond Run	Lack of AMD issues as evidenced in other park wetlands
Aquatic Species	Biological integrity	Macro-invertebrate IBI		Macroinvertebrate populations lack diversity and are depauperate.	Best Professional judgment
Aquatic Species	Biological integrity	Fish Diversity		Fish populations only sampled in one stream (AMD issues elsewhere). Species typical of warm water streams.	Best Professional judgment
Wildlife	Biological integrity	Mammals, Amphibians, Reptiles, and Birds		Wildlife populations appear to be stable and typical of the region, though data are lacking.	Best professional judgment
Threatened and Endangered Species	Biological Integrity	Vulnerable Species Listed by the Government		One species is 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. Increased ERMN monitoring indicates concern.	Best professional judgment and ERMN monitoring
Forest health	Forest dynamics	Forest dynamics		Forest composition appears to be stable in the short term; however, tree regeneration is insufficient in most forest stands. Reference condition: Forest health data from 50 other national parks in the eastern US provide context to evaluate forest health in FRHI.	ERMN monitoring - regeneration would equal, or surpass, replacement levels.
Landscape	Land Use	Forest Cover and Land Use		Surrounding land core forest and agricultural fields with little change in past decade	Best professional judgment

Table 5.1 (continued). Summary of natural resource condition and trends at Friendship Hill National Historic Site.

Priority Resource or Value	Indicator of Condition	Specific Measure	Condition Status/Trend	Rationale and Data Sources for Resource Condition	Reference Condition
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
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 FRHI. Therefore, in addition to continuing to use regional data from the nearest CASTNET station, we encourage FRHI 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. Measuring pH on Ice Pond Run is specifically needed due to ongoing AMD issues. 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. Nonetheless, evaluation of water quality data is more complete when combined with water quantity data, and we suggest that FRHI engage with as many outside research endeavors as possible to build a more complete data set.

Keeping abreast of water quality in the park is crucial to ensure that FRHI's warm water streams continue to provide excellent habitat and do not fall out of compliance. Aquatic macroinvertebrates are now being sampled on a more regular basis by the NPS Eastern Rivers and Mountains Network, 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 FRHI 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 FRHI bird sightings on the Cornell Lab of Ornithology's eBird site (https://ebird.org/hotspot/L2322644), with entries from

2009 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 FRHI. The NPS Eastern Rivers and Mountains Network monitors birds at several locations within FRHI on a regular basis (Marshall et al. 2016).

To prevent and monitor the spread of invasive plants, FRHI 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, FRHI 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).

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 FRHI 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 Friendship Hill National Historic Site are moderately impacted. Most of the serious concerns reflect regional air quality issues and AMD 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.

Literature Cited

Ambrose, J. P., and S. P. Bratton. 1990. Trends in landscape heterogeneity along the borders of Great Smoky Muntains National Park. *Conservation Biology* 4(2):135-143.

Anderssen, S. H., R. B. Nicolaisen, and G. W. Gabrielsen. 1993. Autonomic response to auditory stimulation. *Acta Paediatrica* 82:913-918.

Black, A. 2005. Light induced seabird mortality on vessels operating in the Southern Ocean: Incidents and mitigation measures. *Antarctic Science* 17:67-68.

Bogovich, W. M., and P. E. Member. 1992. Twelve years of abandoned mineland reclamation activities by the United States Department of Agriculture - Soil Conservation Service in southwest Pennsylvania. Pages 230-239 *In* Land reclamation; advances in research & technology; proceedings of the international symposium, T. Younos, P. Diplas, and S. Mostaghimi, eds. ASAE Publication 14-92. St. Joseph, MI: American Society of Agricultural and Biological Engineers.

Boldogh, S., D. Dobrosi, and P. Samu. 2007. The effects of the illumination of buildings on house-dwelling bats and its conservation consequences. *Acta Chiropterologica* 9:527-534.

Bonan, G. 2015. Ecological climatology: Concepts and applications. New York, NY: Cambridge University Press.

Boone, T., and R. Lisk. 2002. Hydrological Assessment, Ice Pond Run Acid Mine Drainage Research Project Friendship Hill National Historic Site FY 2001-2002.

Buglife. 2011. A review of the impact of artificial light on invertebrates. Peterborough, England: C. Bruce-White and M. Shardlow.

Burghardt, J. E., E. S. Norby, and H. S. Pranger, II. 2014. Abandoned mineral lands in the National Park System — Comprehensive inventory and assessment. Denver, Colorado.

Chapin III, F. S., M. S. Torn, and M. Tateno. 1996. Principles of ecosystem sustainability. The American Naturalist 148:1016-37.

Cinzano, P., and C. Elvidge. 2003. Night sky brightness at sites from satellite data. *Memorie Societa Astronomica Italiana* 74:456-457.

City-Data.com. 2018. Fayette County, Pennsylvania (PA). Advameg, Inc. Available at: http://www.city-data.com/county/Fayette_County-PA.html (accessed 21 June 2018).

Clough, G. 1982. Environmental effects on animals used in biomedical research. *Biological Reviews* 57:487-523.

Cole, C. A. 2017. Riparian plant communities in two Pennsylvania state parks with an assessment of non-native plants. Unpublished report to PA DCNR.

Cooper, E. L., H. H. Genoways, and F. J. Brenner. 1985. “Fishes”. Species of Special Concern in Pennsylvania. *Special Publication of Carnegie Museum of Natural History* 11:169-256.

Corfidi, S. F. 2013. Haze over the central and eastern United States. NOAA/NWS Storm Prediction Center. Available at: https://www.spc.noaa.gov/publications/corfidi/haze.html (accessed 24 June 2019).

Cravotta, C. A. III, and H. L. Eggleston. 2011. Streamwater quality assessment of Friendship Hill National Historic Site and Fort Necessity National Battlefield, Pennsylvania, November 2011. USDI, U.S. Geological Survey Administrative Report.

Davey, C. A., K. T. Redmond, and D. B. Simeral. 2006. Weather and climate inventory National Park Service Eastern Rivers and Mountains Network. Natural Resource Technical Report, NPS/ERMN/NRTR—2006/006.

Driscoll, C. T., G. B. Lawrence, A. J. Bulger, C. S. Cronan, C. Eagar, K. F. Lambert, G. E. Likens, J. L. Stoddard, and K. C. Weathers. 2001. Acidic deposition in the northeastern United States: sources and inputs, ecosystem effects, and management strategies. *BioScience* 51:180-198.

Driscoll, C. T., D. Whitall, J. Aber, E. Boyer, M. Castro, C. Cronan, C. Goodale, P. Groffman, C. Hopkinson, K. Lambert, G. Lawrence, and S. Ollinger. 2003. Nitrogen pollution in the northeastern United States: Sources, effects and management options. *BioScience* 3:357-374.

Dupont, J., T. A. Clair, C. Gagnon, D. S. Jefferies, J. S. Kahl, S. J. Nelson, and J. M. Pechenham. 2005. Estimation of critical loads of acidity for lakes in northeastern United States and eastern Canada. *Environmental Monitoring and Assessment* 109:275-291.

Faulk, E. A., and A. S. Weber. 2017. Eastern Rivers and Mountains Network stream fish monitoring: Summary of 2013-2014 pilot sampling. Natural Resource Data Series NPS/ERMN/NRDS—2017/1084. National Park Service, Fort Collins, Colorado.

Fayette County Conservation District (FCCD). 2016. Pennsylvania Watersheds. Available at: http://www.fayettecd.org/wp-content/uploads/Pennsylvania-Watershed.pdf. (accessed 24 June 2019).

Forman, R. T. T., D. Sperling, J. A. Bissonette, A. P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, and T. C. Winter. 2003. Road ecology: Science and solutions. Washington, DC: Island Press.

Gates, E. J., and J. B. Johnson. 2007. Bat inventory of four Eastern Rivers and Mountains Network National Parks, NPS/NER/NRTR—2007/098.

Haas, G. and T. Wakefield. 1998. National parks and the American public: A national public opinion survey on the national park system. Washington, DC and Fort Collins, CO: National Parks and Conservation Association and Colorado State University.

Hartmann, L. A., W. J. Makel, and R. T. Harrison. 1992. Potential impacts of aircraft overflights of National Forest System wildernesses. Washington, D.C.: United States Department of Agriculture, Forest Service.

Hedin, R. S., D. H. Dvorak, S. L. Gustafson, D. M. Hyman, P. E. McIntire, R. W. Nairn, and H. M. Edenborn. 1991. Use of a constructed wetland for the treatment of acid mine drainage at the Friendship Hill National Historic Site, Fayette County, PA. US National Park Service and US Bureau of Mines, Pittsburgh, PA.

H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center). 2008. The state of the nation's ecosystems 2008: Measuring the land, waters, and living resources of the United States. Washington, DC: Island Press.

Horsley, S. B., R. P. Long, S. W. Bailey, R. A. Hallett, and P. M. Wargo. 2002. Health of eastern North American sugar maple forests and factors affecting decline. *Northern Journal of Applied Forestry* 19:34-44.

Imhoff, K. and A. Person. 2016. Weather of Fort Necessity National Battlefield and Friendship Hill National Historic Site: Eastern Rivers and Mountains Network summary report for 2015. NPS Report NPS/ERMN/NRDS—2016/1050. Natural Resource Data Series. National Park Service, Fort Collins, Colorado.

Jacobson, M., R. J. Charlson, H. Rodhe, and G. H. Orians. 2000. Earth system science: From biogeochemical cycles to global changes vol. 72. London, England: Elsevier Academic Press.

Jensen, M. and H. Thompson. 2004. Natural sounds: An endangered species. *George Wright Forum* 21:10-13.

Keefer, J. S., M. R. Marshall, and B. R. Mitchell. 2010. Early detection of invasive species: surveillance, monitoring, and rapid response: Eastern Rivers and Mountains Network and Northeast Temperate Network. Natural Resource Report NPS/ERMN/NRR–2010/196. National Park Service, Fort Collins, Colorado.

Klusman, R. W., D. H. Dvorak, and S. L. Borek. 1993. Modeling of wetlands and reactor systems used for mine drainage treatment. In Proceedings of the Annual National Meeting (Vol. 2, pp. 685–704). Spokane, Washington: American Society for Surface Mining and Reclamation.

Knight, P., K. Imhoff, and A. Person. 2015. Weather of Fort Necessity National Battlefield and Friendship Hill National Historic Site: Eastern Rivers and Mountains Network summary report for 2014. Natural Resource Data Series, NPS/ERMN/NRDS—2015/815.

Kohut, R. 2007. Assessing the risk of foliar injury from ozone on vegetation in parks in the U.S. National Park Service's Vital Signs Network. *Environmental Pollution* 149:348-357.

Kopas, F. A. 1991. Soil Survey, Fayette County, Pennsylvania. U.S. Department of Agriculture Soil Conservation Office; Pennsylvania State University, Agriculture Experiment Station and

Agricultural Extension Service; Pennsylvania Department of Agriculture, State Soil and Water Conservation Commission.

Kowalski, M. J., B. K. Paulson, and M. J. Ross. 2005. Inventory of amphibian and reptile species at Fort Necessity National Battlefield and Friendship Hill National Historic Site. California, PA.

Lorne, J. K., and M. Salmon. 2007. Effects of exposure to artificial lighting on orientation of hatchling sea turtles on the beach and in the ocean. *Endangered Species Research* 3:23-30.

LRIP. 2002. Long Range Interpretive Plan.

Luck, G. W. 2007. A review of the relationships between human population density and biodiversity. *Biological Review* 82:607-645.

Lynch, E., D. Joyce, and K. Fristrup. 2011. An assessment of noise audibility and sound levels in U.S. National Parks. *Landscape Ecology* 26:1297-1309.

Manning, D. R. 2016. Early Detection of invasive species — Surveillance monitoring and rapid response Eastern Rivers and Mountains Network 2013-2015 Summary, NPS/ERMN/NRDS—2016/1032.

Marshall, M. R., and N. B. Piekielek. 2007. Eastern Rivers and Mountains Network ecological monitoring plan. Natural Resource Report NPS/ERMN/NRR—2007/017. National Park Service, Fort Collins, CO.

Marshall, M., B. Mattsson, K. Callahan, and T. Master. 2013. Streamside bird monitoring: Eastern Rivers and Mountains Network 2007–2012 summary report. Natural Resource Data Series NPS/ERMN/NRDS—2013/449. National Park Service, Fort Collins, Colorado.

Marshall, M., C. Tzilkowski, and K. Callahan. 2016. Streamside bird monitoring protocol for the Eastern Rivers and Mountains Network: Protocol narrative version 3.0. Natural Resource ReportNPS/ERMN/NRR—2016/1224. National Park Service, Fort Collins, Colorado.

McDonald, C. D., R.M. Baumgartner, and R. Iachan. 1995. National Park Service aircraft management studies (US Department of Interior Rep. No. 94-2). Denver, CO: National Park Service.

Mennitt, D., K. Fristrup, K. Sherrill, and L. Nelson. 2013. Mapping sound pressure levels on continental scales using a geospatial sound model. 43rd International Congress and Exposition on Noise Control Engineering, Innsbruck, Austria, Sept 15-18:1-11.

Miller, M.W. 2006. Apparent effects of light pollution on singing behavior of American robins. The Condor 108:130-139.

Mitchell, M. J., C. T. Driscoll, J. S. Owen, D. Schaefer, R. Michener, and D. J. Raynal. 2001. Nitrogen biogeochemistry of three hardwood ecosystems in the Adirondack Region of New York. *Biogeochemistry* 56:93-133.

Nagel, J., and J. E. Gates. 2018. Post-white-nose syndrome monitoring of bat populations in five western Pennsylvania parks. Draft final report. Western Pennsylvania National Parks (WEPA), Gallitzin, Pennsylvania. 53 pp.

National Park Service (NPS). 2005. Assessment of effect for fire management plan, Fort Necessity National Battlefield and Friendship Hill National Historic Site.

National Park Service (NPS). 2006. Management Policies 2006. U.S. Department of Interior, National Park Service, Washington, DC.

National Park Service (NPS). 2013. Foundation Document Friendship Hill National Historic Site. Denver, Colorado.

National Park Service (NPS). 2016. National Park Service Procedural Manual #77-1: Wetland Protection. USDI, NPS, Water Resources Division, Fort Collins, CO.

National Park Service (NPS). 2017. Endangered Species. U.S. Department of the Interior. Available at: https://www.nps.gov/subjects/rareandendangered/index.htm (accessed 24 June 2019).

National Park Service (NPS). 2018. Friendship Hill National Historic Site Pennsylvania. Available at: https://www.nps.gov/frhi/index.htm (accessed 24 June 2019).

National Park Service Air Resources Division (NPS ARD). n.d. Ozone effects on plants. U.S. Department of the Interior. Available at: https://www.nps.gov/subjects/air/nature-ozone.htm (accessed 24 June 2019).

National Park Service Air Resources Division (NPS ARD). 2009. Visibility monitoring. U.S. Department of the Interior. Available at: https://www.nps.gov/subjects/air/air-monitoring.htm (accessed 24 June 2019).

National Park Service Air Resources Division (NPS ARD). 2010. Rating Air Quality Conditions. National Park Service. Fort Collins, CO. Available at: https://www.nps.gov/subjects/air/index.htm (accessed 24 June 2019).

National Park Service Air Resources Division (NPS ARD). 2015. National Park Service Air Quality Analysis Methods: September 2015. Natural Resource Report NPS/NRSS/ARD/NRR–2015/XXX. National Park Service, Denver, CO.

National Park Service Air Resources Division (NPS ARD). 2017. Park Conditions & Trends. National Park Service. Available at: https://www.nps.gov/subjects/air/park-conditions-trends.htm (accessed 24 June 2019).

National Park Service Air Resources Division (NPS ARD). 2018a. Ozone effects on tree growth. National Park Service. Available at: https://www.nps.gov/subjects/air/nature-trees.htm (accessed 24 June 2019).

National Park Service Air Resources Division (NPS ARD). 2018b. Park Conditions & Trends. National Park Service. Available at: https://www.nps.gov/subjects/air/park-conditions-trends.htm (accessed 24 June 2019).

National Park Service Natural Sounds and Night Skies Division (NPS NSNSD). 2016. Night sky monitoring database. U.S. Department of the Interior. Available at: https://www.nps.gov/subjects/nightskies/skymap.htm (accessed 24 June 2019).

NPScape. 2016. Landscape dynamics viewer. U.S. Department of the Interior. Available at: https://nps.maps.arcgis.com/apps/webappviewer/index.html?id=2ec2585fa978404fbe316ec280645518 (accessed 24 June 2019).

NPStats. 2018. https://irma.nps.gov/Stats/SSRSReports/Park%20Specific%20Reports/Annual%20Park%20Recreation%20Visitation%20(1904%20-%20Last%20Calendar%20Year. Accessed 3/6/2019.

National Research Council (NRC). 1995. Science and the Endangered Species Act. Washington DC: The National Academies Press.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 1998a. A bird community index of biotic integrity for the Mid-Atlantic Highlands. *Environmental Monitoring and Assessment* 51:145-156.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 1998b. The bird community index: A tool for assessing biotic integrity in the Mid-Atlantic Highlands. Report 98-4 of the Penn State Cooperative Wetlands Center, The Pennsylvania State University, University Park.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 2000. Bird guilds as indicators of ecological condition in the central Appalachians. *Ecological Applications* 10:1706-1721.

Pennsylvania Department of Environmental Protection (PA DEP). 2018. Abandoned mine land inventory sites. Pennsylvania Spatial Data Access. Available at: http://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=460 (accessed 24 June 2019).

Perles, S. J., D. Manning, K. Callahan, and M. Marshall. 2016. Forest Dynamics in National Parks in the Eastern Rivers and Mountains Network, (NPS/ERMN/NRR—2016/1182.).

Perles, S. J., D. R. Manning, K. K. Callahan, and M. R. Marshall. 2014. Forest health monitoring in the Eastern Rivers and Mountains Network: 2009–2012 summary report. Natural Resource Report NPS/ERMN/NRR—2014/803. National Park Service, Fort Collins, Colorado.

Perles, S. J., G. S. Podniesinski, E. A. Zimmerman, W. A. Millinor, and L. A. Sneddon, L. A. 2006. Vegetation classification and mapping at Friendship Hill National Historic Site. Philadelphia, PA.

Rentch, J. S. and J. T. Anderson. 2006. A wetland floristic quality index for West Virginia. West Virginia Agricultural and Forestry Experiment Station Bulletin 2967, Morgantown, West Virginia.

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

Rusek, J. and V. G. Marshall. 2000. Impacts of airborne pollutants on soil fauna. *Annual Review of Ecology, Evolution, and Systematics* 31:395-423.

Santos, C. D., A. C. Miranda, J. P. Granadeiro, P. M. Lourenço, S. Saraiva, and J. M. Palmeirim. 2010. Effects of artificial illumination on the nocturnal foraging of waders. *Acta Oecologica* 36:166-172.

Schindler, D.W. 1988. Effects of acid rain on fresh water ecosystems. *Science* 239:149-157.

Schindler, D. W., S. E. M. Kaslan, and R. H. Hesslein. 1989. Biological impoverishment in lakes of the midwestern and northeastern United States from acid rain. *Environmental Science and Technology* 23:573-80.

Schlesinger, W. H. 1997. Biogeochemistry: An analysis of global change. San Diego, CA: Academic Press.

Schneider, R. M., A. F. Teets, and J. L. Dorr. 2012. Natural resource condition assessment for Richmond National Battlefield Park, Virginia. Natural Resource Report NPS/NER/NRR—2012/548. National Park Service. Fort Collins, Colorado.

Schomer, P., J. Freytag, A. Machesky, C. Luo, C. Dossin, N. Nookala, and A. Pamdighantam. 2011. A re-analysis of day-night sound level (DNL) as a function of population density in the United States. *Noise Control Engineering Journal* 59:290-301.

Selye, H. 1956. The stress of life. New York, NY: McGraw-Hill.

Sharpe, P. J., G. Kneipp, and A. Forget. 2016. Comparison of alternative approaches for wetlands mapping: A case study from three U.S. National Parks. *Wetlands* 36:547-556.

Sibrell, P. L., B. J. Watten, T. Boone, and P. Marion. 2003. Remediation of acid mine drainage at the Friendship Hill Nationl Historic Site. *Hydrometallurgy* 2:1823-1838.

Sibrell, P. L., and B. J. Watten. 2003. Evaluation of sludge produced by limestone neutralization of AMD At the Friendship Hill National Historic Site. *Proceeedings of the American Society of Mining and Reclamation* 20:1151-1169.

Stewart, D. K, and M. V. Mathes. 1995. Drainage areas of the Monongahela River Basin, West Virginia. USGS Open File Report 95-170, Charleston, WV.

Stone, E. L., G. Jones, and S. Harris. 2009. Street lighting disturbs commuting bats. *Current Biology* 19:1123-1127.

Sullivan, T. J., G. T. McPherson, T. C. McDonnell, S. D. Mackey, and D. Moore. 2011a. Evaluation of the sensitivity of inventory and monitoring national parks to acidification effects from atmospheric sulfur and nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/349. National Park Service, Denver, CO.

Sullivan, T. J., T. C. McDonnell, G. T. McPherson, S. D. Mackey, and D. Moore. 2011b. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: main report. Natural Resource Report NPS/NRPC/ARD/NRR—2011/313. National Park Service, Denver, CO.

Svensson, A. M. and J. Rydell. 1998. Mercury vapour lamps interfere with the bat defense of tympanate moths (*Operophtera* spp.; Geometridae). *Animal Behavior* 55:223-226.

Taylor, K. A. 2017. National Park Service Air Quality Analysis Methods, Fort Collins, Colorado.

Thormann, M. N. 2006. Lichens as indicators of forest health in Canada. *The Forestry Chronicle* 82:335-343.

Thornberry-Ehrlich, T. 2008. Friendship Hill National Historic Site Geologic Resource Evaluation Report. Natural Resource Report NPS/NRPC/GRD/NRR—2008/022. National Park Service, Denver, Colorado.

Tzilkowski, C. J., and S. A Sheeder. 2006. Aquatic Resource Assessment of Fort Necessity National Battlefield and Friendship Hill National Historic Site, Technical Report No. NPS/NER/NRTR-2006/065). Philadelphia, PA: National Park Service, Northeast Region.

Tzilkowski, C. J., K. K. Callahan, M. R. Marshall, and A. S. Weber. 2010. Integrity of benthic macroinvertebrate communities in Fort Necessity National Battlefield and Friendship Hill National Historic Site, Eastern Rivers and Mountains Network, 2009 Summary Report. Natural Resource Data Series NPS/ERMN/NRDS—2010/028. National Park Service, Fort Collins, CO.

Tzilkowski, C. J., M. R. Marshall, and A. S. Weber. 2015. Eastern Rivers and Mountains Network wadeable stream monitoring: Water quality and benthic macroinvertebrate summary report (2008–2013). Natural Resource Data Series NPS/ERMN/NRDS—2015/769. National Park Service, Fort Collins, Colorado.

United States Army Corps of Engineers (USACE). 2012. Monongahela River Watershed initial watershed assessment, September 2011 (Revised February 2012). USACE, Pittsburgh District.

United States Census Bureau (US Census). 2010. 2010 Census Urban and Rural Classification. Available at: http://www2.census.gov/geo/tiger/TIGER2010/UA/2010 (accessed 24 June 2019).

United States Environmental Protection Agency (US EPA). 1971. Community Noise. Washington, D.C.: U.S. Government Printing Office.

United States Environmental Protection Agency (US EPA). 2009. Provisional assessment of recent studies on health and ecological effects of ozone exposure. EPA/600/R-09/101. National Center for Environmental Assessment, Research Triangle Park, NC. 49 pp.

United States Environmental Protection Agency (US EPA). 2013. Streams. EPA Web Archive. Available at: https://www2.census.gov/geo/tiger/TIGER2010/UA/2010/ (accessed 24 June 2019).

United States Environmental Protection Agency (US EPA). 2014. Policy assessment for the review of the Ozone National Ambient Air Quality Standards. Policy Assessment Report EPA-452/R-14-006. Research Triangle Park, NC.

United States Environmental Protection Agency (US EPA). 2017a. Level III and IV ecoregions of the continental United States. Available at: https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states (accessed 24 June 2019).

United States Environmental Protection Agency (US EPA). 2017b. What is acid rain? Available at: https://www.epa.gov/acidrain/what-acid-rain (accessed 24 June 2019).

United States Environmental Protection Agency (US EPA). 2018a. Laurel Hill (LRL117). Available at: https://www3.epa.gov/castnet/site_pages/LRL117.html (accessed 24 June 2019).

United State Environmental Protection Agency (US EPA). 2018b. Abandoned mine drainage. Available at: https://www.epa.gov/nps/abandoned-mine-drainage (accessed 24 June 2019).

United States Geological Survey (USGS). 2004a. NHDFlowline – Monongahela. Pennsylvania Spatial Data Access. Available at: http://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=752 (accessed 24 June 2019).

United States Geological Survey (USGS). 2004b. NHDWaterbody – Monongahela. Pennsylvania Spatial Data Access. http://www.pasda.psu.edu/uci/DataSummary.aspx?dataset=753 (accessed 24 June 2019).

Unrau, H. D. 1981. FRHI historic resources study 1981.pdf.

Wagner, J. 1989. Wetland regulatory compliance: A guidance manual for the National Park Service, Mid-Atlantic Region.

Wagner, J. D., and R. B. Coxe. 2000. Fayette County natural heritage inventory. Western Pennsylvania Conservancy, Natural Heritage Inventory. Pittsburgh, PA.

Wagner, R., C. A. Cole, M. Brittingham, C. P. Ferreri, L. Gorenflo, M. W. Kaye, B. Orland and K. Tamminga. 2014. Morristown National Historical Park natural resource condition assessment. Natural Resource Report NPS/NERO/NRR—2014/869. National Park Service, Fort Collins, Colorado.

Wallace, Z. P., G. M. Lovett, J. E. Hart, and B. Machona. 2007. Effects of nitrogen saturation on tree growth and death in a mixed-oak forest. *Forest Ecology and Management* 243:210-218.

Webber, J. S. 2012. Water quality condition assessment of streams in national parks of the mid-Atlantic, USA, integrating physical, chemical, and biological datasets. M.S. Thesis, Penn State University, University Park, PA.

Webster, J. R. 1983. The role of benthic macroinvertebrates in detritus dynamics of streams: A computer simulation. *Ecological Monographs* 53:383-404.

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

Woods, A. J., Omernik, J. M., and D. D. Brown. 1999. Level III and IV ecoregions of Delaware, Maryland, Pennsylvania, Virginia, and West Virginia. Corvallis, Oregon.

Yahner, R. H. 1995. Eastern deciduous forest: Ecology and wildlife conservation (Vol. 4). University of Minnesota Press.

Yahner, R. H., B. D. Ross, and J. E. Kubel. 2004. Comprehensive inventory of birds and mammals at Fort Necessity National Battlefield and Friendship Hill National Historic Site, NPS/NERCHAL/NRTR—04/093.

Zimmerman, E. A., and J. Yoder. 2006. Distribution and abundance of non-native plant species at Fort Necessity National Battlefield and Friendship Hill National Historic Site, NPS/NER/NRTR—2006/053.

Appendix A. Mammals present, or probably present, at Friendship Hill National Historic Site

Table A-1. Mammals present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Blarina brevicauda	Short-tailed shrew	Common
Castor canadensis	Beaver	Uncommon
Didelphis virginiana	Virginia opossum	Common
Eptesicus fuscus[1]	Big brown bat	–
Glaucomys volans[1]	Eastern flying squirrel	–
Marmota monax	Woodchuck	Common
Mephitis mephitis	Striped skunk	Uncommon
Microtus pennsylvanicus	Meadow vole	Abundant
Napaeozapus insignis[1]	Woodland jumping mouse	–
Odocoileus virginianus	White-tailed deer	Abundant
Ondatra zibethicus[1]	Muskrat	–
Parascalops breweri	Hairy-tailed mole	Uncommon
Peromyscus leucopus	White-footed mouse	Abundant
Peromyscus maniculatus	Deer mouse	Uncommon
Procyon lotor	Common raccoon	Common
Sciurus carolinensis	Gray squirrel	Common
Sciurus niger	Fox squirrel	Common
Sorex cinereus	Masked shrew	Common
Sylvilagus floridanus	Eastern cottontail	Common
Tamias Striatus	Eastern chipmunk	Abundant
Tamiasciurus hudsonicus	Red squirrel	Common
Urocyon cinereoargenteus[1]	Gray fox	–
Vulpes vulpes	Red fox	Rare

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Appendix B. Amphibians present, or probably present, at Friendship Hill National Historic Site

Table B-1. Amphibians present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Ambystoma jeffersonianum	Jefferson salamander	Rare
Abystoma maculatum[1]	Spotted salamander	–
Ambystoma opacum[1]	Marbled salamander	–
Bufo americanus americanus	Eastern American toad	Common
Bufo woodhousii fowleri	Fowler's toad	Occasional
Desmognathus fuscus fuscus	Northern dusky salamander	Uncommon
Desmognathus monticola	Seal salamander	Uncommon
Desmognathus ochrophaeus	Mountain dusky salamander	Common
Eurycea bislineata	Northern two-lined salamander	Rare
Gyrinophilus porphyriticus porphyriticus	Northern spring salamander	Occasional
Hyla chrysoscelis	Cope's gray treefrog	Occasional
Hyla versicolor	Gray treefrog	Occasional
Notophthalmus viridescnes viridescens	Red-spotted newt	Occasional
Plethodon cinereus	Redback salamander	Occasional
Plethodon glutinosus	Slimy salamander	Rare
Pseudacris crucifer crucifer	Northern spring peeper	Common
Rana catesbeiana	Bullfrog	Uncommon
Rana clamitans melanota	Green frog	Uncommon
Rana palustris	Pickerel frog	Rare
Rana pipiens	Northern leopard frog	Uncommon
Rana sylvatica	Wood frog	Uncommon

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Appendix C. Reptiles present, or probably present, at Friendship Hill National Historic Site

Table C-1. Reptiles present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Agkistrodon contortrix mokasen	Northern copperhead	Occasional
Chelydra serpentine	Common snapping turtle	Uncommon
Chrysemys picta	Painted turtle	Occasional
Coluber constrictor constrictor	Northern black racer	Occasional
Diadophis punctatus edwardsii	Northern ringneck snake	Occasional
Elaphe obsolete obsolete	Rat snake	Rare
Glyptemys insculpta[1]	Wood turtle	–
Heterodon platirhinos	Eastern hognose snake	Occasional
Lampropeltis triangulum triangulum[1]	Eastern milk snake	–
Nerodia sipedon sipedon	Northern water snake	Rare
Terrapene carolina carolina[1]	Eastern box turtle	–
Thamnophis sirtalis sirtalis	Eastern garter snake	Uncommon

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Appendix D. Birds present, or probably present, at Friendship Hill National Historic Site

Table D-1. Birds present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Accipiter cooperii	Coopers hawk	Rare
Accipter striatus	Sharp-skinned hawk	Rare
Actitis macularia	Spotted sandpiper	Occasional
Agelaius phoeniceus	Red-winged blackbird	Abundant
Aix sponsa	Wood duck	Occasional
Ammodramus savannarum	Grasshopper sparrow	Occasional
Anas platyrhynchos	Mallard	Abundant
Anthus rubescens[1]	American pipit	–
Achilochus colubris	Ruby-throated hummingbird	Rare
Ardea herodias	Great blue heron	Rare
Baeolophus bicolor	Tufted titmouse	Abundant
Bombycilla cedrorum	Cedar waxwing	Abundant
Bonasa umbellus[1]	Ruffed grouse	–
Branta canadensis	Canada goose	Abundant
Bubo virginianus	Great horned owl	Rare
Buteo jamaicensis	Red-tailed hawk	Uncommon
Buteo lagopus	Rough-legged hawk	Occasional
Buteo lineatus	Red-shouldered hawk	Uncommon
Buteo platypterus	Broad-winged hawk	Rare
Butorides virescens[1]	Green-backed heron	–
Caprimulgus vociferous[1]	Whip-poor-will	–
Cardinalis cardinalis	Cardinal, northern cardinal	Abundant
Carduelis pinus	Pine siskin	Occasional
Carpodacus mexicanus	House finch	Rare
Carpodacus purpureus	Purple finch	Rare
Cathartes aura	Turkey vulture	Abundant
Catharus fuscescens	Veery	Rare

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Table D-1 (continued). Birds present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Catharus guttatus	Hermit thrush	Rare
Catharus minimus	Gray-cheeked thrush	Occasional
Catharus ustulatus	Swainson's thrush	Rare
Certhia americana	Brown creeper	Rare
Ceryle alcyon	Belted kingfisher	Uncommon
Chaetura pelagica	Chimney swift	Abundant
Charadrius vociferous	Killdeer	Uncommon
Chordeiles minor	Common nighthawk	Rare
Coccothraustes vespertinus[1]	Evening grosbeak	–
Coccyzus americanus	Yellow-billed cuckoo	Rare
Coccyzus erythropthalmus	Black billed cuckoo	Rare
Colaptes auratus	Common flicker, northern flicker, yellow-shafted flicker	Common
Colinus virginianus	Northern bobwhite	Occasional
Columba livia	Domestic dove, pigeon, rock dove	Uncommon
Contopus cooperi[1]	Olive-sided flycatcher	–
Contopus virens	Eastern wood pewee	Common
Coragyps atratus	Black vulture	Rare
Corvus brachyrhynchos	American crow, common crow	Abundant
Corvus corax	Common raven, raven	Rare
Corvus ossifragus	Fish crow	Occasional
Cyanocitta cristata	Blue jay	Abundant
Dendroica caerulescens[1]	Black-throated blue warbler	–
Dendroica castanea	Bay breasted warbler	Occasional
Dendroica cerulea	Cerulean warbler	Rare
Dendroica coronata	Yellow rumped warbler	Common
Dendroica discolor	Prairie warbler	Rare
Dendroica dominica	Yellow throated warbler	Uncommon
Dendroica fusca	Blackburnian warbler	Rare
Dendroica magnolia	Magnolia warbler	Uncommon

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Table D-1 (continued). Birds present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Dendroica palmarum	Palm warbler	Occasional
Dendroica pensylvanica	Chestnut-sided warbler	Rare
Dendroica petechia	Yellow warbler	Rare
Dendroica pinus	Pine warbler	Occasional
Dendroica striata	Blackpoll warbler	Rare
Dendroica tigrina	Cape May warbler	Occasional
Dendroica virens	Black-throated green warbler	Occasional
Dolichonyx oryzivorus	Bobolink	Occasional
Dryocopus pileatus	Pileated woodpecker	Common
Dumetella carolinensis	Catbird, gray catbird	Uncommon
Empidonax alnorum[1]	Alder flycatcher	–
Empidonax flaviventris[1]	Yellow-bellied flycatcher	–
Empidonax minimus	Least flycatcher	Rare
Empidonax traillii[1]	Traill's flycatcher, willow flycatcher	–
Empidonax virescens	Acadian flycatcher	Abundant
Eremophila alpestris[1]	Horned lark	–
Euphagus carolinus[1]	Rusty blackbird	–
Falco sparverius	American kestrel, sparrow hawk	Occasional
Geothylpis trichas	Common yellowthroat, yellowthroat	Common
Haliaeetus leucocephalus	Bald eagle	Occasional
Helmitheros vermivorus	Worm-eating warbler	Occasional
Hirundo rustica	Barn swallow	Common
Hylocichla mustelina	Wood thrush	Abundant
Icteria virens	Yellow-breasted chat	Rare
Icterus galbula	Baltimore oriole, northen oriole	Common
Icterus spurius	Orchard oriole	Rare
Junco hyemalis	Dark-eyed junco, junco	Common
Melanerpes carolinus	Red-bellied woodpecker	Common
Meleagris gallopavo	Turkey, wild turkey	Abundant
Melospiza georgiana	Swamp sparrow	Occasional

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Table D-1 (continued). Birds present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Melospiza lincolnii[1]	Lincoln's sparrow	–
Melospiza melodia	Song sparrow	Abundant
Mimus polyglottos	Mockingbird, northern mockingbird	Rare
Mniotilta varia	Black-and-white warbler	Rare
Molothrus ater	Brown-headed cowbird	Common
Myiarchus crinitus	Great crested flycatcher	Rare
Oporornis agilis[1]	Connecticut warbler	–
Oporonis formosus	Kentucky warbler	Rare
Oporornis philadelphia	Mourning warbler	Occasional
Otus asio	Eastern screech-owl, screech owl	Uncommon
Pandion haliaetus	Osprey	Occasional
Parula americana	Northern parula, parula warbler	Rare
Passer domesticus	House sparrow	Rare
Passerella iliaca[1]	Fox sparrow	–
Passerina cyanea	Indigo bunting	Abundant
Petrochelidon pyrrhonota	Cliff swallow	Occasional
Pheucticus ludovicianus	Rose-breasted grosbeak	Rare
Picoides pubescens	Downy woodpecker	Common
Picoides villosus	Hairy woodpecker	Uncommon
Pipilo erythrophthalmus	Rufous-sided towhee, towhee	Abundant
Piranga olivacea	Scarlet tanager	Abundant
Piranga rubra	Summer tanager	Occasional
Poecile atricapillus	Black-capped chickadee, chickadee	Uncommon
Poecile carolinensis	Carolina chickadee	Abundant
Polioptila caerulea	Blue-gray gnatcatcher	Common
Pooecetes gramineus	Vesper sparrow	Rare
Progne subris[1]	Purple martin	–
Quiscalus quiscula	Common grackle	Uncommon
Regulus calendula	Ruby-crowned kinglet	Uncommon
Regulus satrapa	Golden-crowned kinglet	Common

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Table D-1 (continued). Birds present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Riparia riparia[1]	Bank swallow	–
Sayornis phoebe	Eastern phoebe	Uncommon
Scolopax minor	American woodcock, woodcock	Occasional
Seiurus aurocapilla	Ovenbird	Abundant
Seiurus noveboracensis	Northern waterthrush	Occasional
Setophaga ruticilla	American redstart	Rare
Sialia sialis	Eastern bluebird	Common
Sitta canadensis	Red-breasted nuthatch	Rare
Sitta carolinensis	White-breasted nuthatch	Common
Sphyrapicus varius	Yellow-bellied sapsucker	Occasional
Spizella arborea	American tree sparrow, tree sparrow	Rare
Spizella passerina	Chipping sparrow	Common
Spizella pusilla	Field sparrow	Common
Stelgidopteryx serripennis	Rough-winged swallow	Rare
Strix varia	Barred owl	Uncommon
Sturnella magna	Eastern meadowlark, meadowlark	Uncommon
Sturnus vulgaris	European starling, starling	Abundant
Tachycineta bicolor	Tree swallow	Rare
Thryothorus ludovicianus	Carolina wren	Abundant
Toxostoma rufum	Brown thrasher	Rare
Troglodytes aedon	House wren	Rare
Troglodytes troglodytes[1]	Winter wren	–
Turdus migratorius	American robin, robin	Abundant
Tyrannus tyrannus	Eastern kingbird	Occasional
Vermivora celata[1]	Orange-crowned warbler	–
Vermivora peregrine	Tennessee warbler	Rare
Vermivora pinus	Blue-winged warbler	Uncommon
Vermivora ruficapilla	Nashville warbler	Rare
Vireo flavifrons	Yellow-throated vireo	Uncommon
Vireo gilvus	Warbling vireo	Rare

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

Table D-1 (continued). Birds present, or probably present, at Friendship Hill National Historic Site (NPSpecies, n.d.).

Scientific Name	Common Name	Abundance[2]
Vireo griseus	White-eyed vireo	Rare
Vireo olivaceus	Red-eyed vireo	Abundant
Vireo philadelphicus	Philadelphia vireo	Rare
Vireo solitarius	Blue-headed vireo, solitary vireo	Rare
Wilsonia canadensis	Canada warbler	Occasional
Wilsonia citrina	Hooded warbler	Rare
Wilsonia pusilla	Wilson's warbler	Occasional
Zenaida macroura	Mourning dove	Abundant
Zonotrichia albicollis	White-throated sparrow	Uncommon
Zonotrichia leucophrys	White-crowned sparrow	Occasional

[1] Probably present

[2] Abundance codes:

Abundant: May be seen daily, in relatively large numbers

Common: May be seen daily, but not in large numbers

Uncommon: Likely to be seen monthly

Rare: Usually seen only a few times annually

Occasional: Occurs at least once every few years

– : No abundance information listed

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.

NPS 476/159884, August 2019

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525